Sunday, 3 March 2013

TEE for the Generalist (Myers) ................................................................. 01

Perioperative Management of the Morbidly Obese Patients – Size Does Matter (Chung)

Monday, 4 March 2013

Acute Pain Management Update (Fiegel)..................................................... 24

The Practical Approach to STOP-Bang Questionnaire and Management Of Patients with Obstructive Sleep Apnea (Chung)

Non-Obstetric Surgery during Pregnancy (Hawkins)...................................... 48

Pediatric Ambulatory Anesthesia (Agarwal).................................................. 62

Tuesday, 5 March 2013

Postoperative Visual Loss – A Preventable Complication? (Janik)............... 70

An Update on Ambulatory Anesthesia (Chung)............................................. 82

Mitigating Legal and Ethical Risks (O’Rourke, Altmix)................................... 94

Wednesday, 6 March 2013

Pediatric Anesthesia Update 2013 (Agarwal).............................................. 100

What’s New in Obstetric Anesthesia form 2012? (Hawkins)....................... 110

Where Did All Our Drugs go?
- Drug Shortages: What is the Current Situation? (Lyda) .........................135
- Suggamadex, and FDA and How that Impacts Our Drug Supply (Sloan)..... 144
- Drug Shortages, Practical Considerations (Majcher)..............................151
Thursday, 7 March 2013

Cardiac Anesthesia Update (Gravlee) 154

ASA 4 and Beyond from the ICU to the OR and Back Again
- It came from the ICU (Sullivan) 166
- Techniques from Managing Esophagectomy (Weitzel) 169

Friday, 8 March 2013

Anesthetic Choices for the Occasional Neuroanesthesiologist (Mongan) 181

Thoracic Anesthesia (Gravlee) 194

WORKSHOPS

Comprehensive Airway Management 205
Geoffrey Lane, MB; Thomas Henthorn, MD; Daniel Janik, MD; Donald Penning, MD; Marina Shindell, DO

TEE Review Course for the General Anesthesiologist 223
Basic Principles of Echo; Basic TEE Views; Doppler Modalities; Artifacts and Pitfalls; Systolic Function; Diastolic Function; Evaluation of AV; Evaluation of MV; Evaluation of the Aorta; Pericardial Diseases; Right Heart Function; Congenital heart Disease; Case Presentations, Barbara Arnold, MD & Kevin Wilkey, MD

Beginner Ultrasound-Guided Regional Anesthesia 315
Phantom; Vascular Access; Femoral / Saphenous; Popliteal Sciatic; Abdominal Wall [TAP and Rectus]; Interscalene Brachial Plexus; Supraclavicular Brachial Plexus; Peripheral Nerves of Upper Extremity; Spine and Paravertebral

Advanced Ultrasound-Guided Regional Anesthesia 329
Mixed Bag / Ask the Expert; Femoral [Catheter] / Saphenous; Fascia Iliaca/LFC/Otburator; Popliteal Sciatic [Catheter]; Abdominal Wall [TAP/Rectus/Ilioinguinal]; Interscalene Brachial Plexus Catheter; Supraclavicular / Infraclavicular; Peripheral Nerves of Upper Extremity; Spine and Paravertebral
CRASH 2013 PROGRAM

Sunday – 3 MARCH 2013

9:00am-7:30pm Registration

4:00-5:00pm TEE for the Generalist
Greg Myers, MD

5:00-6:00pm Perioperative Management of the Morbidly Obese Patients – Size Does Matter
Frances Chung, MBBS FRCPC

6:00-6:30pm Questions and Answers
Chung and Myers

6:30-7:30pm Opening Reception

Monday – 4 MARCH 2013

6:30-8:00am Continental Breakfast/View Exhibits

7:00-8:00am Acute Pain Management Update
Matthew Fiegel, MD

8:00-9:00am The Practical Approach to STOP-Bang Questionnaire and Management of Patients with Obstructive Sleep Apnea
Frances Chung, MBBS, FRCPC

9:00-9:30am Questions and Answers
Fiegel and Chung

9:30am View Exhibits/Recess
3:30pm View Exhibits/Refreshments (Après Ski)

WORKSHOPS

4:00-7:00pm Comprehensive Airway Management
Geoffrey Lane, MB; Thomas Henthorn, MD; Daniel Janik, MD; Donald Penning, MD;
Marina Shindell, DO
CRASH 2013 PROGRAM
(continued)

4:00-7:00pm  TEE Review Course for the General Anesthesiologist Day 1 of 3
1. Basic Principles of Echo: Tamas Seres, MD
2. Basic TEE Views: Bryan Ahlgren, DO
3. Doppler Modalities: Bryan Ahlgren, DO
4. Artifacts and Pitfalls: Tamas Seres, MD
Case Presentations: Barbara Arnold, MD and Kevin Wilkey, MD

PANEL DISCUSSION/LECTURES

4:00-4:50pm  Non-Obstetric Surgery During Pregnancy
Joy Hawkins, MD

4:50-5:40pm  Pediatric Ambulatory Anesthesia
Rita Agarwal, MD

5:40-6:30pm  Current Health Care Policy and Anesthesia
Randall Clark, MD

6:30-7:00pm  Questions and Answers
Hawkins, Agarwal, and Clark

Tuesday – 5 MARCH 2013

6:30-8:00am  Continental Breakfast/View Exhibits

7:00-8:00am  Postoperative Visual Loss – A Preventable Complication?
Daniel Janik, MD

8:00-9:00am  Hot Topics in Ambulatory Anesthesia
Frances Chung, MBBS, FRCPC

9:00-9:30am  Questions and Answers
Janik and Chung

9:30am  View Exhibits/Recess
3:30pm  View Exhibits/Refreshments (Après Ski)
CRASH 2013 PROGRAM
(continued)

WORKSHOPS

4:00-7:00pm  Introduction to Ultrasound-Guided Regional Anesthesia
Phantom: Matthew Fiegel, MD
Vascular Access: Chris Lace, MD
Femoral / Saphenous: Alan Bielsky, MD
Popliteal Sciatic: Adrian Hendrickse, MD
Abdominal Wall [TAP and Rectus]: Glenn Merritt, MD
Interscalene Brachial Plexus: Peter Fuhr, MD
Supraclavicular Brachial Plexus: John Armstrong, MD
Peripheral Nerves of Upper Extremity: Chris Ciarallo, MD
Spine and Paravertebral: Ron Valdivieso, MD

4:00–7:00pm  TEE REVIEW COURSE for the General Anesthesiologist Day 2 of 3
5.  Systolic Function: Tamas Seres, MD, PhD
6.  Diastolic Function: Tamas Seres, MD, PhD
7.  Evaluation of AV: Ferenc Puskas, MD, PhD
8.  Evaluation of MV: Fadi Nasrallah, MD, MBA
Case Presentations: Kevin Arnold, MD & Barbara Wilkey, MD

PANEL DISCUSSION/LECTURES

4:00-4:50pm  The Ethics of Looking the Other Way
Scott Markowitz, MD

4:50-6:00pm  Mitigating Legal and Ethical Risks
Patrick O’Rourke, JD and Julie Altmix, RN, BSN

6:00-6:30  Question and Answer
Markowitz, O’Rourke, and Altmix
Wednesday, 6 MARCH 2013

6:30-8:00am Continental Breakfast/View Exhibits

7:00-8:00am Pediatric Anesthesia Update 2013
Rita Agarwal, MD

8:00-9:00am What’s New in OB Anesthesia
Joy Hawkins, MD

9:00-9:30am Questions and Answers
Agarwal and Hawkins

9:30am View Exhibits/Recess
3:30pm View Exhibits/Refreshments (Après Ski)

WORKSHOPS

4:00-7:00pm TEE REVIEW COURSE for the General Anesthesiologist Part 3 of 3
9. Evaluation of the Aorta: Quinn Stevens, MD
10. Pericardial Diseases: Daniel Beck, MD
11. Right Heart Function: Ferenc Puskas, MD, PhD
12. Congenital heart Disease: Fadi Nasrallah, MD, MBA
Case Presentations: Barbara Arnold, MD & Kevin Wilkey, MD

4:00-7:00pm Advanced Ultrasound-Guided Regional Anesthesia
Mixed Bag / Ask the Expert: Matt Fiegel, MD
Femoral [Catheter] / Saphenous: Chris Lace, MD
Fascia Iliaca/LFC/Opturator: Alan Bielsky, MD
Popliteal Sciatic [Catheter]: Adrian Hendrickse, MD
Abdominal Wall [TPA/Rectus/Ilioinguinal]: Glenn Merritt, MD
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Supraclavicular / Infraclavicular: John Armstrong, MD
Peripheral Nerves of Upper Extremity: Chris Ciarallo, MD
Spine and Paravertebral: Ron Valdivieso, MD

PANEL DISCUSSION/LECTURES

4:00-7:00pm PANEL: Where Did All Our Drugs go?
Drug Shortages: What is the Current Situation?
Clark Lyda, PhamD
Suggamadex, and FDA and How that Impacts Our Drug Supply
Tod Sloan, MD, PhD, MBA
Drug Shortages, Practical Considerations
Tom Majcher, DO
Thursday – 7 MARCH 2013

6:30-8:00am  Continental Breakfast/View Exhibits

7:00-8:00am  Cardiac Anesthesia Update
Glenn Gravlee, MD

8:00-9:00  OR Management and Efficiency
Donald Penning, MD

9:00-9:30am  Questions and Answers
Gravlee and Penning

9:30am  View Exhibits/Recess
3:30pm  View Exhibits/Refreshments

LECTURE

4:00-7:00pm  ASA 4 and Beyond: from the ICU to the OR and Back Again
Bryan Ahlgren, MD, Christopher Lace, MD; Breandan Sullivan, MD; and Nathaen Weitzel, MD

Friday – 8 March 2013

6:30-8:00am  Continental Breakfast/View Exhibits

7:00-8:00  Anesthetic Choices for the Occasional Neuroanesthesiologist
Paul Mongan, MD

8:00-9:00am  Thoracic Anesthesia
Glenn Gravlee, MD

9:00-9:30am  Questions and Answers
Mongan and Gravlee

9:30am  Lottery: Books (must be present to win)

10:00am  Adjourn until 2014
2 March – 7 March
Disclosure of Commercial Interest

CRASH 2013

Colorado Review of Anesthesia for SurgiCenters and Hospitals

March 3-8, 2013 Vail, Colorado

As a sponsor accredited by the Accreditation Council for Continuing Medical Education, the University of Colorado School of Medicine must insure balance, independence, objectivity, and scientific rigor in all its sponsored educational activities. All speakers/contributors participating in a sponsored activity are expected to disclose to the accredited provider any significant financial interest or other relationship(s) involving themselves or their spouse/partner within the last 12 months with any proprietary entity producing health care goods or services related to the content of the activity. The intent of this disclosure is not to prevent a speaker with a significant financial or other relationship from making the presentation, but rather to identify and resolve any conflicts of interest that may control the content of the activity. It is also intended that any potential conflict be identified openly so that the listeners have a full disclosure of the facts and may form their own judgments about the presentation. It remains for the audience to determine whether the speaker's interests or relationships may influence the presentation with regard to exposition or conclusion.

Alan Bielsky, MD has received Honoraria from IFlow

All other faculty/contributors have reported no commercial affiliation associated with this conference or intent to reference off-label/unapproved uses of products or devices in their presentations.

Dated 01/31/2013 cjw
IMPORTANT! PLEASE READ

WELCOME TO CRASH 2013!

We encourage you to take five minutes to read this prior to the start of CRASH 2013.

1. **CME Certificates** – Physicians and nurses should receive a *Continuing Medical Education* certificate during the registration process. Above the perforation is the *actual certificate* which you keep for your record. Below the perforation of the form you must complete, sign, and return to us for your certificate to be valid.. Place your completed sign-in sheet (the bottom portion of your certificate) in one of the evaluation boxes after your final session. If you did not receive a CME certificate, please take all the materials you were given and return to the CRASH Registration Desk. If you have any questions, please check at the CRASH desk.

2. **Audience Response** – clickers will be provided in the lecture hall and some of the workshops. Please be sure to return to the back of the room after each lecture or workshop.

3. **Opening Reception** – Please plan to attend the Opening Reception hosted by Dr. Henthorn on Sunday night, **3 MARCH**. This will be held from **6:30 and 7:30 PM**, in the pre-function exhibitor area. All members and your family are welcome.

4. **Questions or Problems** - Please contact Beverly Janik, Anne Caulfield, Russ Ingram, Dr. Rita Agarwal, Dr. Joy Hawkins, or Dr. Daniel Janik with any questions or problems. Our nametags have ribbons that say Committee or Staff with “Ralphie” stickers and we spend a LOT of time at the CRASH registration desk.

5. **Please turn off all cell phone and pagers to vibrate for the speakers.** All messages will be displayed on the bulletin board which is located next to the CRASH registration desk.

6. **Limited Seating** – *Children are not allowed in the lectures or workshops*. The presence of children has been cited as a problem by participants at previous CRASH conferences and we ask your help in this matter. The lecture/workshop areas are for **PAID PARTICIPANTS ONLY**.

7. **Workshops** – If you wish to attend a workshop, please check at the CRASH desk for space available, payment, and notate this information on your name tag. Comprehensive Airway Management, Ultrasound Guided Regional Anesthesia, and all TEE Review Course workshops (offering TEE CME Certificate) are paid prior to the beginning of the conference or at the Registration Desk before the workshop begins. All other workshops/panel discussions are free.

8. **Complimentary Breakfast Buffet and Afternoon Snack (Après Ski)** – Participants guest who paid the $150.00 fee will be allowed to attend the breakfast and afternoon snack. **Each paying guest & registrant must have a name tag in order to attend.**
a. Each morning’s breakfast will begin at 6:30 a.m. and will close at 8:00 a.m. for participants and their paying guest. The Breakfast will run from 6:30-8:30am but the hot items will not be available after 8:00am. A seating area for family and friends who have paid the guest fee will be available in Salons. This room will also have high chairs and booster chairs for the kids.

b. Afternoon Refreshment - Are available from 3:30–5:30p.m. These are not meant to be dinner, but rather a sustaining refreshment to tide you over. The afternoon sessions begin at 4:00. Refreshments are for paid participants & paid guest.

9. Break – There will be a ten minute break between the first and second lectures each morning and each afternoon. When you hear the Bell, the next lecture will begin in 3 minutes.

10. NASTAR Race - Will be held Wednesday, March 6th. The race time is 12:00 p.m. This activity is complimentary for you and your guests. No matter what your level of skiing, we encourage you to take your 2 runs through the gates. It’s WAY COOL! All racers will need to sign a waiver card available at the registration desk.

11. Friday Morning Raffle - Once again we will hold a raffle at the very end of the very last talk on the very last day of the conference. We will be giving away medical books. You must be IN ATTENDANCE at the very end of the very last talk on the very last day of the Conference to be eligible.

12. Evaluations forms – CRASH Evaluations can now be done on-line by going to www.cucrash.com and select Evaluation or use the QR code provide (to right). Paper evaluations will still be accepted and are provided in the lecture hall. Baskets will be furnished at the back of the conference room by the exit doors and at the registration desk for your completed evaluation forms; if you have other ideas or concerns, let one of the CRASH committee members know or write them down and put them into one of the baskets. Your reviews are very important to us, so please take a moment to give us your feedback!

13. Trivia Questions – Due to continued public demand, we are again offering the trivia questions. The answer sheets will be provide in the lecture hall and the questions will be projected on the big screen in the main room and on the Announcements Bulletin Board. A winner will be chosen from the correct answers at the close of each eligible session so mark those answers and turn in those forms! Be sure to write your name on the answer portion of your evaluation sheet.

HAVE FUN, PLAY SAFELY, DRINK LOTS OF WATER, AND USE PLENTY OF SUNSCREEN.

DO NOT HESITATE TO ASK DRs. AGARWAL, HAWKINS, JANIK, or HENTHORN or BEV, RUSS, or ANNE for ASSISTANCE:

OUR PHONE NUMBER IS (970) 477-5630
<table>
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<tr>
<th>Company/Medical Device Manufacturer</th>
<th>Acknowledgment</th>
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<td>B. Braun</td>
<td>Grifols Therapeutics, Inc.</td>
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<tr>
<td>Baxter Healthcare</td>
<td>Hospira, Worldwide, Inc.</td>
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<td>BBVA Compass</td>
<td>I-Flow LLC, a Kimberly-Clark Health Care Company</td>
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<td>Cadence Pharmaceutical</td>
<td>Karl Storz Endoscopy-America, Inc.</td>
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<td>Cheetah Medical</td>
<td>LMA North America, On-Q Pain Management</td>
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<td>Colorado Academy of Anesthesiologist Assistants</td>
<td>Maquet</td>
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<td>Cook Medical</td>
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<td>Olympus America, Inc.</td>
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<td>Glidescope/Verathon Medical</td>
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Learning Objectives

1. Describe which clinical situations are appropriate for TEE monitoring in noncardiac surgery including indications / contraindications for TEE placement.
2. Demonstrate the key diagnostic TEE views needed for quick assessment of an unstable patient.
3. Utilize basic TEE imaging to diagnose and differentiate hypovolemia, myocardial ischemia, heart failure, pericardial / pleural effusions from normal function.
4. Describe the process of certification in Basic TEE for noncardiac surgery.

Denver Health Medical Center

- Primary Safety Net Hospital
- Level One Trauma
- Wide Range of Cases
- Affiliated With the University of Colorado Hospital - Anesthesia Residency Program

Why is this important?

- Written and Oral Exams - ABA
- Provides an excellent diagnostic and real-time monitoring tool
- Minimally invasive and low risk

Advanced Topics in Anesthesia

- Echocardiography: Technical Aspects, Complication
- Echocardiography: Heart Anatomy: Chambers, Valves, Great Vessels, Pericardium, Basic Transesophageal Echocardiography (TEE) Views
- Perioperative Diagnosis and Treatment of Congestive Heart Failure
- Ischemic HD
- Echocardiography: Myocardial Infarction and Acute Coronary Syndrome; Clinical, ECG, Echocardiography
- Pericardial Effusion and Tamponade
- Valvular Heart Disease
- Cardiac Tamponade and Constrictive Pericarditis
- Pulmonary Embolism

TEE – ischemic heart disease, valve function, embol detection, congenital heart disease, pericardial fluid/tamponade, ventricular function and preload assessment
ACGME Curriculum

- CA1/CA2/CA3 Anesthesiology Resident Trauma Anesthesia Rotation
  - Ultrasound and echocardiography in trauma

Practice Guidelines for Perioperative Transesophageal Echocardiography

- Noncardiac surgery
- Task Force:
  - ASA and Society of Cardiovascular Anesthesiologists
    - 13 members
      - Anesthesiologists (private and academic)
      - Two Cardiologists (American College of Cardiology and American Society of Echocardiography)
  - Two Methodologists (ASA Committee on Standards and Practice Parameters)

Indications for TEE

ASA Members and Consultants

Strongly Agree
- Unexplained persistent hypotension
- Life-threatening hypotension anticipated

Agree
- Known or suspected CV pathology - hemodynamic, pulmonary, or neurological compromise
- Persistent unexplained hypoxia
- Lung transplantation or major abdominal or thoracic trauma

Equivocal
- Open Abdominal
- Liver transplantation

Myers, Gregory, MD  TEE for the Generalist

CRASH 2013 2
### ASA Members and Consultants

**Equivocal**

- Endovascular Aortic Procedures
- Neurosurgery - sitting position
- Percutaneous CV interventions
  (e.g., Femoral Stenting)

### ASA Members and Consultants

**Disagree**

- Use of TEE for Orthopedic Surgery

### Absolute contraindication?

**SURVEY**

<table>
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<th>Condition</th>
<th>n (%)</th>
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<tr>
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<tr>
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<tr>
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<tr>
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<tr>
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<td>4.5 Tracheoesophageal fistula</td>
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n=430 ASA member personally perform TEE

### Absolute contraindication?

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n=430 ASA member personally perform TEE
### Complications

- **Rare - estimated 1/5000 (n)**
- **Potential Complications**
  - Esophageal Perforation - 10,000 patients 1 hypopharyngeal, 2 cervical, no fatalities

### Complications Increase

- Gastrointestinal Bleeding
- Thrombocytopenia
- Anticoagulation
- Bleeding disorder
- Esophageal varices do not appear to be at increased risk

### Absolute contraindication?

#### Survey

<table>
<thead>
<tr>
<th>Cause</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
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Studies of TEE in trauma

- Mollod and Felner: Retrospective review of 16 patients with chest trauma (10 penetrating, 6 blunt)
  - 15 of 16 patients had TEE findings that influenced management:
    • Timing of surgical intervention
    • Type of repair
    • Location of intracardiac foreign body
    • Time to extubation
    • Optimization of medical management

- TEE revealed new diagnoses in 70% of patients of Group 1 and 33% of Group II.
- TEE both discovered and ruled out myocardial contusions and aortic injuries.
- Severe hypovolemia, left ventricular dysfunction and pericardial effusions were commonly observed.
  - Authors Concluded:
    - "TEE is of utmost importance in multiple injury patients, with or without any evidence of thoracic or mediastinal injury, providing safe and rapid examination of the mediastinal structures and evaluation of the hemodynamic status."

TEE in Blunt Aortic Injury

- Richens et al: Retrospective review of 132 cases of aortic rupture due to blunt chest trauma in MVCs in the UK.
  - Results:
    • 2% survival rate for blunt traumatic aortic rupture
    • TEE rapidly and accurately diagnosed these aortic injuries by direct visualization of dissection, intimal/medial flap, aortic wall hematoma or intraluminal thrombus or debris

TEE during intraoperative cardiac arrest

- Memtsoudis and Rosenberger et al: Retrospective review of 22 patients with intraoperative cardiac arrest during noncardiac surgical procedures who underwent TEE during the course of resuscitation.
  - Results:
    • TEE established a suspected primary diagnosis in 19 of the 22 patients.
    • Findings aided in further management in 18 patients, including specific surgical interventions in 12.

  - 6 had signs of MI on TEE → 3 underwent emergent CABP, 1 received IABP and medical management
  - Pulmonary emboli was diagnosed 9 Patients → 4 underwent emergent embolectomy
  - 2 had pericardial tamponade treated with pericardiotomy
  - 2 were diagnosed with hypovolemia leading to aggressive fluids
  - Overall 14 of 22 patients survived the OR, 7 were discharged from the hospital.

TEE in trauma

- Catoire et al: Prospective study of 70 trauma patients with multiple injuries
  - Divided in 2 groups:
    • High suspicion group: patient or suspected thoracic or mediastinal injury
    • Low suspicion group: no sign of chest wall, pulmonary or cardiothoracic injury
Questions to ask yourself?
• Could TEE alter management?
• Will this delay or distract from acute care?
• Is other staff available?
- Traumatic Aortic Rupture
- Dissection
- Pleural Effusion

**ME Desc Aorta**

**SAX**

**MOVIE**

**Pathology:**
- Pulmonary Embolism
- RV strain / dilation
- Pericardial Effusion
- *Left Side*
- Pericardial Effusion
- Ischemia
- Volume

**Lateral / Apical Akinesia**

**MOVIE**

**Septal / Inferior Hypokinesis**

**MOVIE**

**Inferior / Apical Akinesia**

**MOVIE**
Inferior / Lateral Akinesis

MOVIE

Pulmonary Embolism

MOVIE

Hypovolemia

MOVIE

Atherosclerosis

MOVIE

Ascending Aortic Dissection

MOVIE

Pericardial Effusion

MOVIE
Pericardial Effusion

Left Pleural Effusion

Right Pleural Effusion

Certification

Two Certifications
1. Advanced TEE
2. Basic TEE
Advanced Certification
- Certification requires fellowship - Cardiac Anesthesia
- Can take the test without fellowship but cannot be certified

Basic Certification
- NO fellowship required (new as of 2010)
- Current Medical License
- Current Anesthesia Board Certification

Basic PTEeXAM Scope of Practice
- Limited to non-diagnoses
- Focused on intraoperative monitoring
- Not specific diagnosis, except in emergent situations
- Diagnoses requiring intraoperative cardiac surgical intervention or postoperative medical/surgical management must be confirmed by an individual with advanced skills in TEE or an independent diagnostic technique.

Basic PTEeXAM Content Outline
1. Patient Safety
2. Acquisition and Optimization
3. Normal Cardiac Anatomy and Imaging Plane Correlation
4. Global Ventricular Function
5. Regional Ventricular Systolic Function & Recognition of Pathology
6. Basic Recognition of Cardiac Valve Abnormalities
7. Identification of Intracardiac Masses in Non-Cardiac Surgery
8. Basic Hemodynamic Assessment
9. Related Diagnostic Modalities
10. Basic Recognition of Congenital Heart Disease in the Adult
11. Surface Ultrasound for Vascular Access
Supervised Training Pathway

- Letter from the hospital or appropriate department
- Training Director
- 150 Total Echo’s Performed
  - At least 50 performed live and reviewed
  - Tampered log of reviewed not performed

Practice Experience Pathway

- Performed and interpreted 150 basic intraoperative TEE
  - 4 consecutive years
  - No less than 25 in any year
  - 40 hours of GME credits devoted to TEE

Future of NBE Basic Exam

- The National Board of Echocardiography and the ASA
- Initial projections included an estimate of 300 examinees per year
  - Only an average of 141 examinees per year have taken the exam
  - Average pass rate of 87% over the past three years

Reference

Size Matters: Perioperative Management of the Morbidly Obese

Frances Chung
Professor, Dept. of Anesthesiology
Toronto Western Hospital
University Health Network
University of Toronto

Periop Mx of Morbidly Obese Pt

- Prevalence
- Preop evaluation and preparation
  - Metabolic syndrome
  - OSA, OHV
- Intraop Mx
  - Difficult intubation
  - Position
  - Ventilation strategy
- Postop Mx

Long term mortality after gastric bypass surgery

- Retrospective cohort
- 7929 surgical pts vs. 7929 severely obese control
- Long term mortality from any cause (DM, CAD, cancer etc.) decreased by 40%

Adam TD et al. NEJM 2007;357:753-61

Obesity surgery mortality risk score: To predict risk in pts for gastric bypass

5 factors
- BMI > 50
- Male
- Hypertension
- Risk of thromboembolism
- 45 yrs or older

DeMaria EJ et al. Surg Obes Relat Dis 2007;3:134-140

Respiratory CX in Ambulatory Surgery (Prospective study)

- 17,368 outpts
- 15% morbidly obese
- 4-fold increase
  - intraop & postop respiratory events
  - Desaturation
  - Bronchospasm

F Chung et al. Br J Anaesth 1999; 83:262-270

Obesity as a Risk Factor for Unanticipated Admission after Ambulatory Surgery

- 235 obese pt (BMI>40) vs. control
  - Intraop bronchospasm
  - PONV
  - Postop O2 requirement
- Not a risk factor for unplanned admission
  - 26% vs. 22.1% Odds ratio 1.3

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Preoperative Assessment and Preparation

- Recognize metabolic syndrome
- Recognize OSA, Recognize OHV

Preop Measurement

- BMI; IBW
- Waist and hip circumference; WHR
- Abdominal wall thickness; intra-abdominal fat
- Neck circumference; difficult intubation 43 cm
- STOP-Bang questionnaire

Preoperative Evaluation

- STOP-Bang questionnaire
- Oxygen saturation
- Glucose intolerance
- Liver function

Neck circumference & probability of problematic intubation

43 cm neck circumference 30% probability of DI

Preop wt loss with a low energy diet reduces size of liver dramatically

- 8% reduction of wt: 80% reduction of liver volume 0-2 wks
- Min. duration for a preop diet: 2 wk
- 6 wk: maximal liver vol. reduction
- Easier approach for surgery

Preop 10% wt loss a shorter LOS, and few postop Cx after gastric bypass surgery

Benotti PN et al Arch Surg 2009;144:1150-54

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Prevalence of OSA in Morbidly Obese Pt for Bariatric Sugary

- 71% dx to have OSA by sleep studies

WC Frey, Obese Surg 2003; 13:676-83

STOP questionnaire to screen OSA

- S - Snoring
- T - Tiredness / sleepiness / fatigue
- O - Obstruction of breathing
- P - Blood Pressure (>140/90) treated or untreated

STOP- Bang

- STOP
- B BMI>35
- A Age >50
- N Neck circumference >40 cm
- G Gender male

- Higher sensitivity and specificity
- 3 / 8 questionnaire positive

Chung, Frances, MBBS FRCPC Size Matters: Perioperative Management of the Morbidly Obese

CRASH 2013
ODI > 10 sensitive and specific for moderate and severe OSA

Mean overnight PaO2 <94.6% has higher postop adverse events

MO pts after surgical wt loss still has significant OSA: a meta-analysis

Periop Mx of Morbidly Obese Pt

MO accounts for high incidence of difficult airway: ASA closed claims study

Morbid obesity and difficult airway Mx – What is the risk?


Kheterpal S et al Anesthesiology 2006;105:885-91

F Chung et al Anesth Analg 2012
**Difficult tracheal intubation: controversial**

- 13-20% of all intubation in MO
- High Mallampati score > 3
- Increased neck circumference > 43 cm
- Excessive pre-tracheal fat

Ezi T et al, CJA 2003;50:179-83

**Mouth opening and morbid obesity**

- Full mouth opening obtained with 26 degree of cranio cervical extension from neutral
- Pts with restricted cranio cervical movement
- Reduced mouth opening ability

Calder I et al, Anesthesiology 2003;99:799-801

**Periop Mx of Morbidly Obese Pt**

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  - Position
  - Ventilation strategy
  - Anesthetic strategy
- Postop Mx

**Pulmonary atelectasis between morbidly obese and non-obese pts**

AS Eichenberger et al, Anesth Analg 2002; 95:1788-95

**Preoxygenation is effective in 25* head-up vs. supine position**

- Severely obese pts, 3 min preoxygenation, 25* head-up vs. supine
- PaO2 increased by 82 mm Hg
- Apnea time to desaturate to 92% increased by 1 min


**Low FiO2 prevent atelectasis at induction**

- 100% O2 6.8% atelectasis
- 80% O2 0.8% atelectasis
- Decrease critical time available for intubation
- Cannot be recommended

Akca O et al Anesthesiology 1999;91:991-8
Edmark I et al Anesthesiology 2003;98:28-33
NPPV and RM improve PaO2 after intubation of MO pts
- Preoxygenation + NPPV + RM
- NPPV (Pr support 8ml/kg + PEEP 8cm)
- RM: 40cm H2O for 40s
- Improves PaO2
- Improves end-expiratory lung volume

Futier E et al Anesthesiology 2011;114:1354-63

Increase in PaO2 with PEEP in obese pts but not in normal subjects

P Pelosi et al, Anesthesiology 1999; 91:1221-31

Recruitment maneuvers open up collapsed area by plateau pr.
- CPAP maneuvers
  40 cm H2O for 10-30 s
  PEEP after CPAP maneuvers keep lung open
- “Cycling” maneuvers

FX Whalen et al, Anesth Analg 2006; 102:298-305

Pr. controlled ventilation is better than volume controlled ventilation
- Pr. controlled ventilation vs. volume controlled ventilations
- Improve oxygenation without side effects
- Lower tidal volumes
- PEEP

Soni N et al Br J Anaesth 101: 446-57
Cadi P et al Br J Anaesth 2008’100:709-16

Performing the recruitment maneuver by a ventilator

FX Whalen et al, Anesth Analg 2006; 102:298-305

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  Ventilation strategy
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Chung, Frances, MBBS FRCPC  Size Matters: Perioperative Management of the Morbidly Obese
Obese Patients

- Goals for Obese pts:
  - Rapid awakening & assessment
  - Recovery of mobility & function
  - Rapid recovery of airway patency, effective ventilation and protective airway responses

Summary of Drugs and Pharmacokinetic Considerations

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Lean BW: a more appropriate wt-based scalar for propofol infusion for induction of GA in MO pts


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Succinylcholine Dose

- Increased conc. of pseudocholinesterase
- Increased volume of ECF
- Increased Sux requirements
- Based on TBW
- Better intubating condition


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</tr>
</tbody>
</table>

**Rocuronium**

- Rocuronium dose in MO: IBW
- When dosed on TBW, duration of action: 2X


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**Summary of Drugs and Pharmacokinetic Considerations**

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**Fentanyl for MO pts: Use LBW**

- High CO in MO pts results in lower fentanyl conc.
- Dose of fentanyl: based on LBW
- Dose based on TBW may cause overdosing in MO

Shibutani K et al BJA 2005;95:377-83

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**Opioid requirements after lap. bariatric surgery**

- 42% severe pain
- More opioids in first 48h postop
- Predictors of severe pain
  - Younger pt
  - Male
  - Previous psychiatric hospitalization

Weingarten TN et al Obes Surg 2011; 21:1407-12

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<td>IBW may be inadequate</td>
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Llaurado et al Anesthesiology 2012; 117:1-1
Opioid requirement in pediatric pts with OSA

- Opioid req’d of children with preop hypoxia (OSA) lower than those without preop hypoxia
- Suggesting increased sensitivity to opioid
- Lower opioid doses for OSA pts


Dexmedetomide Infusion during Laparoscopic Bariatric Surgery

- Dose ranging study 0.2, 0.4, 0.8 μg/kg/hr
- Dex infusion rate 0.2 μg/kg/hr
- Recommended to minimize risk of CVS side effects

B Tufanogullari, Anesth Analg 2008; 106:1743-8

Dexmedetomide Infusion during Laparoscopic Bariatric Surgery

- Reduce average end-tidal desflurane by 19%
- PACU stay shorter 20 min
- Reduce PACU fentanyl 36%
- Reduce nausea
- Fail to facilitate late recovery

B Tufanogullari, Anesth Analg 2008; 106:1743-8

Sugammadex 2mg/kg vs. neostigmine 0.05mg/kg in MO pts

- Mean time to 90% on TOF 3.5X faster
- TOF at PACU > 90% in Sugammadex gp
- Sugammadex prevents postop residual curarization better in MO pts

Gasznzinski T et al BJA 2012;108:236-9

Impact of morbid obesity on epidural Cx in labor

- 125 MO pts vs. 125 control
- Systolic hypotension 16% vs. 4% p=0.003
- Diastolic hypotension 49% vs. 29% p=0.002
- Prolonged fetal ht decelerations
- 16% vs. 5% p=0.002

Vricella LK et al AJOG 2011;205:307.e1-6

Fast-track Surgery for Bariatric Laparoscopic Gastric Bypass

- Preoxygenation: 10 cm PEEP
- Induction: TCI
  - Propofol target 6 μg/ml
  - Remifentanil target 8 ng/ml
  - Fentanyl 100 μg
- Intubation: vecuronium

Fast-track Surgery for Bariatric Laparoscopic Gastric Bypass

- Maintenance
  - Desflurane 3-6% (0.5-1 MAC)
  - Oxygen 40%
  - Remifentanyl TCI

- End
  - Fentanyl 100 µg
  - Reversal agents
  - BIS
  - PEEP 5 cm


Fast-track Surgery for Bariatric Laparoscopic Gastric Bypass

- Antiemetic Prophylaxis
  - Droperidol 1.25 mg
  - Ondansetron 4 mg
  - Dexamethasone 8 mg

- Postop Pain
  - Acetaminophen 1 gm IV
  - Parecoxib 40 mg
  - Bupivacaine infiltration


Fast-track Surgery for Bariatric Laparoscopic Gastric Bypass

- Perioperative Time
  - Arrival OR - Induction - Induction start surgery - End surgery - End anesthesia
  - 7.4 min - 11 min - 3 min


Fast-track Surgery for Bariatric Laparoscopic Gastric Bypass

- PACU
  - 3-4 hr stay
  - 20 m walk to toilet
  - Discharge to ward
  - 2-day stay


5 Principles in the anesthetic Mx of MO pt

- RA when possible
- Be prepared: Boy Scout’s motto
- GA: tracheal intubation and ventilation
- Postop care: monitoring, early mobilization
- Judicious use of any opioid by any route

Morbidly obese pt : 5 tips

- STOP-Bang questionnaire to screen OSA, OHV
- Use Troop pillow for intubation
- RM + PEEP to prevent atelectasis
- Use short acting agents
- Reverse trendelenburg position for extubation
To cure sometimes
To relieve often
To comfort always
Regional Anesthesia and Pain Medicine
Update: 2013
CRASH

Matthew J. Fiegel, M.D.
Associate Professor of Anesthesiology
University of Colorado
Director, Acute Pain Service

Objectives

• To present a thorough review of the relevant regional anesthesia and pain medicine literature for the year of 2012.
• In discussing this data, utilize evidenced based medicine to potentially implement changes into your daily management of perioperative pain.

ASA Task Force

• Practice Guidelines for Acute Pain Management in the Perioperative Setting (Anesthesiology Jan 2012)
  – A directed pain history, physical examination and pain control plan should be included in the preop evaluation of every patient
  – “Whenever possible, anesthesiologists should use multimodal pain management therapy”
    • ATC regimen of COXIBs, NSAIDs, or acetaminophen

Joint Commission Sentinel Event Alert

• JCAHO released a sentinel event alert in August of 2012 regarding the safe use of opioids in hospitals
  – Identified characteristics of patients who are at risk for oversedation or respiratory depression
    • Sleep apnea, obesity, age, opioid naivety, concomitant meds, multiple comorbidities
  – Recommendations:
    • Improved patient education
    • Improved physician education
    • Improved systems (respiratory monitoring/ETCO2 v. pulse ox)
    • Avoidance of opioids
      • Multimodal analgesia

Adjuvant Medications
**Adjuvant Meds: Ketamine**

- Double blinded, randomized study of parturients undergoing elective repeat c-sections with spinal anesthesia (Minerva Anesthel July 2012):
  - Ketamine v. Placebo
  - Ketamine group received 0.5mg/kg bolus after delivery as well as 2mcg/kg/min infusion for 12 hours
  - Ketamine group had reduced morphine consumption out to 24 hours
  - No differences in residual pain after 3 years

- Double blinded, randomized trial of parturients undergoing caesarian section with spinal anesthesia (Int J of Obst. Anest July 2012):
  - Ketamine v. Placebo
  - Ketamine group received 0.15mg/kg bolus after spinal placement
  - Ketamine group displayed lower 24 hour analgesic requirement, longer times to analgesic administration, and lower 24 hour pain scores

**Adjuvant Medications: Dexamethasone**

- Metaanalysis of perioperative dexamethasone effects on postoperative analgesia showed: (BJA 1/15/2013)
  - 45 studies, dose ranging from 1.25-20mg
  - Decreased postoperative pain at 2 and 24 hours
  - Decreased morphine consumption at 2 and 24 hours
  - No increased incidence of wound healing or postoperative infection
  - Higher glucose levels at 24 hours

**Adjuvant Meds: Alpha 2 Agonists**

- Metaanalysis of 30 studies and 1792 patients examining the effects of alpha2 agonists (clonidine and dexmedetomidine) when administered systemically in surgical patients (Anesthesiology June 2012):
  - Both drugs decreased morphine consumption for 24 hours
  - Decreased pain at 24 hours with both
  - Decreased nausea with both
  - Increased hypotension with clonidine
  - Increased bradycardia with dexmedetomidine

**Intravenous Regional Anesthesia: Bier Blocks**

- Addition of either 0.5mg/kg of ketamine or 1mcg/kg of dexmedetomidine to 20cc of 1% lidocaine to bier block showed (JACP 12/20/2012):
  - Ketamine reduced the block onset time, delayed the tourniquet pain time, and had improved patient satisfaction over lido or lido/dex groups
  - Dexmedetomidine and ketamine reduced postoperative analgesic requirements

**Spinal Anesthesia**
Spinal Anesthesia: Safety
- In vitro studies with chlorhexidine antisepsis have shown that the cleaning solution is toxic to both neurons and schwann cells
- However, a four year review at the Mayo clinic (12,465 spinal anesthetics) in which chlorhexidine was utilized showed (RAPM March-April/2012):
  - A neurologic complication rate of 0.04%
  - Same as the complication rate of spinals performed without chlorhexidine

Spinal Anesthesia: Safety/Benefits
- 45 patients older 75 years old or greater undergoing hip fracture repair under either continuous spinal anesthesia, TIVA, or sevoflurane anesthesia (RAPM 7/2012)
  - Blood pressure stability was best in the continuous spinal group
    - No hypotensive episodes
    - Achieved by 2.5mg bupivacaine boluses
- 180 patients undergoing planned outpatient laparoscopic cholecystectomy randomized to receive spinal or general anesthesia (Journ of Laparoend Adv Surg Tech July/2012)
  - Spinal group had less:
    - Postoperative pain
    - Nausea/Vomiting
    - Overnight admissions (8 v. 0)
    - Four conversions to GETA for shoulder pain

Spinal Anesthesia: Benefits
- 18,158 patients undergoing hip fracture surgery with either regional or general anesthesia (Anesthesiology July 2012):
  - 29% Regional, 71% General
  - Lower odds ratio for mortality and respiratory complications in regional group
    - 0.71 v. 0.54
    - Results more prevalent with intertrochanteric fractures

Spinal Anesthesia: Adjuvants
- Dexmedetomidine:
  - The addition of 0.25-0.5mcg/kg of intrathecal dexmedetomidine to hyperbaric bupivacaine (J Anaesth 1/11/2013)
    - Significantly increased the duration of motor and sensory block
    - 160min. V. 210 min.
    - No increased hypotension/bradycardia noted in dex groups
- Neostigmine:
  - Patients undergoing TKA, received a spinal anesthetic (bupivacaine/fentanyl) with and without neostigmine 1mcg (JACP 12/2012):
    - Neostigmine group had increased duration of analgesia with decreased opioid consumption (210 v. 270 min)
    - No increased side effect in neostigmine group (n/v)

Spinal Anesthesia: Intrathecal Morphine
- 256 patients undergoing idiopathic scoliosis surgery randomized to receive intrathecal morphine or nothing (Ped An 1/2013)
  - Intrathecal morphine group showed decreased blood loss, transfusion requirements, and improved hemodynamic stability
- 60 patients undergoing total hip arthroplasty randomized to receive either local infiltration analgesia (LIA) with levobupivacaine or intrathecal morphine (Acta Anesth Scand July/2012):
  - IT morphine group had less opioid consumption on the day of surgery
    - Equal consumption on P.O.D. 1 and 2
  - Comparable pain scores and patient satisfaction
  - Comparable PONV

Spinal Anesthesia: Intrathecal Morphine cont.
- 50 patients undergoing laparoscopic colon resection under general anesthesia randomized to receive intrathecal morphine or nothing (Br J Aneseth May/2012):
  - Less postoperative opioid consumption in the IT group
  - No other benefits
    - Return of bowel function
    - Length of stay
    - Readiness for discharge
Epidural Anesthesia

- Obstetric patients scheduled for elective caesarian section with epidural
- Study of 8000 non-obstetric epidurals to assess known epidural complications: intravenous placement, dural puncture, and insufficient analgesia (BMC Anesthesiology 12/2012)
  - Unsuccessful catheter placement occurred in smaller individuals and at lower sites (1%)
  - Insufficient analgesia (9%) seen more often with high thoracic or low lumbar blocks
  - Intravenous placement more common in the elderly (3%)
  - Dural perforation more common in the elderly (1.6%)

Epidural Anesthesia: Benefits

- Case report of the use of epidural anesthesia to treat an intractable paralytic ileus (Acta Anaesthesiol Taiwan June/2012)
  - 65 year old man s/p colectomy develops an ileus unresponsive to traditional therapies
  - Thoracic epidural placed for four days
  - Resolution of ileus
- 19 yo GIPO at 28 weeks with sickle cell disease in vasoocclusive crisis unresponsive to high dose IV opioid therapy (J Anaesthes Oct 2012)
  - Lumbar epidural placed with complete resolution of symptoms
- 42 patients undergoing elective coronary artery bypass surgery randomized to receive thoracic epidural (Acta Anaesthesi Scand July 2012) or nothing:
  - Less stress hyperglycemia and subsequent insulin use seen in thoracic epidural group

Epidural Anesthesia: Complications

- 15,687 patients undergoing bilateral total knee arthroplasty with general, neuraxial, or combined general-neuraxial anesthesia (RAPM 11/2012)
- Looking at 8610 patients who underwent a Whipple procedure, 11% received epidurals. (Am J of Surg 12/2012)

Epidural Anesthesia: Efficacy and Dosing

- Obstetric patients in labor randomized to receive either standard automated boluses v. continuous infusion (both had PCEAs) (Anaesth 1/2013)
  - Automated bolus group displayed higher satisfaction
  - No difference in maternal/fetal side effects or outcomes
- Obstetric patients scheduled for elective caesarian section with epidural to receive either morphine, sufentanil, or both showed (JACP 12/2012):
  - Faster onset of action and prolonged duration of analgesia in the combined morphine/sufentanil group (2mg/25mcg)

Epidural Anesthesia: Benefits

- 860 patients undergoing anterior resection for colorectal cancer (Int J of Colorectal Disease Sept/2012)
  - Neuraxial anesthesia group had lower rates of transfusion and subsequently morbidity (28% v. 45%)
  - Epidurals shortened the length of hospital stay in 1312 patients undergoing anterior resection for colorectal cancer (Int J of Colorectal Disease Sept/2012)
  - Did not affect anastamotic breakdown

Epidural Anesthesia: Benefits

- Less stress hyperglycemia and subsequent insulin use seen in thoracic epidural group

Education
Education: Patient Education

- As adequate pain control becomes a potential point of reimbursement, more pain assessment questionnaires have been developed:
  - Perioperative Satisfaction Questionnaire in Regional Anesthesia (anesthesiology 1/2013) EVAN-LR
    - Demonstrated adequate postoperative assessment
    - Patients greater than 55 reported higher satisfaction scores
  - 1030 patients undergoing either THA or TKA were interviewed regarding chronic pain after surgery:
    - 38% after THA
    - 53% after TKA
    - Risk factors were female sex, younger age, prior surgery, knee replacement, and poor perioperative pain control

Education: Resident Education

- ABA accredited residency programs were surveyed regarding their ultrasound use (Pain Med Oct 2012):
  - 82 programs responded
  - 75% of programs used ultrasound as their first choice technique
  - 20% used a concurrent nerve stimulator
  - Three most common reasons for ultrasound use were:
    - Improved teaching ability
    - Achieved a higher success rate
    - Safer
  - Three most common barriers for ultrasound use were:
    - Decreased efficiency
    - Lack of equipment
    - Lack of training

Peripheral Nerve Blocks

Peripheral Nerve Blocks: Benefits

- Continuous Blocks
- Metaanalysis comparing continuous nerve blocks with single injection nerve blocks (RAPM Nov 2012)
  - Including femoral, paravertebral, lumbar plexus, interscalene, infraclavicular, and popliteal
  - Continuous nerve blocks associated with:
    - Improved pain control
    - Decreased opioid analgesic consumption
    - Less nausea
    - Greater patient satisfaction
    - Functional outcome data unclear

Peripheral Nerve Blocks: Benefits Cont.

- Addition of a single shot sciatic or continuous sciatic to a femoral catheter in patients undergoing TKA (RAPM Jan 2013):
  - Did not yield improved pain, physical function, or stiffness at 3 or 12 months

Peripheral Nerve Blocks: LA volume

- What is the correct local anesthetic volume for any given nerve block?
  - 30 patients received either 15mL or 40mL of mepivacaine for an ultrasound guided axillary brachial plexus block (RAPM May 2012):
    - Reducing the dose to 15mL shortened the time to first request for postoperative analgesia by 30%
    - MEV90 was 1mL
    - 2.34 provided adequate postoperative analgesia (as defined by 6 hours)
    - No phrenic nerve blockade was noted with less and 4.29mL

Peripheral Nerve Blocks: LA volume

- Patients undergoing ultrasound guided interscalene brachial plexus block (BJA 12/2012):
  - MEV90 was 1mL
  - 2.34 provided adequate postoperative analgesia (as defined by 6 hours)
  - No phrenic nerve blockade was noted with less and 4.29mL
Peripheral Nerve Blocks: Anesthetic Volume
- Minimal Effective Volume of Lidocaine: 1.5% for double injection
- MEV90 was 23.5mL for axillary block
- MEV90 was 5.5mL for musculocutaneous nerve
- Success defined by surgical block
- Excellent Lipid Emulsion Review article by Guy Weinberg in
  RAPM Sept 2012:
  - Modulation of cardiac sodium channels
  - Metabolism
  - Partitioning (lipid sink)
- Avoidance of high dose epinephrine
- Superiority over epinephrine, vasopressin, epi/vaso
- Discusses mechanisms of action
- Double block added deposition of local at 6 o’clock position
- Triple block added deposition of local at 6 and 12 o’clock position
- 232 patients undergoing ulnar nerve block (RAPM May 2012)
  - No perioperative strokes
- 1569 patients undergoing total shoulder arthroplasty (TSA) (RAPM Sept 2012)
  - Median follow up was 2.5 years
- 15,014 patients undergoing shoulder arthroscopy under regional blockade
  - Average follow up was 2.5 years
  - 18 of 13 had residual effects at 2.5 years
- 12,688 patients undergoing ultrasound guided peripheral nerve blocks
  - In all, 100 blocks of data
diagram: 120 patients randomized to receive either a double, triple or quadruple injection axillary brachial plexus block (RAPM May 2012)
  - Block success rate was 72%, 79%, 79%
  - All doses provided adequate surgical anesthesia
- Incidence per 1000 blocks of side effects:
  - 0.08 for seizure
  - 0.9 for prolonged neurologic symptoms (> 6 months)
  - 1.8 for temporary neurologic symptoms (~5 days)
  - 0.6 – 1.2 for unintended vascular puncture
  - 0 for pneumothorax (1500 supraclavicular blocks)
- Peripheral Nerve Blocks: Safety cont.
  - Double block therefore recommended
  - Discussed usefulness of epi/vaso compared to plain lidocaine
- Use of interscalene block
- 12,688 patients undergoing ultrasound guided peripheral nerve blocks
  - In all, 100 blocks of data
- Anterior Cut/Field block
  - All injections done at 12 o’clock position
- Subjects undergoing rotator cuff repair with surgical interscalene block
  - Minimal Effective Volume of lidocaine 1.5% for double injection
  - 1569 patients undergoing total shoulder arthroplasty (TSA) (RAPM Sept 2012)
  - Average follow up was 2.5 years
  - No perioperative strokes
  - Advantage of high dose epinephrine
- Subjects undergoing rotator cuff repair with ultrasound guided peripheral nerve blocks
  - 325 patients underwent a subgluteal, ultrasound guided sciatic nerve block
  - 120 patients undergoing shoulder surgery randomized to receive different

Peripheral Nerve Blocks: Adjuvants
- 128 patients undergoing shoulder surgery randomized to receive different
  - Ultrasound guided brachial plexus blocks (Minerva Anesth Feb/2012)
  - Ropivacaine infusion
  - All patients started on an infusion of 0.2% ropivacaine (BMC Anesth
    March/2012)
  - 15,014 patients undergoing shoulder arthroscopy under regional blockade
  - 5mL volume associated with higher PACU pain scores
  - 20mL volume associated with higher incidence of dyspnea
  - All doses provided adequate surgical anesthesia

Peripheral Nerve Blocks: Axillary
- 129 patients randomized to receive either a double, triple or quadruple
  - Injection axillary brachial plexus block (RAPM May 2012)
  - Block success rate was 72%, 79%, 79%
  - All doses provided adequate surgical anesthesia

Peripheral Nerve Blocks: Safety
- Block durations were 7.6 hours, 14.5 hours, and 10 hours for the three groups
- 50 patients enrolled
- 0.5 levobupivacaine with 1.5mg/kg of I.M. tramadol
- 0.5% levobupivacaine
- Excellent Lipid Emulsion Review article by Guy Weinberg in
  RAPM Sept 2012:
  - Discussed usefulness of epi/vaso compared to plain lidocaine
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  - All doses provided adequate surgical anesthesia
Peripheral Nerve Blocks: Paravertebrals

- 84 patients undergoing open thoracic surgery randomized to receive either thoracic epidural or paravertebral block + intrathecal morphine (BJA 11/2012):
  - Epidural group showed lower VAS scores at rest and with cough (first 72 hours)
  - However, pain control in the paravertebral group was still good
    - TEA: 1.2, 1.3
    - PVB/IT: 1.9, 3.5

Peripheral Nerve Blocks: Popliteal Fossa

- Using three dimensional ultrasound, the effects of subfascial v. extrafascial local anesthetic spread were compared for a popliteal fossa block (RAPM 10/2012):
  - The subfascial spread group displayed better local anesthetic spread
    - Perineural volumes of 5.57mL v. 1.48mL
  - The subfascial group displayed a complete sensory block of 90% v. 63% for the extrafascial group
  - Anatomic studies on cadavers showed that injection (RAPM 7/2012):
    - inside the fascial sheath resulted in 10-15cm of spread longitudinally along the sciatic nerve
    - Outside the fascial sheath resulted in 5-6cm of spread

Peripheral Nerve Blocks: TAP Blocks

- 69 women undergoing elective caesarian section received either 100mcg of intrathecal morphine or bilateral TAP blocks (IJ of Obst Anesth 4/2012):
  - Intrathecal morphine group had lower pain scores and morphine consumption (2.5mg v. 7.5mg)
  - IT group displayed higher opioid related side effect profile
- Metaanalysis of women undergoing caesarian section to determine if addition of TAP block to intrathecal morphine is beneficial (312 Patients) (BJA Oct/2012):
  - TAP blocks alone reduced 24 hour morphine consumption by 24 mg.
  - TAP blocks in combination with IT morphine offered no additional benefit
  - TAP blocks are useful in the setting of caesarian section when intrathecal morphine was not administered

Peripheral Nerve Blocks: Sciatic Nerve

- Patients undergoing total knee arthroplasty randomized to received femoral nerve block plus a sciatic nerve block or selective tibial nerve block (A and A July 2012):
  - Pain scores and opioid consumption similar between the two groups
  - No foot drop seen in selective tibial nerve block group

Peripheral Nerve Blocks: TAP Blocks cont.

- 40 women undergoing caesarian section with general anesthesia randomized to receive transversis abdominis plane block v. no block (Eur J Anesth Feb/2012):
  - TAP group consumed one third as much morphine in the first 24 hours
  - No difference between pain scores, nausea and vomiting, or sedation

Anticoagulation and the Neuraxis
Anticoagulation Cont.

- Review of 928 patients who received a thoracic epidural in conjunction with subcutaneous unfractionated heparin 5000U three times daily (RAPM Nov/2012):
  - No Neuraxial bleeding
  - 34% of patients received ketorolac
  - 7% of patients had a thrombotic event (PE or DVT)

- German review of 33,142 non obstetric epidurals placed over a two year time span (Eur J Anesth April/2012):
  - Incidence of epidural hematoma was 1:6628

Local Anesthetics: The future

- Microsphere encapsulated bupivacaine significantly reduced pain levels in rats for four days (single dose) (RAPM Nov/2012)
- Liposomally encapsulated bupivacaine administered epidurally resulted in a longer duration of sensory blockade than normal bupivacaine
  - Duration of numbness to pinprick was 36 hours v. 11 hours
  - Duration of numbness to cold was 69 hours v. 12 hours

Cancer Recurrence and Regional Anesthesia

- 275 patients undergoing lower extremity lymph node dissection for malignant melanoma (BJA Sept/2012):
  - Increase in survival duration in the spinal group
    - 95 months v. 70 months

- Retrospective analysis of patients undergoing laparoscopic colon resection for cancer from 2003-2010 receiving either epidural, spinal or morphine PCA (BJA August 2012):
  - No difference in overall or disease free survival

- 42,151 patients undergoing colectomy for colon cancer retrospectively examined (Anesthesiology April 2012):
  - 23% had epidurals
  - 5 year survival rate in epidural group was 61%
  - 5 year survival rate in non epidural group was 65%
  - No association between epidural use and cancer recurrence

Local Anesthetics

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Thank You

References

- Anesthesiology
- Anesthesia and Analgesia
- British Journal of Anesthesia
- Regional Anesthesia and Pain Medicine
- International Journal of Anesthesia
Practical approach to STOP-Bang questionnaire and Mx of OSA pts

Frances Chung
Professor, Dept. of Anesthesiology
Toronto Western Hospital
University Health Network
University of Toronto

Disclosure
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  - Physicians Services Incorporated Foundation
  - University Health Network Foundation
  - ResMed Foundation

OSA and Anesthesia
- Perioperative complications
- Screening by STOP-Bang questionnaire
- Use of oximetry
- Perioperative management

Prevalence of OSA
- Moderate - Severe OSA (AHI>15)
  - Men 11.4%
  - Women 4.7%
- Recent study 9-22%

Prevalence of Sleep Apnea by Year


OSA and Anesthesia
- Perioperative complications
- Screening by STOP-Bang questionnaire
- Use of oximetry
- Perioperative management

T Young et al, NEJM 1993; 328:1230-5
Sleep apnea and narcotic postop pain medication: a morbidity and mortality risk
● 8 cases of ‘unexplained’ postop arrests in hospitalized pts.
● All pts had iv narcotics.
● All pts were eventually dx with OSA

40 yr old male (Nova Scotia)
● Hand surgery
● Pt had pain at 12 am
● Nurse gave IM morphine
● 4 am, found cardiac resp arrest
● Anoxic brain damage

USA Seattle
● Adult ACL repair.
● At home next day.
● Found arrest by spouse on returning home.

60 yr old female (England)
● Abdominal hysterectomy
● OSA
● Monitored in ICU for 1st night, step down unit 2nd night
● Arrest in ward on third night

Incidence of respiratory Cx for pts with and without OSA

Meta-analysis: OSA and postop Cx
13 studies
● OSA was associated with significantly higher odds of any postop cardiac events

45 /1195 [3.76%] vs. 24 /1420 [1.69%]

OR 2.1 95% CI 1.23-3.50, p=0.007

R Kaw et al B J A Sept 2012
**Meta-analysis: OSA and postop Cx**
13 studies

- Acute respiratory failure
  - 33/1680 [1.96%] vs. 24/3421 [0.70%]
  - OR 2.4 95% CI 1.34-4.39, p=0.003

  R Kaw et al  BJA Sept 2012

- OSA was also significantly associated with higher odds of desaturation
  - 189/1764 [10.71%] vs. 105/1881 [5.58%]
  - OR 2.0 95% CI 1.48-2.60, p<0.00001

  R Kaw et al  BJA Sept 2012

**Meta-analysis: OSA and postop Cx**
13 studies

- ICU transfer
  - 105/2062 [5.09 %] vs. 58/3681 [1.57%]
  - OR 2.3 95% CI 1.62-3.24, p<=0.00001

  R Kaw et al  Chest abstract Oct 2011

**A systematic review of OSA pts undergoing ambulatory surgery (7 studies)**

- No increase in unanticipated hospital admission or mortality.

  Anki Chetty S, et al. Anesthesiology 2011;A231

**No increase in unanticipated admission in outpt surgery**

- 234 OSA pts vs. match control
- No increase in unanticipated admission
- 23.9% vs. 18.8%


**Risk assessment of OSA in 2139 pts undergoing ambulatory surgery**

- 94 pts: self report of OSA
- 103 pts: high risk of OSA
- No increase in unplanned admission
- ↑ in difficult intubation
- ↑ in intraop use of pressors
- ↑ in postop O2 desaturation

No increase in unplanned admission in 674 OSA pts

- Rate of unplanned admission was 7% in OSA pts vs. 5.6% in pts without OSA
- Median hospital LOS was 7h with OSA vs 6h without OSA (P = 0.058).
- Severity of OSA was not associated with unplanned admission.


Are OSA at increased risk of periop Cx?

Anesthesia Risk of OSA Pts

- Hypertension & co-morbidity
- Anesthesia Risk
- OSA
- Obesity

Clinical conundrum

- Many with untreated OSA or undiagnosed OSA pts are undergoing anesthetic everyday
- Why do most pts not have death or adverse events?

OSA and Anesthesia

- Perioperative complications
- Screening by STOP-Bang questionnaire
- Perioperative management

At what level of AHI is pt at risk of periop Cx?

- AHI > 30
- AHI > 60
Undiagnosed OSA is Common

- 82% of men and 93% of women with moderate - severe sleep apnea are undiagnosed.

Young et al. Sleep 1997; 20: 705-6

Surgical pts with Undiagnosed OSA

- 111 surgical pts with pre-existing OSA
  - 15% were not identified by anesthesiologists

Singh M et al. BJA submitted 2012

Undiagnosed OSA by Anesthesiologists (N=536)

Singh M etal BJA submitted 2012

- 69.6% AHI>15-30
- 47.1% AHI>30

Contribution of Body Habitus and Craniofacial Characteristics to Segmental closing Pr. of the Passive pharynx in pts with SDB


GOLD STANDARD FOR CONFIRMATION

Polysomnography!
Sleep lab testing for both adults and children

Apnea hypopnea index (AHI)
Apneas + hypopnea / hr of sleep

STOP questionnaire to screen OSA

- Grade 5 level
- Made in English Language
- Easy to remember “STOP”
- Validated in surgical setting

F Chung et al Anesthesiology 2008;108:1-10
STOP questionnaire to screen OSA

- **S** - Snoring
- **T** - Tiredness / sleepiness / fatigue
- **O** - Obstruction of breathing
- **P** - BP (>140/90) Rx or no Rx

- 2/4 positive, high risk of OSA

F Chung et al. Anesthesiology 2008; 108:1-10

**Predictive Parameters for STOP Questionnaire**

<table>
<thead>
<tr>
<th>Cutoff</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHI&gt;5</td>
<td>66</td>
<td>60</td>
<td>78</td>
<td>44</td>
</tr>
<tr>
<td>AHI&gt;15</td>
<td>74</td>
<td>53</td>
<td>51</td>
<td>76 (65-85)</td>
</tr>
<tr>
<td>AHI&gt;30</td>
<td>80</td>
<td>49</td>
<td>30</td>
<td>89</td>
</tr>
</tbody>
</table>

* Value expressed as percentage with 95% confidence interval

**PPV for STOP Combined With Other Factors**

F Chung et al Anesthesiology 2008;108:1-10

**STOP- Bang**

- STOP
- B BMI>35
- A Age >50
- N Neck circumference >40 cm
- G Gender male

- Higher sensitivity and specificity
- 3/8 questionnaire positive

Chung et al. Anesthesiology 2008; 108:1-10

**Predictive Parameters for STOP-Bang**

<table>
<thead>
<tr>
<th>Cutoff</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHI&gt;5</td>
<td>84</td>
<td>56</td>
<td>81</td>
<td>61</td>
</tr>
<tr>
<td>AHI&gt;15</td>
<td>93</td>
<td>43</td>
<td>52</td>
<td>90</td>
</tr>
<tr>
<td>AHI&gt;30</td>
<td>100</td>
<td>37</td>
<td>31</td>
<td>100</td>
</tr>
</tbody>
</table>

* Value expressed as percentage with 95% confidence interval

**Higher the STOP-Bang score, higher the specificity for OSA (AHI>30)**

STOP Bang score | Sensitivity % | Specificity %
---|---|---|
3 | 94.8 | 27.6 |
4 | 78.4 | 52 |
5 | 56 | 74 |
6 | 28.4 | 88 |
7/8 | 11.9 | 96 |

Chung F et al BJA 2012;108:768-75
### STOP-Bang Score and Odds Ratio
#### Severe OSA

<table>
<thead>
<tr>
<th>Score</th>
<th>3</th>
<th>2.6</th>
<th>3.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>7,8</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chung F et al, BJA 2012; 108: 768-75

### Predictive parameter of different pattern of factors in screening pt with mod/severe OSA

<table>
<thead>
<tr>
<th>Cutoff</th>
<th>N</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP ≥2</td>
<td>146</td>
<td>74</td>
<td>41</td>
</tr>
<tr>
<td>STOP-Bang ≥3</td>
<td>172</td>
<td>87</td>
<td>31</td>
</tr>
<tr>
<td>STOP ≥2 and BMI &gt;35</td>
<td>41</td>
<td>21</td>
<td>85</td>
</tr>
<tr>
<td>STOP ≥2 and Age &gt;50</td>
<td>117</td>
<td>59</td>
<td>56</td>
</tr>
<tr>
<td>STOP ≥2 and Neck &gt;40</td>
<td>66</td>
<td>34</td>
<td>79</td>
</tr>
<tr>
<td>STOP ≥2 and Male</td>
<td>79</td>
<td>40</td>
<td>78</td>
</tr>
</tbody>
</table>

Chung F et al ASA abstract 2012

### Serum HCO₃ and OSA
- As severity of OSA increases, nocturnal hypercapnia may develop
- Sustained nocturnal hypercapnia may lead to elevation in serum HCO₃
- ~10-20% of obese OSA pts have obesity hypoventilation syndrome (OHS)

Mokhlesi. Respir Care. 2010; 55:1347-62
Mokhlesi et al. Sleep Breath. 2007; 11: 117-24

STOP positive + 1 item from Bang

- STOP≥2 + 1 item from Bang: 78.4%
- STOP≥2 + BMI>35: 85%
- STOP ≥2 + Neck circum. >40: 79%
- STOP ≥2 + male: 76.8%
- Age is not specific

F Chung et al ASA abstract 2012
AHI and Serum HCO$_3^-$

- Regression analysis:
- Every 10 point increase in AHI is associated with a 0.17 mmol/L increase in HCO$_3^-$ ($p<0.05$)
  
  ↑ AHI 10 events/h → ↑ HCO$_3^-$ 0.17 mmol/L

- Correlation coefficient = 0.13 ($p<0.05$)

Distribution of HCO$_3^-$

<table>
<thead>
<tr>
<th></th>
<th>Derivation HCO$_3^-$ (mmol/L)</th>
<th>Validation HCO$_3^-$ (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>26.2 ± 2.8</td>
<td>26.6 ± 2.6</td>
</tr>
<tr>
<td>25th</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>50th</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>75th</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>95th</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>99th</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>

Sensitivity and Specificity of Combining STOP-bang and HCO$_3^-$

<table>
<thead>
<tr>
<th></th>
<th>AHI &gt; 5</th>
<th>AHI &gt; 15</th>
<th>AHI &gt; 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP-bang ≥ 3</td>
<td>82.6</td>
<td>37.0</td>
<td>88.3</td>
</tr>
<tr>
<td>STOP-bang ≥ 3 + HCO$_3^-$ ≥ 28</td>
<td>30.4</td>
<td>85.2</td>
<td>30.4</td>
</tr>
<tr>
<td>STOP-bang ≥ 3 + HCO$_3^-$ ≥ 29</td>
<td>17.4</td>
<td>88.9</td>
<td>20.8</td>
</tr>
<tr>
<td>STOP-bang ≥ 3 + HCO$_3^-$ ≥ 30</td>
<td>7.2</td>
<td>94.4</td>
<td>9.1</td>
</tr>
</tbody>
</table>

SN: Sensitivity; SP: Specificity

Chau E et al  ASA abstract 2011

Positive and Negative Predictive Values of Combining STOP-Bang and HCO$_3^-$

<table>
<thead>
<tr>
<th></th>
<th>AHI &gt; 5</th>
<th>AHI &gt; 15</th>
<th>AHI &gt; 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP-bang ≥ 3</td>
<td>77.0</td>
<td>45.5</td>
<td>45.9</td>
</tr>
<tr>
<td>STOP-bang ≥ 3 + HCO$_3^-$ ≥ 28</td>
<td>84.0</td>
<td>32.4</td>
<td>58.0</td>
</tr>
<tr>
<td>STOP-bang ≥ 3 + HCO$_3^-$ ≥ 29</td>
<td>80.0</td>
<td>29.6</td>
<td>53.3</td>
</tr>
<tr>
<td>STOP-bang ≥ 3 + HCO$_3^-$ ≥ 30</td>
<td>76.9</td>
<td>28.5</td>
<td>53.8</td>
</tr>
</tbody>
</table>

PPV: Positive Predictive Value; NPV: Negative Predictive value

Chau E et al  ASA abstract 2011

2-Step Assessment Process for OSA

- STOP-Bang ≥ 3 is highly sensitive but moderately specific for OSA
- Adding HCO$_3^-$ (≥ 28 mmol/L) to STOP-Bang ≥ 3 improves specificity
- 2-step process may be useful in stratifying pts at risk of OSA
Information about STOP-Bang
- www.stopbang.ca

Screening for OSA has advantages
- Early identification
- Better preparation
- Cx may be prevented

Preop Suspicion
- Recognize the problem
  - OSA is common

We are the airway specialist
Anesthesiologists may be the 1st physician to identify pts having OSA

Perioperative Physician
- We refer pts for Rx of unDx hypertension, DM, angina etc.
- Similarly, we should refer suspected OSA pts.
- Prolong life span by 20 yrs.
- Resistant hypertension and DM.

What Effect Does OSA Have on Life Span?
- American life expectancy
  - Male – 76.7 yrs  Female – 83.6 yrs
- Mean age of death among people with untreated OSA is 59 years.
- OSA untreated or undiagnosed died yrs earlier

Young T. SLEEP 2008;31:1077-78
Marshall NS, SLEEP 2008;31:1079-1085
Marin JM, Lancet 2005; 365: 1046–53

10 yr life expectancy due to smoking vs. pts with non-treated OSA

Should we routinely screen for OSA in preop clinic?

- What do we do if pts are screened positive?
- When should we refer our patients?

We cannot be ostrich head in the sand. Don’t ask, don’t tell and don’t know

- STOP Bang 3 At risk of OSA
- STOP Bang 5-8 Very high risk of OSA
- STOP Bang + HCO3 Be careful

When do we refer pts for Investigation?

- Pts with high STOP-Bang score 5-8 + daytime sleepiness
- Pts with high STOP-Bang score 5-8 + Resistant hypertension
  Nocturnal angina
  CHF
  COPD, hypercapnic resp failure


Preop screening for OSA: One death is too many

Preoperative Screening

F Chung, Anesth Int Care;2010:38: 949-50

E Seet & F Chung C J A, 2010; 57: 849-64
American Society of Anesthesiologists

Practice guideline for the periop Mx of pts with OSA

Gross JB et al. Anesthesiology. 2006;104:1081-93

Anesthetic Mx is determined by 4 factors:

- Severity of OSA
- Mx of OSA: CPAP or not
- Surgical procedure; major or minor
- Postop analgesic requirement. Opioid or not

Gross JB et al. Anesthesiology. 2006;104:1081-93

Recurrence of PACU events predicts postop resp Cx

Low risk of OSA + PACU events Resp Cx 11%
High risk of OSA PACU events Resp Cx 33%

Recurrent PACU Resp Events

No Recurrent Events

Suspected OSA

Recurrent PACU Resp Events

Yes

No

Monitored bed

Home or Ward.

Perioperative Management

E Seet & F Chung Can J Anesthesia, 2010; 57: 849-64
Known OSA Pt

- Noncompliant CPAP
- Severe OSA
- Recurrent PACU Resp Events

Yes

No

Postop Monitoring

Ward or home

SDB

- Emphasis on clinical basics of individual pt assessment and careful titration of anesthetics and opioids
- Preventive and Monitoring strategies must be applied on an individual pt basis

Preop Preparation of OSA

- Premed: Avoid
- Aspiration prophylaxis

Anesthetic Implications

- Co-morbid conditions: GI reflux, Cardioresp. disease, Supine hypoxemia, DVT
- Instruct pt to bring CPAP
- Meticulous airway assessment/Mx

Sleep Apnea and difficult intubation

- Difficult endotracheal intubation in pts with OSA.
- 22% incidence
- In bariatric pts, a Mallampati score of >3 and male gender predicted DI. Not BMI, OSA or neck circumference

JMA Siyam, Anesth Analg 2002; 95:1098-1102
Kim JA, Lee JJ, CJA;2006:53:393-7

Optimal positions for morbidly obese

- Reverse Trendelenburg 30% vs.
  - Supine – horizontal
  - Back up Fowler 30%
- Safe apnea period longest
- Least drop in O2 saturation

Boyce RB. Obesity Surg 13: 4-9,2003
Isono S, Semin anesth Periop Med Pain 2007;26:83-93
Altermatt FR et al BJA 2005;95:706-9
PEEP during induction of GA increases duration of non-hypoxic apnea in morbidly obese pts
- 10 cm H2O CPAP 5 min before induction for preoxygenation.
- 10 cm PEEP by mask before intubation.
- 1 min of additional time before significant desaturation.

OSA and Opioids
- Opioids Induced Ventilatory Impairment (OIVI): Central resp depression
- Sedation
- Upper airway obstruction

Both Propofol and Opioids suppress central tonic outflow to genioglossus muscle, primary airway dilator

Ketamine Activates Breathing and Abolishes the Coupling between Loss of Consciousness and Upper Airway Dilator Muscle Dysfunction
- Ketamine is a respiratory stimulating hypnotic and analgesic
- In rats it is associated with increased genioglossus electromyogram compared with propofol and sleep

Postop Mx of OSA
- A sitting or lateral position
- Use of a pillow for sniffing position

Auto-CPAP
- Preliminary data from Auto-CPAP RCT indicates that Auto-CPAP prevented postop increase in episodes of obstructive apnea, hypopnea, respiratory arousal and oxygen desaturation.

Obesity and Hypoventilation Syndrome
- Obesity BMI ≥ 30 kg/m^2
- Daytime awake hypercapnia PaCO2 ≥ 45 mmHg
- Hypoxemia PaO2 < 70 mmHg
- 0.15-0.3% of general population
- Pulmonary hypertension
Automated notification of suspected OSA pts to the preop respiratory therapist: a pilot study

- Ramachandran SK. Respir Care 2010; 55:414-418

Anesthesia Pt Safety Foundation Recommendations

- Continuous electronic monitoring of oxygenation and ventilation should be available for all postop pts.

- It would reduce the likelihood of unrecognized clinically significant opioid induced depression of ventilation.

APSF newsletter Sept 2011

SDB

- Emphasis on clinical basics of individual pt assessment and careful titration of anesthetics and opioids

- Preventive and Monitoring strategies must be applied on an individual pt basis

Thank you

www.stopbang.ca

Frances.chung@uhn.ca
NON-OBSTETRIC SURGERY DURING PREGNANCY

Joy L. Hawkins, M.D.
University of Colorado SOM
(* I have no conflicts to disclose.*)

GOALS & OBJECTIVES

Upon completion of this presentation, participants will be able to:
1. Explain issues related to teratogenicity
2. Discuss the risks of occupational exposure to anesthetics
3. Cite outcome studies of parturients having surgery
4. Develop a rational approach to anesthetic management, including special surgical situations.

Br J Anaesth 2011; (S1): i72-i78

OUR PATIENTS ARE CONCERNED

Pregnant women who sought counseling after exposure to non-teratogenic drugs estimated they had a 25% risk of major malformations.


THE PUBLIC IS CONCERNED

“The fetus usually dies from the anesthesia administered to the mother before the procedure begins . . . The intravenous anesthetic administered to the woman during the procedure induces a medical coma in the fetus and eventually a neurological fetal demise.”

Congressional Testimony 6/23/95

ANESTHESIOLOGISTS ARE CONCERNED

A retrospective survey of female veterinarians related preterm delivery (< 37 weeks) to self-reported occupational exposures.
- OR 2.5 for those who performed surgery without scavenging anesthetic gases vs. with scavenging
- OR 3.69 for those working > 45 hours a week.

Obstet Gynecol 2009;113:1008
Controversial Issues in Anesthetic Care During Pregnancy

Controversy #1. Which patients need to have preoperative pregnancy testing?

Case: A healthy 25-year old woman presents to your operating room for knee arthroscopy on an outpatient basis. Does she need to have a pregnancy test?

50% of pregnancies in the U.S. are unplanned!

From the ASA Practice Advisory for Pre-anesthesia Evaluation:

“The Task Force recognizes that patients may present for anesthesia with early undetected pregnancy. The Task Force believes that the literature is inadequate to inform patients or physicians on whether anesthesia causes harmful effects on early pregnancy. Pregnancy testing may be offered to female patients of childbearing age and for whom the result would alter the patient’s management.”

PREGNANCY TESTING

PREGNANCY TESTING

For one year, all women of childbearing age having ambulatory surgical procedures had preoperative pregnancy testing.

- 7/2056 (0.3%) of tests were positive.
- All 7 patients elected to cancel surgery (2 were infertility procedures).
- The estimated cost to diagnose one pregnancy was $2879.

Anesthesiology 1995;83:690
PREGNANCY TESTING

A specialty orthopedic hospital initiated mandatory pregnancy testing. After 1 year:
• 2588 tested—8 positives, but 4 were false positives.
• 3 of the false positives subsequently had a negative serum hCG, and surgery then proceeded.
• 4/2588 (0.15%) of tests were true positives and their surgery was canceled.
• NNT for 1 true positive: 647
• Cost for 1 true positive: $3273

Anesth Analg 2008;106:1127

PREGNANCY TESTING

“...should a spontaneous abortion occur after surgery, or the baby be born with a congenital anomaly, this may be attributed to the surgery or anesthetic...screening may decrease litigation, although potential cost savings are difficult to quantify.”

Anesth Analg 2008;106:1127

PREGNANCY TESTING

A retrospective review of 2 years of mandatory pregnancy testing in a freestanding pediatric hospital revealed that 2.4% of patients age 16 and older were positive. None were positive in patients less than 15 years of age (overall 1.3%).

Their conclusions: A policy of mandatory pregnancy testing in patients aged 15 and older is advisable. Specific written consent for the test is not necessary, but proper notification processes must be established.

Anesth Analg 1996;82:4-7

PREGNANCY TESTING

What about ethical and privacy concerns?
• Can you test without the patient’s consent?
• Will you cancel the case if they refuse testing?
• If positive, can/should you inform a minor’s parents?

If testing is required, patients should be informed they will be tested, that they could be denied their surgery if positive, and that the results will be on their medical record and therefore potentially available to insurance companies and/or their employers.

PREGNANCY TESTING

Do pregnant women have greater morbidity after surgery than non-pregnant?
• Using the NSQIP database from 2005-9, 857 appendectomy and 436 cholecystectomy cases in pregnancy were reviewed.
• Morbidity was no different than non-pregnant.
• Pregnant women were more likely to be infected.

Obstet Gynecol 2011;118:1261
**Controversy #2. Are benzodiazepines and nitrous oxide safe to use during pregnancy?**

Case: A woman at 12 weeks gestation requests general anesthesia for a cervical cerclage placement scheduled for ~ 20 minutes. She is extremely anxious about the procedure and asks you for preoperative sedation.

---

**DOCUMENTED TERATOGENS**

- ACE Inhibitors
- Alcohol
- Androgens
- Antithyroid Drugs
- Chemotherapy Agents
- Cocaine
- Coumadin
- Diethylstilbestrol
- Isoretinoin
- Lead
- Lithium
- Mercury
- Phenytoin
- Streptomycin
- Thalidomide
- Trimethadione
- Valproic Acid

---

**TERATOGENICITY**

How long after a drug is marketed does it take to establish safety for use in pregnancy?

- Experts assessed 469 drugs approved by the FDA between 1980 and 2000, reviewing available studies.
- 91% of drugs were still classified as their risk of use during pregnancy being “undetermined”.
- Inadequate information is available for women and their physicians to determine risks of most drugs.

*Obstet Gynecol* 2002;100:465

---

**NITROUS OXIDE**

Pregnant rats given nitrous oxide 75% for 24 hours on day 9 of gestation had a 4-fold increase in resorptions (abortions) and a 15-fold increase in anomalies when compared to rats given equi-anesthetic concentrations of xenon.

*Science* 1980;210:899

---

**NITROUS OXIDE**

Why might N\textsubscript{2}O cause adverse effects?

N\textsubscript{2}O inactivates vitamin B\textsubscript{12}, a coenzyme of methionine synthetase, causing depression of methionine synthetase activity and potentially affecting production of thymidine and DNA.
**NITROUS OXIDE**

*However*, even very low concentrations of N₂O (<1%) will abolish methionine synthetase activity, yet it requires 24 hours of high N₂O concentrations (75%) to cause teratogenesis.

Are the adverse effects of nitrous oxide biochemical (reduced methionine synthetase activity), or could they be due to hemodynamic effects?

**NITROUS OXIDE**

- N₂O enhances adrenergic tone and causes vasoconstriction.
- Halothane (a sympatholytic) and other volatile anesthetics administered with N₂O protect against major and minor anomalies in rodents. Folic acid does not.

Teratology 1988;38:121

**NITROUS OXIDE**

The largest retrospective study of exposure to surgery and anesthesia during pregnancy compared 5405 women who had surgery (of 720,000 total = 0.75%) to case controls.

- 54% had GETA, 97% of those had N₂O
- No difference in stillbirth or anomalies
- Increase in IUGR and prematurity

Am J Obstet Gynecol 1989;161:1178

**NITROUS OXIDE: SUMMARY**

- Teratogenic effects in animal studies may be due to vasoconstriction and decreased uterine blood flow. Combine N₂O with a sympatholytic agent.
- Adverse human effects have never been documented, even in large outcome studies.
- Studies in modern hospital settings with O.R. scavenging do not show an association with nitrous and adverse pregnancy outcomes.

**BENZODIAZEPINES**

Two studies in 1975 reported an association between maternal exposure to benzodiazepines (Valium® and Librium®) and cleft lip and/or palate.

Int J Epidemiol 1975; 4:37
Lancet 1975; 306:478

But later work refuted these reports....

**BENZODIAZEPINES**

- 611 infants with cleft lip and/or palate were compared to 2498 control infants with other birth defects.
- The risk of clefts was no different between women who were or were not exposed to diazepam during first trimester of pregnancy.
- For cleft lip ± palate: RR 0.8 (0.4-1.7).
- For cleft palate alone: RR 0.8 (0.2-2.5).

NEJM 1983; 309:1282
BENZODIAZEPINES

- An NIH-supported prospective study did not find any increased risk of cleft anomalies associated with diazepam use:
  
  RR 1.2 versus controls
  95% CI 0.17-8.95

  NEJM 1984; 311:919

- A meta-analysis of 7 cohort studies involving 1090 infants who were exposed to benzodiazepines found no increased risk of major malformations, or specifically oral clefts (RR 1.19, CI 0.34-4.15).
  
  “Even when the worst case scenario is assumed, benzodiazepines do not seem to be major human teratogens….”

  BMJ 1998;317:839

ACOG Clinical Expert Series on Teratogenicity

“Anxiolytics (benzodiazepines): No evidence of significant risk of teratogenicity”

- Initial findings of clefts have not been confirmed by long-term follow-up studies.
- Overall results are reassuring, revealing no adverse effects on neurodevelopment.
- May be beneficial adjunct for hyperemesis (!)

  Obstet Gynecol 2009;113:166

Controversy #3. When and how should fetal monitoring be used?

Case 1: An elective cholecystectomy done at 34 weeks gestation.

Case 2: An emergency femoral thrombectomy at 31 weeks gestation.

Case 3: A series of 5 ECTs performed between 17 and 19 weeks of gestation.

INTRAOP MONITORING

- Blood pressure (normal or slightly above)
- Oxygenation, ventilation
- Temperature (avoid hyperthermia)
- Blood glucose for longer cases
- Fetal heart rate (FHR) > 24 weeks: intermittent, or continuous if possible
- FHR < 24 weeks: preop and postop check
**INTRAOP FETAL MONITORING**

- This should not be discussed and decided as a medicolegal issue! It is a medical issue.
- Monitoring may help assess placental perfusion during induced hypotension, cardiopulmonary bypass, volume shifts/blood loss.
- It provides an important reassurance for the mother.
- Helps assure the intrauterine environment is optimized
- But FHR monitoring is imprecise and not predictive of outcome.

**ELECTRONIC FETAL HEART RATE MONITORING (EFM)**

EFM has a 98% false positive rate, yet is used in 85% of births. Does it prevent brain injury and/or death?

- 13 RCT and 3 observational studies were reviewed.
- EFM has no effect on cerebral palsy or perinatal death.
- EFM use does parallel the increase in cesarean rates.
- There are related increases in litigation and payments for negligent fetal injury, despite a lack of evidence that EFM can predict outcome.

Obstet Gynecol 2006;108:656

**CASE 1: FETAL MONITORING**

A patient at 34 weeks gestation required cholecystectomy. During skin prep (before any surgical intervention), severe persistent fetal bradycardia occurred. An emergency cesarean was performed and the umbilical cord was tightly coiled and twisted.

- Apgar scores = 1 / 5 / 7
- Umbilical cord pH = 7.17 and 7.18

Can J Anesth 2003;50:922

**CASE 2: FETAL MONITORING**

During the 30th week of an uncomplicated pregnancy, a patient underwent femoral thrombectomy under routine GETA. During surgery the fetal monitor showed absent variability, so an emergency cesarean delivery was performed for presumed fetal distress. Umbilical pH=7.23 (normal). The child was intubated for prematurity and had to be admitted to the ICU.

Br J Anaesth 2001; 87:791

**CASE 3: FETAL MONITORING**

A series of ECTs was required in a woman between 17 and 19 weeks gestation. FHTs checked before and after the first 4 procedures were normal. FHTs monitored during the 5th procedure showed a severe deceleration. No intervention was done due to non-viability. She went on to deliver a normal healthy baby at 38 weeks.

Acta Anaesthesiol Scand 2003;47:101
FETAL MONITORING
What should you do for intra-operative fetal distress?
• ↑ maternal FIO₂ and blood pressure
• ↑ left uterine displacement or try the right side
• Move the surgeons or their retractors
• Administer a tocolytic (terbutaline 0.25mg)
• Document your efforts in the record
** Remember: loss of BTBV is normal; decels are not.
** Consider preop / postop FHR monitoring for most cases in consultation with the obstetricians.

Controversy #4. Should pregnant patients > 24 weeks gestation have surgery in a specialty hospital without L&D coverage?
(no fetal monitoring, no capability for a C/S, no neonatologists)

PERIOPERATIVE BACK-UP
Case: A woman at 28 weeks gestation was evaluated for deteriorating vision, and a large meningioma was found on MRI. Urgent craniotomy was planned to preserve her sight. The surgery proceeded without fetal monitoring or provision for cesarean delivery as obstetric care was not available at the hospital where neurosurgery was performed.
Can J Anesth 2004;51:573

ACOG / ASA STATEMENT
If fetal heart rate monitoring is to be used:
“Surgery should be done at an institution with neonatal and pediatric services; an obstetric provider with cesarean delivery privileges should be readily available, and a qualified individual should be readily available to interpret the fetal heart rate.”
www.asahq.org, October 2009

ACOG / ASA JOINT STATEMENT
“Non-obstetric Surgery During Pregnancy”
“Due to the difficulty of conducting large-scale randomized clinical trials in this population, there are no data to allow for specific recommendations...When non-obstetric surgery is planned, the primary obstetric provider should be notified. If that provider is not at the institution where surgery is to be performed, another obstetric care provider with privileges at that institution should be involved.”

Controversy #5. What is the best way to manage the EXIT (ex-utero intrapartum treatment) procedure?
Case: A healthy gravida at term has a fetus with a large neck mass found on ultrasound. The mass is compromising its airway and intubation will be required immediately after delivery.
EXIT PROCEDURE
(Ex Utero Intrapartum Treatment)

1. Maternal GETA is maintained with 2 MAC volatile agent and narcotics for uterine relaxation and to provide adequate fetal anesthesia.
2. After uterine incision and hemostasis, only the head and arm are delivered. A pulse oximeter is placed, IM relaxant and narcotic are given to the fetus. The placenta remains intact.
3. The trachea is intubated or tracheostomy is performed. Surfactant may be administered.
4. Once the airway is secure, volatile agent is discontinued, delivery is completed and oxytocics are begun.

Anesthesiology 2011;114:1446

Controversy #6. Is there a “best” anesthetic during pregnancy to protect the fetal brain from neurotoxicity?

Do anesthetic drugs cause developing neurons to commit suicide (apoptosis)?

ANIMAL STUDIES

Case: A healthy well-educated woman requires emergency appendectomy at 26 weeks gestation. Based on information she obtained on the internet, she questions you about the effect of your general anesthetics on her fetus’ developing brain.

In a simulated clinical scenario:
• 7-day old rats (0-6 months in humans) received 6 hours of general anesthesia: midazolam, nitrous oxide, isoflurane.
• Animals had memory/learning impairments, apoptotic neurodegeneration, hippocampal synaptic function deficits.

J Neuroscience 2003;23:876
ANIMAL STUDIES
Are the adverse effects attributable to the direct effects of anesthetics, or are they the result of factors we would not see clinically; eg. high doses over long periods, acidosis, hypoxia, starvation?

Problems:
- Inter-species differences
- Simulating normal O.R. conditions
- Adequate monitoring

PRIMATE STUDIES
Are non-human primates also susceptible to anesthetic toxicity?
- Rhesus macaques received 5 hours of 1 MAC isoflurane while ventilated.
- There was a 13-fold increase in neuro-apoptosis in exposed animals, largely concentrated in the cerebral cortex.

Anesthesiology 2010;112:834

ANIMAL STUDIES
What are the fetal effects of maternal anesthesia?
- Pregnant rats were exposed to isoflurane for 4 hours in mid-gestation, equivalent to 2nd trimester in humans.
- Offspring had memory and behavioral abnormalities.

Anesthesiology 2011;114:521

ANIMAL STUDIES
From an accompanying editorial:
“…it is not clear which anesthetic technique might be least toxic, nor has any general anesthetic been convincingly shown to be more toxic…certainly non-urgent surgery should continue to be postponed until after pregnancy. Considerations should be made to using regional anesthesia when possible.”

Anesthesiology 2011;114:479

IS REGIONAL BETTER?
A retrospective study of adnexal mass surgery during pregnancy compared 137 women having general anesthesia with 71 having regional anesthesia. The incidence of preterm labor was higher in the regional (30%) than the general (6%) anesthetic group. Both were higher than the non-surgical group (3%).


ANESTHETIC MANAGEMENT OF THE PREGNANT SURGICAL PATIENT
COMMON SURGERIES

The most common indications for surgery unrelated to pregnancy:
1. Appendicitis, 1:2000 pregnancies
2. Cholecystitis, 1:6000 pregnancies
3. Maternal trauma
4. Maternal malignancies

PREOP ASSESSMENT

- Is my patient pregnant?
  Document LMP on record.
  Offer pregnancy testing.
- Operate during second trimester if possible.
  Less risk of early spontaneous miscarriage.
  Theoretical risks of teratogenicity are avoided.
  3rd trimester ↓ introp visibility, ↑ preterm labor
- Reassure her about risks to fetus or pregnancy.
- Educate about uterine displacement, symptoms of preterm labor.

PREOP MEDICATIONS

- Sedation
  Narcotics
  Benzodiazepines
- Aspiration Prophylaxis
  Antacid
  Metoclopramide
  H-2 receptor blocker

MAGNESIUM TOCOLYSIS

Usual dose: 4-6 gm loading, then 2 gm/hr
Implications: Neuromuscular blockade
  Attenuated vascular responses
  Vasodilation

INDOMETHACIN TOCOLYSIS

<table>
<thead>
<tr>
<th>Usual dose</th>
<th>50 mg loading, 25 mg q 6 hours PO or PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implications</td>
<td></td>
</tr>
<tr>
<td>Maternal</td>
<td>Fetal</td>
</tr>
<tr>
<td>Platelet function</td>
<td>Necrotizing enterocolitis</td>
</tr>
<tr>
<td>GI symptoms</td>
<td>Oligohydramnios</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>Closure of fetal ductus</td>
</tr>
</tbody>
</table>

CHOICE OF ANESTHETIC

- There is no evidence in humans (yet) that any drug or anesthetic technique is dangerous to the fetus.
- Choose the safest anesthetic for the mother’s condition, and modify for the physiologic changes of pregnancy.
- Avoid hypoxia and hypotension!
GENERAL ANESTHESIA

- Full preoxygenation/denitrogenation
- Rapid sequence induction, smaller ETT
- First trimester: use tried and true drugs
- Nitrous oxide versus FIO2
- ET CO2 28-32; avoid hyperventilation
- Inhalational agents < 2.0 MAC
- Slow or no reversal of relaxants
- Compression stockings

REGIONAL ANESTHESIA

- Advantage of minimizing drug exposure
  - First trimester
  - Fetal monitoring
- Prevent hypotension
  - Adequate fluid replacement
  - Uterine displacement
- Decrease neuraxial local anesthetic dose by 30%
- Choose ephedrine vs. phenylephrine based on maternal heart rate
- Continue to provide postoperative pain control

POSTOPERATIVE CARE

- Continue monitoring fetal heart rate and uterine activity. Provide L&D nursing expertise.
- Maintain maternal oxygenation and LUD.
- Notify Pediatrics if the fetus is a viable gestational age ≥ 24 weeks.
- Use neuraxial narcotics or regional blocks for pain management if possible to encourage early ambulation.

TRAUMA

- A leading cause of maternal death, especially MVA without use of seat belts.
- Fetal loss is due to maternal death or placental abruption.
- Need early ultrasound in E.R. to determine gestational age and viability.
- Perform all necessary diagnostic tests on the mother with shielding as necessary.
- Maternal ↑ blood volume may mask blood loss.

Obstet Gynecol 2009;114:147
TRAUMA

What are the risks of radiation exposure?

- ACOG has stated: “no single diagnostic x-ray procedure results in radiation exposure to a degree that would threaten the well-being of the developing fetus.”
- Teratogenic risks are not increased with < 5 rad exposure (eg. a head CT < 1 rad).
- Ultrasound and MRI are safe alternatives.

Anesth Analg 2010;110:863

TRAUMA

Indications for emergent C/S:

- Stable mother, viable fetus in distress
- Uterine rupture
- Gravid uterus interfering with repairs
- Mother unsalvageable, fetus viable

If the fetus is previable or dead, focus on optimizing the mother. She will tolerate vaginal delivery at a later time better than an emergent laparotomy.

NEUROSURGERY

- Intracranial aneurysms or AVM may require repair in this age group.
- Usual anesthetic techniques can be used.
- Fetal monitoring is remote from the field and may be beneficial in some cases, eg. aggressive diuresis, hyperventilation, bleeding and fluid shifts.

Anesth Analg 2008;107:193

NEUROSURGERY

Successful endovascular treatment of acutely ruptured intracranial aneurysms in pregnancy:

- 32 wks gestation with HA and vomiting. CT and MRI show SAH and aneurysm: C/S → angio → embolization with coils.
- 22 wks gestation with HA, vomiting, LOC. CT shows SAH: GETA → angio → occlusion with coils using fetal shielding → SVD at term.

Am J Obstet Gynecol 2001;185:1261

CARDIOPULMONARY BYPASS

Pregnant patients who had cardiopulmonary bypass procedures were reviewed:

- Fetal prematurity or death were associated with emergent procedures, maternal co-morbidities, and early gestational age.
- Recommendations: normothermic, high-flow bypass, postponing until 2nd trimester.
- Elective delivery before CPB should be considered if the fetus is viable.

Ann Thorac Surg 2011;91:1191

GOALS DURING CPB

- High pump flows (>2.5 L/min/m²)
- High MAP > 65 mmHg
- Hematocrit > 28%
- Normothermic CPB (limit < 32°C)
- Pulsatile flow?
- Optimize CO₂, acid-base, glucose
- Continuous fetal HR monitoring
LAPAROSCOPY
Symptomatic cholelithiasis during pregnancy is not rare. Choice of medical versus surgical management has been controversial.
• Compared to medical management, surgery patients had less preterm labor, fewer premature deliveries, and fewer days in-hospital.
• 38% of medical patients had relapses. Each relapse accounted for additional 5 inpatient days.

LAPAROSCOPY
Is laparoscopy better for fetal outcome than an open procedure?
• There are no outcome differences between laparoscopy and laparotomy in maternal complications or fetal outcome.
• Laparoscopy patients (the mothers) had longer operative times but shorter hospital stays, less parenteral narcotics, and earlier resumption of regular diet.
Clin Obstet Gynecol 2009;52:557

LAPAROSCOPY
Following laparoscopy (n=2181) or laparotomy (n=1522) performed between the 4th and 20th weeks of gestation, there were no differences in:
• Infant survival to one year
• Rate of fetal malformations
• Birth weight
• Gestational duration
• Growth restriction
There was an increased risk of low birth weight < 2500 gm, delivery before 37 weeks, and growth restriction when comparing the operated groups to the general population.
Am J Obstet Gynecol 1997; 177:673

GOALS FOR LAPAROSCOPY
• Consider an open technique to enter abdomen
• Maintain normal end-tidal CO₂, consider blood gas monitoring
• Keep inflation pressure < 15 mmHg
• Can be used in any trimester of pregnancy
• Maintain uterine displacement and monitor the fetus if feasible
• Use compression devices for DVT prophylaxis

SUMMARY
Approach the pregnant surgical patient with respect, rather than apprehension.
Recognize her fears related to her pregnancy.
Doing what is best for the mother will almost always be best for the fetus and the outcome of the pregnancy.
Out Patient Anesthesia in Children

Rita Agarwal MD, FAAP
Professor of Anesthesiology
The Children’s Hospital/UCHSC

Selection Criteria

- ASA 1-2
- ASA 3-4
  - Medical condition is stable and well controlled
  - Appropriate resources in case of complications
  - Willing and able parents
  - Procedure with minimal physiologic derangements

The Child With a Runny Nose

- Older than 44 weeks PCA if full term
- Older than 60 weeks PCA if preemie
- OSA???
  - Age
  - Documentation of symptoms
  - Co-morbidity
  - Surgery

The Child With a Runny Nose

- “although anesthesia is not good for the common cold, might it not be a good way of passing the time till the cold is gone?”
- Acute respiratory tract infections (RTI’s) are no longer a reason for automatic cancellation
- Although there is an anesthetic risk most are minor and easily managed
- Intubation increases risk

The Child With a Runny Nose

- Tait et.al examined >1000 children for elective surgery. Risk factors for increased complications included:
  - Use of ETT in child < 5 yrs
  - H/O prematurity or RAD
  - Paternal smoking (?)
  - Airway surgery
  - Copious secretions and/or nasal congestion

The Child With a Runny Nose

- Cohen and Cameron:
  - >20,000 children
  - 2-7 x increased risk of respiratory complications with URI
  - 11 x increased risk if they were intubated
  - Study criticized for incomplete documentation as to signs and symptoms of URI
The Child With a Runny Nose

Parnis et al examining predictors of complications in 2051 patients found that the risk increased with:
- ETT > LMA > mask airway
- Parent’s report that child has a “cold”
- H/o snoring, passive smoking
- Presence of sputum and or nasal congestion
- Induction with STP > halo > sevo > propofol
- Non-reversal of muscle relaxant


The increased risk associated with RTI’s seems to be minimal
- No closed claims cases
- There are a few cases of increased atelectasis
- In Tait et al’s study of >1000 pts, 3 required admission post-op, 2 for pneumonia, 1 for stridor
- One case report of death related to laryngospasm and cardiac arrest after extubation in a 15 month old child with a URI

Tait and Malviya. Anesthesia with Upper Respiratory Tract Infection, A&A 100, 2005

95% of RTI are viral—wide spectrum of species and respiratory tract involvement
- Hyper-reactivity of airways is common for several weeks
- Airways may be more sensitive to “irritants” (secretions, anesthetic agents etc.)

The Child With a Runny Nose

Assessment:
- History of “cold” by parents better predictor of laryngospasm than reliance on symptoms
- Presence of sputum, nasal congestion and RAD incidence of adverse resp events
- for fever, dyspnea, lethargy, wheezing, productive cough and lung field abnormalities
- Labs, CXR, naso-pharyngeal swabs, rarely practical or helpful

The Child With a Runny Nose

Pulmonary function tests abnormalities are not uncommon, including ↓ FVC, FEV₁ and PEF
- Diffusion capacity and ↓ desaturation after apnea

CRASH 2013

Out Patient Anesthesia in Children
The Child With a Runny Nose

Anesthetic Management
- Avoid irritants!!! (ETT, excessive secretions)
- Keep child well hydrated, consider humidification
- Consider anticholinergics
- Ensure adequate anesthetic depth before any airway manipulations
- Awake or deep extubation per practitioner’s preference

Premedication

Indications
- ↓ separation anxiety
- ↓ general anxiety
- Improve induction
- Minimize emotional trauma and post-operative behavioral changes

Premedication

Midazolam

Midazolam is the most commonly used premedication for children prior to surgery in the US
- Recent attention on pH, composition, and dosage of oral form

Midazolam

Composition of commercially prepared midazolam and pH may be factors
- Other studies have found that mixing IV midazolam with Syrpalta® syrup has a faster onset than commercially available midazolam
- Sodium citrate added to midazolam may speed onset of the medication

Midazolam

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Midazolam

Midazolam exists as equilibrium between a water soluble and lipophilic form. The proportion of each is pH dependant. At a pH < than 2.5 the water soluble form predominates, at a pH > 4.5 the molecule exists almost entirely in the lipophilic form.
- The lipophilic form may increase oral mucosal absorption, thus decreasing first pass metabolism and increasing palms levels.
Midazolam

- Large doses of oral midazolam may prolong recovery after sevoflurane or desflurane anesthesia.
- Smaller doses of intranasal or transmucosal midazolam seem to be as effective.

Midazolam may or may not decrease the incidence of emergence agitation. Kain et al. and others have found a lower incidence of negative postoperative behaviors in children who received midazolam 1-2 weeks after surgery and a lower incidence of EA, but at least one other study showed the opposite.

Other Premedication

Clonidine

- Fazi et al.
  - 134 patients, children ages 4-12 for T&A
  - Clonidine 4ug/kg vs. midazolam 0.5mg/kg
  - Standardized anesthetic technique with desflurane and low dose morphine
  - Clonidine → pre-op anxiety compared to M and a higher incidence of postoperative pain and excitement.

Clonidine

- Nishina and Mikawa have done a series of studies showing:
  - Oral clonidine 4ug/kg to be superior to placebo.
  - May ↓ PONV in strabismus patients, after propofol anesthesia.
  - May be as effective as IV fentanyl for providing analgesia after T&A.

- Other studies have shown oral clonidine (4ug/kg) to be as effective as valium 0.2mg/kg.
- Several studies have shown that there is a lower incidence of emergence agitation with clonidine.
**Ketamine**

- Ketamine- 3-6mg/kg po is effective
- However side effects of oral ketamine are often unacceptable
  - ↑sedation, dysphoria, dizziness and hallucinations
- May be better when used in combination with midazolam

**Ketamine**

- 2 studies have found that adding either 1.8mg/kg or 3 mg to 0.5 mg/kg of midazolam provides better anxiolysis than either alone
- Side effects were minimal
- Emergence was not delayed
- There did not appear to be any long term (1 week) problems

**Oral Transmucosal Fentanyl Citrate**

- All studies have shown taste and form are more acceptable than oral midazolam
- But with a higher incidence of pre-operative N&V
- Anxiolysis is similar

**Dexmedetomidine**

- 1ug/kg intranasal 20-60 minutes prior to induction in children <5
- Sleepy patient, but may still have anxiety with mask placement
- 2ug/kg intranasal in older children


**Parental Presence at Induction**

- Premedication is probably better for anxiolysis than PPIA in otherwise healthy children having minor surgery
- The combination of PPIA and midazolam has no additional benefits
- However parents want to be with their kids
- Parents are more satisfied feel less anxious if allowed PPIA

**The Studies of Kain et.al**

- 93 ASA I-II pts, 2-8 yrs, outpt surgery
- Randomized to parents only in OR, midazolam 0.5mg/kg only, or neither
- Multiple anxiety scales and coping and temperament measures prior to intervention
- Lower anxiety at induction in midazolam group

Agarwal, Rita, MD FAAP

Out Patient Anesthesia in Children
Kain et al

- 103 pts, 2-8 yrs, ASA I-II outpt surgery
- Randomized to midaz or midaz + PPIA
- Multiple anxiety scales and coping and temperament measures prior to interventions
- Anxiety and compliance scores were equal between the 2 groups, but parental satisfaction was higher

2000 Apr; 92(4): 939-46

PPIA

- If given a choice, the majority parents will choose PPIA, even if their child had minimal or no anxiety on a previous surgery
- PPIA is associated with ↑ HR and skin conductance level, but no EKG changes in the parents

Anesthesiology. 2003 Jan; 98(1): 58-64

Induction and Maintenance

- Halothane- cheap, "gold Standard" for > 30 years
- Increased cardiac depression and arrhythmias
- Least associated emergence agitation

- Isoflurane- cheap, long track record
- Deep extubation is comparable to sevo and halothane, ↑ incidence of coughing and desaturation with awake extubation vs. halothane
- Less emergence agitation than desflurane

Induction and Maintenance

- Sevoflurane– great induction agent
- Minimal airway irritability
- Emergence agitation

- Desflurane- great for maintenance has the least hemodynamic effects
- Airway irritant
- Emergence Agitation

Studies have shown that for non-painful short procedures, 1ug fentanyl helps ↓ EA. For short painful procedures 2-3 ug/kg fentanyl helps ↓ EA. Pre-operative midazolam may also help

Induction and Maintenance

- Propofol has gained popularity, esp for strabismus surgery
- Less PONV
- Lower incidence (although frustratingly still not 0) of EA, esp after T&A
- Not cheap, a little more labor intensive
- Can be combined with remifentanil in varying doses to provide smoother emergence

Post-operative Pain Management

- Combined general-regional techniques are very common
  - Caudal epidurals, ilioinguinal/iliohypogastric nerve blocks, dorsal penile nerve block are the most common
  - Blocks of the upper extremity and lower extremities are gaining popularity.
  - Most blocks are placed after the child is anesthetized.
  - Ultrasound has made this easier and more practical
Post-operative Pain Management

- Fentanyl can be used intra-nasally if no IV access. Blood levels appear to be equivalent to IV
- Morphine 0.05-0.1 mg/kg
- Ketorolac 0.5 mg/kg IV, 1mg/kg IM max doses 30 and 60 mg respectively

Post-operative Pain Management

- Acetaminophen (A) up to 45 mg/kg p.r.
- Bolton et.al measured serum levels in 55 pts undergoing T&T, who received 40 mg/kg p.o. pre-operatively.
- Levels did not reach toxicity in any pts
- Efficacy, esp post discharge was deemed greater (although no control group)

Fentanyl can be used intra-nasally if no IV access. Blood levels appear to be equivalent to IV.


PONV

- Eberhart et.al have developed a score to determine the risk of POV in children. Four independent factors were found:
- Duration of surgery > 30 minutes, age ≥ 3yrs (and the risk increases with increasing age), strabismus surgery + h/o prior POV or a relative with a h/o POV

PONV--Treatment

- Keeping the patient well hydrated
- Don’t force oral intake
- Minimize use of volatile agents
- Medications
  - Dexamethasone has been shown to be anti-emetic in doses of 0.05-1mg/kg
  - Ondansetron, granisetron etc are all effective esp in combination with Dex

Respiratory Complications

- Perioperative respiratory complications occur in about 10-30% of patients in the peri-operative period
- Bronchospasm, laryngospasm, airway obstruction, oxygen desaturation and stridor are the most commonly seen complications
- Deep vs awake extubation is not implicated as a risk factor

Respiratory Complications

- Incidence ↑ with:
  - URI – most studies
  - Trainees
  - ENT procedures
  - Passive smoking
  - Intubation without muscle relaxants
- The risk for laryngospasm is reported to be ~1.7 – 4.2% 
  - Magnesium 15 mg/kg prevented laryngospasm in one study, although lidocaine 1.5mg/kg did not

Laryngospasm-Treatment

- 100% oxygen + Fink maneuver (painful jaw thrust)
- Positive pressure ventilation to PIP of 20cm H2O
- Propofol 0.8mg.kg has been shown to help in ~78% of patients
- Sux 10-20% of intubating dose

Selected References


Conclusion

- Presence of URI is not an automatic cancellation
- While premedication has many beneficial effects especially during induction and post-operatively, it may prolong emergence in selected patients
- Parents want to be with their children
- Sevo and des have many advantages over the older volatile agents, however both are associated with a high incidence of emergence agitation

Conclusion

- A new scale has been developed to help assess the risk of PONV in children
- Respiratory complications are fairly common, but easily treated
POST-OPERATIVE VISUAL LOSS
*A Preventable Complication?*

Daniel J. Janik, MD
Associate Professor
University of Colorado Denver

DISCLOSURE

I have no commercial or other conflicts of interest

Overview

- General incidence of eye injuries
- Visual loss – incidence
- Types of visual loss
- Risk factors
- Strategies for prevention
- ASA recommendations

Eye Injury Associated with Anesthesia


- Eye injury accounts for 3-8% of anesthesia-related malpractice claims
- General anesthesia 83%
- Monitored anesthesia care 11%
- Conduction blockade 7%
- Incidence of corneal abrasion:
  - Roth 1996 – 0.034% (non-ophthalmic surgery)
  - Cucchiara 1988 – 0.17% (neurosurgical, mostly prone)

Eye Injury Associated with Anesthesia


- 30% of claims were for eye injury associated with movement during eye surgery
  - Blindness was outcome in all cases
  - Median payment high ($90,000)
- If you do eye blocks:
  - You will have a significantly altered risk profile related to permanent eye damage from eye block needles than if you only provide MAC (48 vs. 3 in claims study)

Post-operative Visual Loss

Roth S et al, Anesthesiology 1996; 85:1020-7

- 60,965 anesthetics from 1988-1992
- Non-ocular surgery
- 34 Patients (0.056%) with eye injury, 2 patients (0.003%) with visual loss
- Only 21% of all cases had discernible cause
Post-operative Visual Loss
Roth S et al, Anesthesiology 1996; 85:1020-7

- Independent Risk Factors:
  - Length of surgery
  - Lateral positioning
  - Operations on head or neck
  - General anesthesia
  - Surgery on Monday

Post-operative Visual Loss
Warner ME, Anesthesia & Analgesia 2001; 93: 1417-21

- 501,342 anesthetics from 1986-1998
- 405 cases of visual loss
- 216 regained full vision within 30 days
- 189 lost vision > 30 days
  - 185 underwent ophthalmologic/neurosurgical procedure with tissue damage or loss
  - 4 without tissue damage/loss = 0.0008%

Post-operative Visual Loss
Warner ME, Anesthesia & Analgesia 2001; 93:1417-21

- None of 26,212 neuraxial blockade patients had visual loss
- None of 11,942 spinal surgery patients had loss > 30 days (8 had loss < 30 days)
- Data contrasts with 0.06% loss after cardiac surgery (Nuttall, 2001)

Post-operative Visual Loss
Nuttall GA et al, Anesthesia and Analgesia 2001; 93:1410-6

- Study of 27,915 patients undergoing CPB
- 17 had ION; 0.06% (12 AION, 5 PION)
- Bivariate risk factors:
  - Low Hgb conc (<8.5 g/dL)
  - Atherosclerotic vascular disease
  - Pre-operative angiogram
- Univariate risk factors
  - RBC transfusions (OR 1.3)
  - Any non-RBC product (OR 4.4)

Post-operative Visual Loss

- Retrospective study using National Inpatient Sample data from 1993 to 2003 undergoing spine surgery:
  - 4,728,815 patients total
  - 4134 (0.087%) had postoperative visual sx
  - 271 (0.006%) had diagnosis of ION
  - 47 (0.001%) had diagnosis of CRAO
  - Overall incidence was 0.094%
Post-operative Visual Loss

- Highest incidence:
  - Surgery for scoliosis – 0.28%
  - Posterior-only approach – 0.29%
  - Anterior-only approach – 0.17%

- Risk factors for non-ION, non-CRAO loss:
  - Age<18 years: OR 5.8
  - Age>84 years: OR 3.2
  - Peripheral vascular disease: OR 2.0
  - Pre-existing hypertension: OR 1.3
  - Blood transfusion: OR 2.2

Post-operative Visual Loss
Shen Y and Roth S, Anesthesiology 2008; 109: A1013

- Retrospective study using National Inpatient Sample from 1996 to 2005

- Rates of visual loss:
  - Spinal fusion – 1:3364 (0.029%)  
  - Laminectomy – 1:11,453 (0.0087%)  
  - Appendectomy – 1:7,870,593 (0.0012%)

- Spinal fusion with visual loss:
  - 57% lumbar/lumbosacral
  - 35% thoracic/thoracolumbar
  - 8% cervical

Post-operative Visual Loss

- 126,666 operations from 1998-2004
- Retrospective chart review and case-control study
- Non-ocular surgery; ION only
- 17 cases (0.013% overall incidence)
  - CABG – 0.33%
  - Spine – 0.36%
  - Other – 0.003%
- 16/17 were MALE (more on that later)

Post-operative Visual Loss
Roth, Thistead, et al 1996 General Surgical 0.003%
Warner, Warner, et al 2001 General Surgical 0.001%
Nuttall, Garrity, et al 2001 Cardiac 0.060%
Kalyani, Miller, et al 2004 Cardiac 0.113%
Stevens, Kelley, et al 1997 Spine 0.200%
Chang, Miller 2005 Spine 0.028%
Patil, Lad, et al 2008 Spine 0.094%
Shen, et al 2009 Spine 0.01%
Most Common Causes

- Ischemic Optic Neuropathy (ION)
- Central Retinal Artery Occlusion (CRAO)
- Cortical Blindness
- Central Retinal Vein Occlusion

Anatomic Classification of Visual Loss
Williams EL et al; Anesth Analg 1995; 80:1018-29

Cortical Blindness

- Caused by damage to the optic radiation or occipital cortex (resulting in infarction) from:
  - Embolism (particulate or air)
  - Sustained hypotension
  - Cardiac arrest
- Presentation:
  - Painless loss of vision, pattern depends on area affected

Cortical Blindness

- Physical findings:
  - Normal optic disk
  - Retention of pupillary reflex
  - Abnormal CT or MRI
- Prognosis:
  - Good
- Treatment:
  - Maintain Hgb and normal cerebral perfusion pressure to avoid extending damage
  - Hyperbaric O₂ if air embolism is suspected

Central Retinal Artery Occlusion

- Usually caused by compression of the eye leading to increased intraocular pressure with resultant decrease or cessation of flow in the central retinal artery
- End result is retinal ischemia due to lack of oxygen delivery
Central Retinal Artery Occlusion

- Presentation:
  Symptom onset within 24 hours
  Unilateral visual loss
  No light perception

- Physical findings:
  Afferent pupil defect
  Periorbital edema or other trauma
  Cherry red spot on fundoscopic exam

Central Retinal Artery Occlusion

- Prognosis:
  Usually irreversible

- Treatment:
  No consistently effective treatment
  Acetazolamide and inhalation of 5% CO₂

- Etiology:
  Emboli
  Improper positioning
  External compression (head and neck surgery)

Ischemic Optic Neuropathy

- Anterior ischemic optic neuropathy (AION)
  - Non-arteritic (more common perioperative type)
  - Arteritic

- Posterior ischemic optic neuropathy (PION)

Vascular Supply of Anterior Optic Nerve

Williams EL et al; Anesth Analg 1995; 80:1018-29

Anterior Ischemic Optic Neuropathy

- Caused by transient decrease in perfusion pressure of the nutrient vessels of the anterior optic nerve below autoregulatory range
  - Decreased mean arterial pressure
  - Increased intraocular pressure
  - Both

- Injury depends on severity and duration of transient ischemia

Anterior Ischemic Optic Neuropathy

- Presentation:
  - Painless visual loss
  - Usually in first 24-48 hours after surgery
  - Afferent pupil defect or unreactive pupils
  - Usually noted upon awakening
  - Visual field deficits (inferior) or complete loss
  - Commonly bilateral, but may be unilateral
**Anterior Ischemic Optic Neuropathy**

- **Physical Findings:**
  - Early optic disk edema
  - Optic disk hemorrhages
  - Disk edema replaced by pallor in 2-3 months
- **Prognosis:**
  - Poor - <30% show some improvement
- **Treatment:**
  - None

---

**Ischemic Optic Neuropathy – Visual Field Deficit**

Predisposing factors:
- Variable blood supply (posterior ciliary arteries)
- Small optic disk size
- Aging
- Hypertension
- Smoking
- Diabetes mellitus
- Vascular disease

Precipitating Factors:
- Acute systemic hypotension*
- Venous obstruction*
- Raised intraocular pressure
- Lowered hematocrit*
- Increased blood viscosity (sickle cell; polycythemia)

---

**Posterior Ischemic Optic Neuropathy**

- Caused by decreased oxygen delivery to posterior portion of optic nerve (between optic foramen and where central retinal artery enters nerve)
- Nerve only fed by pial vessels which are sensitive to compression
- Not usually associated with occlusive vascular disease
- More likely to be associated with emboli than AION

---

**Vascular Supply of the Eye**

Baig 2007

**Posterior Ischemic Optic Neuropathy**

- Presentation:
  - Similar to AION, but may also develop slower
- Physical findings:
  - Optic disk appears normal early
  - Mild disk edema days later
  - Orbital CT may show enlarged intraorbital optic nerve
Posterior Ischemic Optic Neuropathy

- **Prognosis:**
  - Poor – like AION, usually fixed deficit
- **Treatment:**
  - None

Posterior Ischemic Optic Neuropathy – Etiology
Williams EL. Anesthesiology Clin N Am 2002; 20:367-384

- Multifactorial:
  - Hypotension*
  - Low Hemoglobin*
  - Increased intraorbital venous pressure
  - Infection
  - Venous obstruction*
  - Congenital absence of central retinal artery
  - Internal carotid artery dissection

Posterior Ischemic Optic Neuropathy – Risk Factors

- 7 Institutional cases plus literature search
- Male
- Mean age 50 years old
- Spine surgery
- Intraoperative hypotension
- Large blood loss (2000-16,000ml)
- Drop in hematocrit of 9.5-19% (mean 14%)
- Facial swelling

Fundoscopy

- Normal
- Papilledema
- Atrophied Disc
- Cherry Red Spot

Post-operative Visual Loss
Anatomic Considerations

- Blood supply to optic nerve is vulnerable
- Known variability in blood supply
- Atypical anatomic patterns
- Poor watershed perfusion zones
- Abnormal autoregulation
- Optimal range of hematocrit and blood pressure for adequate O2 delivery to optic nerve unknown (particularly in presence of venous congestion in prone position)

ASA POVL Registry

- Established by ASA in June 1999
- Goal is to obtain sufficient cases (100 or more) so associations can be made and investigated
- Presently have 195 cases reported as of February 2013
- 131 cases (67%) are spine surgery
- 16 cardiac cases
- 6 prostate cases (3 robotic, 3 open)
- 12 orthopedic, 2 liver transplants, 3 aortas
Most Common Procedures

- Spine surgery (67%)
- Cardiac surgery (8%)
- Liver transplant
- Thoraco- and abdominal aneurysms
- Head and Neck surgery
- Thoracotomy
- Others

Post-operative Visual Loss

- Most patients middle-aged (median=49)
- Long duration (median=8 hours)
- Blood pressure decreases (median=37% drop; deliberate hypotension used in 40% of cases)
- Large blood loss (median=2.3L)
- Anemia (median hematocrit=25%)
- Intraoperative course may be completely unremarkable
- 18% of patients were in Mayfield holder (ION can occur without pressure on eye)

Post-operative Visual Loss
Lee LA et al, Anesthesiology 2006; 105(4): 652-659

Anesthesia Duration in Spine ION Cases (n=83)

- Occurs over a wide range of reported blood pressures

Table 5. ASS RHE Registry: lowest blood pressure* in Spine Cases with ION (n=83)

| Lowest SBP, mmHg | n | %
|------------------|---|---
| < 80             | 6 | 6%
| 80-100           | 7 | 7%
| 101-120          | 17 | 20%
| 121-140          | 12 | 15%
| 141-160          | 5 | 6%
| > 160            | 3 | 4%
| Intermittent     | 3 | 4%
| Lowest SBP or DBP as % below baseline, monthly | | |
| 0-20%            | 17 | 20%
| 21-40%           | 21 | 25%
| > 40%            | 7 | 8%
| Unknown          | 9 | 11%
| Deviation hypotension | 22 | 27%

* Blood pressure ranges were based on <50% of blood pressure at a given range.

Post-operative Visual Loss
Lee LA et al, Anesthesiology 2006; 105(4): 652-659

Estimated Blood Loss in Spine Cases with ION (n=83)

- Any type of table; any type of headrest

Table 4. ASS RHE Registry: Type of Surgical Frames, Tables, and Headrests in Spine Cases with ION (n = 83)

| Type of surgical frame or table | n (%)
|--------------------------------|------
| Table free                  | 25 (20)
| Jackson spinal frame        | 17 (13)
| Soft chest rolls            | 12 (10)
| Knobless chest frame         | 12 (10)
| Other/unknown               | 5 (4)
| Type of headrest            | n (%)
| Foam pad                    | 47 (39)
| Mayfield zero               | 9 (7)
| Donut type pad              | 15 (12)
| Other/unknown               | 13 (10)

AAS = American Society of Anesthesiologists; ION = ischemic optic neuropathy; PDIVL = Postdural Visual Loss
Post-operative Visual Loss

Lee LA et al, Anesthesiology 2006; 105(4): 652-659

Table 2. ASA POVS Registry: Split Case with ION POVS

<table>
<thead>
<tr>
<th>Complication</th>
<th>% of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, male, yr</td>
<td>54 (14)</td>
</tr>
<tr>
<td>Female</td>
<td>62 (12)</td>
</tr>
<tr>
<td>ASA 1 or 2</td>
<td>55 (45)</td>
</tr>
<tr>
<td>ASA 3</td>
<td>24 (29)</td>
</tr>
<tr>
<td>ASA 4-5</td>
<td>5 (7)</td>
</tr>
<tr>
<td>Unconsciousness</td>
<td>5 (4)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>34 (15)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>12 (18)</td>
</tr>
<tr>
<td>Tubal failure</td>
<td>35 (18)</td>
</tr>
<tr>
<td>Concomitant disease</td>
<td>31 (18)</td>
</tr>
<tr>
<td>High intracranial pressure</td>
<td>14 (17)</td>
</tr>
<tr>
<td>Obesedy</td>
<td>6 (10)</td>
</tr>
</tbody>
</table>

Most patients had one or more co-existing disease, but can happen in ASA Class 1 patients also.

Interesting Points:

- Most patients with CRAO had evidence of ocular trauma and unilateral vision loss which suggests positioning may be at fault.
- Most patients with ION had bilateral visual loss indicating systemic or patient-specific factors may play role.

Summary of Suggested Risk Factors:

- Hypertension
- Diabetes
- Smoking
- Atherosclerosis
- Male gender
- Middle age
- Spine surgery
- Head and neck surgery
- Cardiac surgery
- Hyperlipidemia
- Intraoperative hypotension
- Intraoperative anemia
- Large blood loss
- Large fluid resuscitation
- Facial edema
- Prone position – head down
- Prolonged surgical time
- Eye trauma
- Vasopressors

BUT

None of these were significant!
Hypotension and Post-operative Ischemic Optic Neuropathy

- 80 adults in POVL registry matched with 315 control patients for year of surgery
- Independent risk factors:
  - Anesthesia duration (OR/1 hr 1.39)
  - Obesity (OR 2.83)
  - Wilson frame use (OR 4.3)
  - Male Sex (OR 2.53)
  - Lower colloid use (OR/5% 0.67)
  - EBL (OR/1L 1.34)
- No independent effect:
  - Any BP > 40% below baseline for 30 min
  - Anemia

Independent risk factors:
- Wilson frame use (OR 4.3)
- Male Sex (OR 2.53)
- Lower colloid use (OR/5% 0.67)
- EBL (OR/1L 1.34)

No independent effect:
- Any BP > 40% below baseline for 30 min
- Anemia

Proposed Theories of Origin of Ischemic Optic Neuropathy

- Etiology of ION may be influenced more by intraoperative physiologic perturbations than pre-existing disease states
- Higher proportion of men to women (69%) suggests protective effect of estrogen
- Acute venous congestion of optic canal suggested by risk factors: Obesity, Wilson frame, long duration, EBL, % colloid (and cases of ION occurring in neck dissections and robotic prostatectomies)
- Role of systemic inflammatory response?

So, What Should I Do To Protect My Patient (and Myself)?

Post-operative Visual Loss: Strategies for Prevention

- Proper positioning:
  - Prone position with head down will cause increase in intraocular pressure and favor development of periorbital edema
  - Keep head above level of heart

- Elevate the head of the bed to prevent edema formation
- Use padded headrest without pressure on eyes

Post-operative Visual Loss: Strategies for Prevention

- Properly pad and protect the eyes from compression

Elevate the head of the bed to prevent edema formation

Murphy DF. Anesth Analg 1985; 64:510-30
Friberg TR, Weinreb RN. JAMA 1985; 253:1755-7
Post-operative Visual Loss: Strategies for Prevention

- Occlusive dressing over eyes to prevent entry of surgical prep solutions
- Stage long procedures into two or more short procedures?

BUT

Is Staging Safer Than A Single Surgery?

- Nationwide Inpatient Sample
- 1998-2006
- 11265 circumferential spine surgeries
- Increased incidence (28.4% vs. 21.7%) of complications including:
  - DVT
  - ARDS
- Age > 65 years old also increased risk

Updated ASA Practice Advisory on POVL
Anesthesiology 2012; 116:274-85

- Use of deliberate hypotension not been shown to be associated with ION
- Colloids should be used along with crystalloids
- No documented hemoglobin level associated with development of ION
- Insufficient evidence to provide guidance on use of α-adrenergic agents
- High-risk patients should be positioned so head is level with or above heart and head in neutral forward position
- Consider staging procedures in high risk patients?

Post-operative Visual Loss: Strategies for Prevention - Updated

- Avoid direct pressure on globe
- Avoid perioperative hypotension
- Avoid perioperative anemia
- Consider 10 degrees of reverse trendelenberg during prone surgery
  - Lower transfusion threshold to keep hematocrit above 30 in high risk patients
- Avoid infusions of large amounts of crystalloid
- Consider staging long spinal surgeries (greater than 8 hours)
  - Maintain mean arterial pressure at patient’s baseline
- Perform a postoperative visual exam as early as possible in high risk patients

Controversial Strategies

- Avoid the use of N₂O:
  - N₂O will ↑ plasma homocysteine by disrupting folate/B6/B12 metabolism; high homocysteine correlated with enhanced inflammation, diabetic neuropathy, and CRAO/CRVO
  - Kempen PM Anesthesiology 2012; 117: 431-2
- Restrict crystalloid to 40 ml/kg total for spine case:
  - Based on findings that total volume of resuscitation, total non-blood replacement, and lower use of colloid were risk factors
  - Larson CP Anesthesiology 2012; 117: 433-4
Can we prevent post-operative vision loss?

MAYBE,

But there is still a lot we do not know!
An Update on Ambulatory anesthesia

Frances Chung
Professor, Dept of Anesthesiology
University Health Network
University of Toronto

Outpt thyroid surgery: should pts be discharged on same day?
- 232 outpt thyroidectomy
- Hospital admission rate 0.4%
- 4 pts readmitted within 1 wk of surgery
- 2 hypocalcemia
- 1 wound infection
- 1 pain

Awake Craniotomy for Removal of Intracranial Tumor: Considerations for Early Discharge
- 241 pts
- 76 pts (31%) 23 h stay
- 15 pts (6%) day surgery
  Blanshard HJ, Anesth Analg 2001; 92:89-94

Newer anesthetic and rehab. Protocols enable outp hip replacement in selected pts
- 150 pts
- Preop teaching, epidural anesthesia till 4h postop
- Preop Celebrex 400mg, Oxycontin 10mg
- Intraop propofol infusion
- Postop, Celebrex 200mg, Oxycontin 20mg, OxyIR for breakthrough pain

Ambulatory Surgery
- 1/16 (6%) readmitted after a seizure
- 1/16 (6%) admitted with nausea & headache
  23 hr stay
- 3/76 (4%) readmitted
  allergy to phenytoin
  ↑ hemi paresis secondary to edema
  subdural hygroma
  Blanshard HJ, Anesth & Analg 2001; 92:89-94

Ambulatory Anesthesia: An update
- Preoperative preparation
- Selection of patients, preop testing
- Ambulatory anesthesia new literature
- Safe discharge
**Adult Outpatients - Unsuitable**

- Unstable ASA III or IV
- MH
- MAO inhibitor
- Morbid obesity +
- Acute substance abuse

**Non-Medical (Psychosocial)**

- Unwilling to participate
- Unable to participate

---

**Ambulatory Patient Selection Criteria**

1337 anesthesiologists interviewed
Agreement among anesthesiologists NOT TO PROCEED with surgery AS DAY SURGERY PATIENTS

<table>
<thead>
<tr>
<th>Presented condition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior MI (1-6 months)</td>
<td>83</td>
</tr>
<tr>
<td>CHF III</td>
<td>82</td>
</tr>
<tr>
<td>CHF IV</td>
<td>98</td>
</tr>
</tbody>
</table>

*Z Friedman & F Chung CJA 2004:51:437-43*

---

**Pt Selection: Exclusion Criteria**

- Unstable ASA physical status 3 and 4
- Complex morbid obesity/complex sleep apnea
- Acute substance abuse
- Sickle cell disease

---

**Ambulatory Patient Selection Criteria with anesthesiologists**

(n=1337) agreement NOT to PROCEED with surgery

<table>
<thead>
<tr>
<th>Presented condition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep apnea-GA narcotics post-op</td>
<td>84</td>
</tr>
<tr>
<td>Morbid obesity (BMI 35-45) with CVS or resp cx</td>
<td>82</td>
</tr>
<tr>
<td>Morbid obesity (BMI&gt;45 kg/m²) with CVS or resp cx</td>
<td>95</td>
</tr>
<tr>
<td>No escort</td>
<td>88</td>
</tr>
</tbody>
</table>


---

**Pt Selection**

- Elderly pt
- Coronary ht disease
- Obstructive sleep apnea
- Asthma
- Upper resp. infection

- DM
- Morbid obesity
- Pediatric pt
- Malignant hyperthermia
- Monoamine oxidase inhibitor

---

**Elderly vs. Younger Pts Intraop Adverse Events**

<table>
<thead>
<tr>
<th>Odds Ratio</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any event</td>
<td>1.4* 0.003</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>2.0* 0.0001</td>
</tr>
<tr>
<td>Respiratory</td>
<td>0.3* 0.004</td>
</tr>
<tr>
<td>Intubation related</td>
<td>0.9 0.78</td>
</tr>
</tbody>
</table>

*F Chung, CJA 46:309-21, 1999*
The risks reported do not constitute a contraindication for elderly pts – day surgery

Require more careful intraop CVS Mx

Risk factors for inpt hospitalization within 7 days of outpt surgery

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 70-74</td>
<td>1.12</td>
</tr>
<tr>
<td>75-79</td>
<td>1.30</td>
</tr>
<tr>
<td>80-84</td>
<td>1.51</td>
</tr>
<tr>
<td>&gt; 85</td>
<td>1.89</td>
</tr>
</tbody>
</table>

Pts with pre-existing medical diseases

What are the risks having outpt surgery?

What happens if pts have pre-existing medical diseases?
The Value of Routine Preop Testing Before Cataract Surgery

- Multicentre RCT
- 9000 testing vs. 9000 no testing
- No difference in postop adverse events or deaths 3.1 per 100 operations

F Chung, Br J Anaesth 1999

Enrollment of Pts and Randomized Assignment to Testing Group and No Testing Group

- 2297 pts screened
- 824 not eligible
- 1061 recruited
- 412 refused
- 12 withdrew
- 23 OR cancelled
- 527 testing
- 499 no testing
- 19 changed to testing

F Chung, Anesthesia and Analgesia 2009

Elimination of Preop Testing in Ambulatory Surgery

- No significant differences in the rates of perioperative adverse events
- Nor the rates of adverse events within 30 days after surgery

F Chung, Anesthesia & Analgesia 2009

Practice Advisory for Preanesthesia Evaluation: A Report by ASA Task Force on Preanesthesia Evaluation

- ‘Routine’ preop testing: no valuable contribution
- ‘Indicated’ testing: help in decision making

Anesthesiology 2002; 96:485-96
Costs of Preop Testing

<table>
<thead>
<tr>
<th>Tests</th>
<th>No. of tests ordered and cancelled*</th>
<th>Test Gp</th>
<th>No. of tests ordered and done</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBC</td>
<td>382</td>
<td>405</td>
<td></td>
</tr>
<tr>
<td>Electrolytes</td>
<td>297</td>
<td>301</td>
<td></td>
</tr>
<tr>
<td>Creatinine/Urea</td>
<td>252</td>
<td>246</td>
<td></td>
</tr>
<tr>
<td>Blood Glucose</td>
<td>170</td>
<td>176</td>
<td></td>
</tr>
<tr>
<td>ECG</td>
<td>421</td>
<td>423</td>
<td></td>
</tr>
<tr>
<td>X-ray</td>
<td>77</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,599</td>
<td>1,632</td>
<td></td>
</tr>
<tr>
<td>Saving/costs</td>
<td>$18,938</td>
<td>$19,470</td>
<td></td>
</tr>
</tbody>
</table>

F Chung, Anesthesia & Analgesia 2009

Ambulatory Anesthesia: An update

- Preoperative preparation
- Selection of patients, preop testing
- Ambulatory anesthesia new literature
  - LMA, pain, PONV
- Safe discharge

Preop lab testing in pts undergoing elective, low risk amb surgery (Hernia Repair) Annals of Surg 2012

- 73,596 pts from National Surgical Quality Improvement Program (NSQIP) database (5 yr)
  - 64% (46,977) pts underwent testing
  - 61.6% with 1 abnormal test
  - In 25,149 pts with no co morbidities and no clear indication for testing, 54% received at least 1 test.


- LMA failure: An airway event requiring LMA removal and tracheal intubation.
  - 170 (1.1%) experienced LMA failure.
  - 60% of pts experienced significant hypoxia, hypercapnia, or airway obstruction
  - 42% presented with inadequate ventilation related to leak.

Preop lab testing in pts undergoing elective, low-risk amb surgery Benarroch-Gampel J et a; Annals of Surg 2012 256;518-28

- Major Cx (reintubation, PE, stroke, renal failure, coma, cardiac arrest, MI, septic shock, bleeding, or death) occurred in 0.3% of pts.
- After adjusting for pt and procedure characteristics, neither testing nor abnormal results were associated with postop Cxs


4 independent risk factors for failed LMA :
- Surgical table rotation, male sex, poor dentition, and increased BMI.
- A 3-X increased incidence of difficult mask ventilation
- 13.7% had unplanned hospital admission, 5.6% needed ICU for persistent hypoxemia.
Systemic lidocaine to improve postop quality of recovery after amb lap surgery
De Oliveira, Gildasio S Jr Anesth Analg 2012; 115: 262-7

- RCT, 63 female were randomized to receive lidocaine or NS
- Lidocaine group: better global quality of recovery scores
- Faster hospital discharge criteria
- Less oral opioids

Periop lidocaine infusion for postop pain control: a meta-analysis

- 29 studies: 1,754 pts
- Periop IV lidocaine reduced postop pain and opioid requirement, as well as ileus, recovery time, hospital LOS and nausea/vomiting.
- IV lidocaine infusion was effective mainly in abdominal surgery populations.

Preoperative Dexamethasone Enhances Quality of Recovery after Laparoscopic Cholecystectomy
Eff on In-hospital and Postdischarge Recovery Outcomes

- 24 RCT with 2,751 subjects were included.
- Dexamethasone at doses more than 0.1 mg/kg is an effective adjunct in multimodal strategies to reduce postop pain and opioid consumption
Effect of Periop Alpha 2 Agonists on Postop Morphine Consumption and Pain Intensity

- 30 studies: 1,792 pts, 933 received clonidine or dexmedetomidine
- Postop morphine-sparing at 24 h
  - 4.1 mg with clonidine and 14.5 mg with dexmedetomidine
- Decrease in pain intensity at 24 h
  - 0.7 cm on a 10-cm VAS with clonidine and 0.6 cm with dexmedetomidine.
- Adverse effects: bradycardia and arterial hypotension

Non-Opioid Drugs for Minimizing Pain After Surgery

- Acetaminophen
- Propacetamol
- Steroid
- Beta blockade
- Ketamine
- Dextromethorphan
- Clonidine
- Dexmedetomidine
- Gabapentin
- Magnesium
- Neostigmine

An ounce of prevention is worth a pound of cure.

Society for Ambulatory Anesthesia Consensus Statement on Perioperative Blood Glucose Management In Diabetic Patients Undergoing Ambulatory Surgery
G Joshi et al, Anesth Analg 2010; 111:1378-87

To cure sometimes
To relieve often
To comfort always
Society for Ambulatory Anesthesia Guideline for the Management of PONV


Strategies to Decrease Risk of PONV

1. Use regional anesthesia (avoid GA)
2. Propofol for induction & maintenance
3. Avoid nitrous oxide
4. Avoid volatile agents
5. Minimize intraop & postop opioids
6. Adequate hydration


Who is at risk for PDNV?

Apfel, Anesthesiology 2012; 117: 475-86

- A prospective multicenter study: 2,170 adults
- Overall incidence of PDNV: 37%
- 5 independent predictors

Simplified risk score for PDNV in adults

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female sex</td>
<td>1</td>
</tr>
<tr>
<td>History of PONV</td>
<td>1</td>
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<tr>
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<td>Opioids in PACU</td>
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<td>Nausea PACU</td>
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Apfel, Anesthesiology 2012; 117: 475-86

Simplified risk score for POV in Children

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<th>Risk Factors</th>
<th>Points</th>
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<td>Surgery &gt; 30 min</td>
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<tr>
<td>Age &gt; 3 yrs</td>
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<tr>
<td>Strabismus surgery</td>
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<tr>
<td>History of POV or PONV in relatives</td>
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<tr>
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Gan TJ, et al submitted 2013

NK₁ Antagonist
Randomized Double Blind Comparison of the NK₁ Antagonist, Aprepitant vs. Ondansetron for the Prevention of PONV

- 805 pts, GA, open abdominal surgery
- Aprepitant 40 mg p.o. 1-3 h before induction
- Aprepitant 125 mg p.o. 1-3 h before induction
- Ondansetron 4 mg iv before induction


Palonosetron

- Unique structural characteristics fused tricyclic ring
- More potent at 5-HT₃ receptors
- Longer acting
  - Plasma half life 40 h vs. 5-12 h

Patients with No Vomiting

- Ondansetron: less effective in pts with ↑ P450 isoform activity (fast metabolization)
- 5HT₃ receptor associated with QT prolongation
- Association of dolasetron with severe arrhythmias
  - HPB (Canada) = black box warning
- Palonosetron
  - no association with QT prolongation
  - long half life
  - Indication for late phase PONV
  - Chemotherapy induced for nausea and vomiting


Advantage of Palonosetron

- Unique structural characteristics fused tricyclic ring
- More potent at 5-HT₃ receptors
- Longer acting
  - Plasma half life 40 h vs. 5-12 h

Ambulatory Anesthesia: An update

- Preoperative preparation
- Selection of patients
- Ambulatory anesthesia new literature
- Safe discharge

CRASH 2013
Discharge

Success of outpatient surgery -- appropriate and timely discharge

British anesthetist
Patient discharged home without escort
Killed in car accident
British anesthetist charged with manslaughter

Car Accidents After Ambulatory Surgery in Pts Without an Escort

- F Chung et al., Anesth and Analg 2008;106:817-20

Hong Kong

- Patient discharged home after monitored anesthesia care
- Patient without escort
- Went home on subway
- Purse was snatched

Intranasal Midazolam Premedication

American Academy of Pediatrics & American Academy of Pediatric dentistry

- Guideline for monitoring and Mx of pediatric pts during and after sedation
- Preferable to have 2 or more adults accompany children still in car safety seats
- 4 children in car seats died during transport
When can patients drive safely after GA?

Objective and subjective sleepiness, alertness and fatigue in normal controls and pts before surgery

<table>
<thead>
<tr>
<th>Measure</th>
<th>Controls Mean (SD)</th>
<th>Patients Mean (SD)</th>
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<tr>
<td>Attention lapses</td>
<td>0.15 ± 0.48</td>
<td>2.5 ± 1.7**</td>
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<tr>
<td>Micro-sleep</td>
<td>0.20 ± 0.61</td>
<td>0.15 ± 0.36</td>
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<tr>
<td>Stanford sleepiness</td>
<td>2.2 ± 0.8</td>
<td>2.4 ± 0.8</td>
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<tr>
<td>Alertness Scale</td>
<td>37.0 ± 5.3</td>
<td>42.6 ± 5.4*</td>
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<tr>
<td>Fatigue Severity</td>
<td>27.5 ± 9.3</td>
<td>26.4 ± 11.3</td>
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</table>

Driving Simulation

- Lower alertness levels & impaired driving performance preop
- Driving simulation, EEG-verified sleepiness & attention deficits at 2h postop, normal at 24 h

Recent Japanese observational report in GI journal
- Over 10,000 pt sent home without escort after gastrocopy- propofol sedation
Ambulatory Anesthesia: An update

- Preoperative preparation
- Selection of patients, preop testing
- Ambulatory anesthesia new literature
- Safe discharge
Mitigating Legal and Ethical Risks

Patrick O’Rourke, JD
Julie Altmix, RN, BSN
University of Colorado Denver
School of Medicine

Conflict of Interest
• We have no conflicts of interest, commercial or otherwise, that apply to this presentation.
• We are receiving no commercial sponsorship or support for this presentation.

Goals
• Provide an overview of the liability system
• Dispel misconceptions
• Provide information that will assist you in avoiding litigation
• Provide information that will assist you in winning a lawsuit

True or False
• There are too many frivolous medical malpractice lawsuits?
Answer: False
The number and total value of medical liability payments made on behalf of physicians declined for the eighth consecutive year in 2011, according to the National Practitioner Data Bank.
• Too expensive – attorneys more selective.
• Typically $100,000 in defense expenses (not counting attorney’s fees).

True or False
• Only certain types of people sue?
Answer: True and False
Patients are predominantly female (62%) and inpatient (63%).
Mean age = 42 years. Children younger than 10 years old were 70% more likely to receive a large payment and patients older than 70 years were 80% less likely.
Patient outcomes are the strongest predictor of both payment size and likelihood of a large payment.

True or False
• Most medical malpractice cases settle?
Answer: False
75-80% of medical malpractice claims were closed with no payment.
15-20% settled.
5% go to trial.
• Of the 5% that go to trial, physicians win 90%.
True or False

- Medical malpractice premiums are driving physicians out of business?
  
  **Answer:** True and False.

- Nearly 60% of premiums nationwide held steady in 2012, about 26% decreased, and 13% increased.

- Rates fell 1.7% in 2012, they dipped 0.5% in 2011 and 0.3% in 2010.

- Depends on where you live.

Liability Premiums?

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</table>

True or False

- There is a better system?
  
  **Answer:** Who knows.

- Depends upon what you believe the liability system is supposed to accomplish.

- Fair compensation vs. Deterrence
- Accountability
- Maximize availability of health care.

What Does Negligence Mean?

- Taking an Action or Failing to Take an Action

- That a Reasonable Physician Practicing in the Same Specialty Would or Would Not Take Under the Same Circumstances

Is it a Good Standard?
Did the Negligence Matter?

- An Error in Judgment
- There Has to Be a Link
- An Injury

What Are They Aiming For?

- Medical Expenses
- Lost Wages
- Physical Impairment & Disfigurement
- Pain & Suffering

Anesthesia Cases

- Reviewed 120 reported anesthesia cases.
- 71 defense verdicts
- 12 verdicts $1-2MM
- 13 verdicts $2-5MM
- 5 verdicts $5+MM (High $33.2MM – rapid detox)

Common Themes

- Wrong level of expertise (CRNA)
- Patient left with resident
- Failure to consider pertinent medical history
- Timeliness of intervention
- Hand off to PACU
- Violation of hospital policy
- Inadequate/missing/altered records
- Anonymous Patient v. Anonymous Anesthesia Team

Avoiding Litigation - Documentation

- “If it’s not in the record, it didn’t happen.”
- Impossible standard, particularly in anesthesia
- We need to see:
  - Information provided by patient
  - Physical assessment
  - Laboratory results
  - Why you select a course of treatment
  - Anticipated follow-up

Avoiding Litigation - Alteration

- Never “change” a medical record after the fact.
- You will be caught.
- You will lose the lawsuit – even if the care was perfect.
- Time + date any amended entries.
- Explain why you are making the amended entry.
Avoiding Lawsuits - Communication

- The quality of care does not affect whether you get sued. *NEJM. Blink.*
- The quality of communication affects whether you get sued.
- Anesthesia is particularly hard.
- If the patient feels treated like a commodity, the likelihood of litigation goes up.
- Communication is a two-way process.

Avoiding Litigation – Informed Consent

- Informed consent is:
  - Substantial risks of the procedure (the patient never hears these).
  - Potential benefits of the procedure (the patient only hears these).
  - The alternatives to the procedure (the physician often forgets to mention these).

Avoiding Litigation - Consultation

- One of the most common problems we see is lack of communication between physicians.
- Vertical and horizontal.
- Everyone has to be on the same page.
- The patient is a lousy conduit of information.

Avoiding Litigation – HMO Directed Medicine

- Realistic or not, patients view medical care as an unlimited resource.
- They resent HMO’s telling them “NO!”
- You must inform of alternatives, even if not covered by insurance.

Avoiding Litigation - Misinformation

- Patients are bombarded with misinformation.
- The “final cure for diabetes” is a combination of bitter melon, cayenne pepper, and licorice extract.
- Your patients are scared.
- You have to correct misinformation.

Avoiding Litigation – Take Responsibility

- Acknowledge when a complication occurs.
- Minimize the consequences.
- Apologize for the situation, not the care.
- “I’m sorry” can’t be held against you, in most states.
- But, even if admissible, why not?
**Avoiding Litigation - Integrity**
- Patients expect doctors to do the right thing.
- So do jurors.
- Don’t give someone a reason to question your integrity.
- Bad facts = bad law. Moore v. UCLA

**Winning Litigation - Engage**
- Getting sued sucks.
- The lawsuit will not go away if you ignore it.
- You have two choices:  
  - Help your lawyer win the case.
  - Help yourself lose the case.

**Winning Litigation - Teach**
- You know more about medicine than your lawyer ever will.
- We’ve never had to care for a patient.
- Teach us what doesn’t appear in the textbooks.

**Winning Litigation - Select**
- We’ve seen the significance of expert witnesses.
- You know the leaders in your field.
- Help us recruit the leaders to support your care.

“Testifying against another doctor would violate my ethics, so I’ll have to change mine.”

**Winning Litigation - Prepare**
- Your deposition is the most important day of the lawsuit.
- The other lawyer is going to be prepared.
- Are you?

**Winning Litigation - Attend**
- The only thing you “have” to attend is your own deposition.
- You can attend every proceeding.
- Don’t you want to hear what the patient is saying?
- Don’t you want to look the other expert in the eye?
Winning Litigation - Demonstrate

- Boring!
- Jurors watch CSI.
- If you don’t entertain them as you educate them, you’re in trouble.

Winning Litigation - Defend

- The opposing lawyer is attacking you.
- The jury needs to hear you defend yourself.
- If you won’t stand up for yourself, why should anyone else?

Winning Litigation - Relax

- You can’t let a lawsuit get in the way of practicing good medicine.
- We get paid to worry on your behalf.
- Get help if you need it.
Pediatric Anesthesia Update 2013

Rita Agarwal
Professor of Anesthesiology
University of Colorado

The 10 most frequently asked questions listed in order of frequency among responders

- What is the clinical relevance of neurotoxicity of general anesthetics?
- Does regional blockade improve outcome in children?
- What is the best anesthetic management for children with pulmonary hypertension?
- How do we eliminate emergence agitation?
- What is the optimal intravenous fluid?
- How do pharmacokinetics and pharmacodynamics change with age?
- What is the optimal sedation and analgesia in pediatric intensive care?
- How do we optimize postdischarge pain management?
- How can we use pharmacogenetic information in children?
- What are the long-term consequences of opioid use in children and how can we reduce the side effects of opioids?

Pediatric Anesthesia
22 (2012) 613–615

Anesthesia Effects on the Developing Brain


Anesthesia Before Age 2 May Be Linked With Learning Disabilities Later On

AAP News

Consensus statement reflects mixed picture on anesthetics’ possible link to learning problems

The Huffington Post: Education News

Pediatric Anesthesia Update 2013

100
Volatile and Other Anesthetics

- Young rodents and other animals have shown apoptosis and cell death during critical periods of brain development
- It appears that a very fine balance between neuronal excitation and inhibition in the CNS is crucial, not only for neuronal survival, but for proper maturation and functioning
- Most anesthetics and sedatives increase inhibition

Of Mice and Men

- **Mice**
  - Brain Growth Spurt: first 1-2 weeks of life
  - Anesthetized for 5-6 hours
  - Many unmonitored
  - Pain and surgical stress are harmful

- **Humans**
  - Brain Growth Spurt: prenatal-24 months
  - Equivalent to several days-months
  - Monitored
  - Pain and surgical stress are harmful

3 Editorials in Anesthesiology

  - Large new epidemiologic based study to examine effects of anesthesia exposure in children<3 under way
  - Siblings used as case controls, 1° outcome; global intelligence and specific domain measures etc in late childhood.
SMART TOTs

- Multidisciplinary team of researchers
  - IARS and FDA working in partnership
  - Drs Roizen and Mehmet Oz
  - Sponsoring many ongoing trials investing both animal and human data

- Timing of exposure
- Duration of exposure
- Multiple exposure
- So far human results are mixed

Abstracts form IARS 2011

- LONG-TERM DIFFERENCES IN COGNITIVE AND LANGUAGE ABILITY AFTER EXPOSURE TO SURGERY AND ANESTHESIA IN INFANCY
  - AUTHORS: C. Ing,1 C. DiMaggio,1 A. Whitehouse,2 M. Hegarty,3 A. Davidson,4 L. Y. Sun1
  - A history of anesthesia/surgery before age 3 was associated with an increased risk of clinical language impairment between 1.7 to 2.5 fold and abstract reasoning of 3.4 fold
  - Controlled for gender, birth weight, APGR, race family income and paternal presence at home

Abstracts from IARS 2011

- Wise-Faberowski et al: Volatile versus narcotic anesthetic for surgical repair of congenital heart disease: the effect on postoperative EEG—Infants undergoing surgical repair for CHD have an 85% risk of an abnormal postoperative EEG, abnormalities being diffuse or localized to the right temporal lobe region and are not seizure activity. A narcotic-based anesthetic technique seems to pose less risk for abnormal EEG findings.
- Moran et al. Excitatory and epileptiform EEG activity in human neonates during sevoflurane-based anesthesia—Some neonates undergoing a general anesthetic with sevoflurane have excitatory and even epileptiform EEG activity.
- Wise-Faberowski et al: Volatile versus narcotic anesthetic for surgical repair of congenital heart disease: the effect on postoperative EEG—Infants undergoing surgical repair for CHD have an 85% risk of an abnormal postoperative EEG, abnormalities being diffuse or localized to the right temporal lobe region and are not seizure activity. A narcotic-based anesthetic technique seems to pose less risk for abnormal EEG findings.
- Moran et al. Excitatory and epileptiform EEG activity in human neonates during sevoflurane-based anesthesia—Some neonates undergoing a general anesthetic with sevoflurane have excitatory and even epileptiform EEG activity.

Anesthesia and Outcome After Neonatal Surgery.

- Davidson et al Dec 2008.—GAS study is ongoing
  - Multi-center study of infants undergoing hernia repair randomized to general vs spinal anesthesia
  - At least 598 infants
  - Outcome: IQ at age 5

Selected Abstracts form SMART Tots 2011

- Creagh et al. Early exposure to anesthesia during cesarean delivery as a factor predisposing to autism spectrum disorder: a population based cohort study
  - Early exposure to anesthesia during cesarean delivery is not associated with the development of autism spectrum disorder
- Flick et al. Exposure to anesthesia and attention deficit hyperactivity disorder
  - Exposure to anesthesia is a significant risk factor for development of attention deficit hyperactivity disorder (ADHD) in children receiving multiple, but not single, anesthetics before age 2 y
Recent abstracts

- Flick et al-2 or more anesthetic exposures before age 5 may be associated with specific language and math difficulties—detailed records
- Sun et al-anesthetic prior to age 3 may have an association with learning problems—Medicaid records
- All concede the difficult in differentiating anesthetic effect from underlying medical condition and surgery

Should we wait to anesthetize infants and young children for elective procedures?

Elective procedures and anesthesia in children: pediatric surgeons enter the dialogue on neurotoxicity questions, surgical options, and parental concerns.


Duration of exposure to cranial vault surgery: associations with neurodevelopment in young children with single-suture craniosynostosis


Maternal anesthesia and fetal neurodevelopment


Cognitive and behavioral outcomes after early exposure to anesthesia and surgery


Sevoflurane Anesthesia in Pregnant Mice Induces Neurotoxicity in Fetal and Offspring Mice


Newly Postulated Neurodevelopmental Risks of Pediatric Anesthesia: Theories That Could Rock Our World


SmartTots: a public-private partnership between the United States Food and Drug Administration (FDA) and the International Anesthesia Research Society (IARS)


Neurotoxicity and the Need for Anesthesia in the Newborn: Does the Emperor Have No Clothes?

regardless of whether or not sevoflurane causes any clinically relevant toxicity, is it time to question the mantra that all babies need a hypnotic agent such as sevoflurane?


- We don't know
- Millions of children have been anesthetized over the years with few obvious problems
- Few procedures in the very young are truly elective

Pre-op Anxiety

Streamed Video Clips to Reduce Anxiety in Children During Inhaled Induction of Anesthesia
• Cartoon Distraction Alleviates Anxiety in Children During Induction of Anesthesia
  • Jeongwoo Lee, MD,* Jihye Lee, MD,* Hyungsun Lim, MD,† Ji-Seon Son, MD, PhD,* Jun-Rae Lee, MD, PhD,‡ Dong-Chan Kim, MD, PhD,§ and Seonghoon Ko, MD, PhD§
  • (Anesth Analg 2012;115:1168–73)

Fasting

• Parents’ understanding of and compliance with fasting instruction for pediatric day case surgery.
  • Cantellow S, Lightfoot J, Bould H, Beringer R.
  • During the fasting period, 4.9% would allow French fries, 22.3% toast/crackers, 17.5% cereal, 14.7% a sweet, 14.9% gum, and 12.6% tea with milk.

The 10 most frequently asked questions listed in order of frequency among responders

• What is the clinical relevance of neurotoxicity of general anesthetics?
  • Does regional blockade improve outcome in children?
  • What is the best anesthetic management for children with pulmonary hypertension?
  • How do we eliminate emergence agitation?
  • What is the optimal intravenous fluid?
  • How do pharmacokinetics and pharmacodynamics change with age?
  • What is the optimal sedation and analgesia in pediatric intensive care?
  • How do we optimize post discharge pain management?
  • How can we use pharmacogenetic information in children?
  • What are the long-term consequences of opioid use in children and how can we reduce the side effects of opioids?

Dexmedetomidine

• Potent α2 agonist, sedation and analgesia
  • Being found to be very useful in children for a variety of conditions
    • MRI
    • Sleep endoscopy
    • Premedication
    • PICU sedation
    • Awake intubation
    • ?? Neuroprotective
Dexmedetomidine and OSA

- 2 studies looking at dex in patients undergoing T&A
  - 1ug/kg dex = 100ug/kg morphine
  - No adverse events
  - 2ug/kg bolus + 0.7ug/kg infusion of dex compared to fentanyl 1ug/kg
    - reduced opioid requirements, less emergence agitation, and fewer episodes of desaturation


Effects on Upper Airway

  - 23 patients received low (1ug/kg) or high (3ug/kg) for MRI sedation
  - Minimal changes in upper airway morphology with dex sedation detected on MRI

Intranasal Dexmedetomidine

- Yuen et al. in a series of studies have found 1 mug/kg intranasal dexmedetomidine to be effective in producing sedation in children at ~30 minutes, effects lasting for ~80 minutes.


Other Uses

- Decreases incidence of emergence agitation
- As an adjunct to decrease N&V
- Minimal effects on SSEP and MEP’s, therefore may be used for spine surgery


Other Uses

- Sleep endoscopy—used to simulate sleep for better evaluation of OSA
- Sole or in combination for MRI/CT scan sedation
- Electrocorticography, challenging medical conditions
- Awake craniotomies
- Sedation in multiple locations and for multiple procedures
Side Effects

- Bradycardia and occasionally arrest
- Depresses AV and SA node conduction
- Hypertension with rapid boluses
- Hypo or hypertension (with repeated boluses)
- May be neuroprotective or at least not destructive

**Ketodex, a combination of dexmedetomidine and ketamine for upper gastrointestinal endoscopy in children: a preliminary report.**

**Dexmedetomidine controls junctional ectopic tachycardia during Tetralogy of Fallot repair in an infant.**

**Spinal anesthesia is a valid alternative to other anesthetic approaches for children with neuromuscular disease, and dexmedetomidine sedation is a safe method for pediatric regional anesthesia.**

**Perioperative use of dexmedetomidine is associated with decreased incidence of ventricular and supraventricular tachyarrhythmias after congenital cardiac operations.**

**The effect of dexmedetomidine during myringotomy and pressure-equalizing tube placement in children.**

**Dexmedetomidine use in pediatric airway reconstruction.**

**Dexmedetomidine infusion for analgesia and prevention of emergence agitation in children with obstructive sleep apnea syndrome undergoing tonsillectomy and adenoidectomy.**

The effect of intraoperative dexmedetomidine on postoperative analgesia and sedation in pediatric patients undergoing tonsillectomy and adenoidectomy.

**Dexmedetomidine use in pediatric airway reconstruction.**

**The comparison of the effects of dexmedetomidine and midazolam sedation on electroencephalography in pediatric patients with febrile convolution.**

**High-dose dexmedetomidine sedation for pediatric MRI.**

**The effect of dexmedetomidine during myringotomy and pressure-equalizing tube placement in children.**

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**High-dose dexmedetomidine sedation for pediatric MRI.**

**Ilan Keidan, Erez Ben-Menachem, Sno Ellen White, and Haim Berkenstadt**
**Intravenous Sodium Bicarbonate Verifies Intravenous Position of Catheters in Ventilated Children.**

It is a common clinical problem to be presented with a pediatric patient with IV access for which there is doubt about the usability of the catheter. Vascular access is often bandaged, obscuring clinical assessment, children may not be capable of verbally communicating pain at injection sites, and a “twiddler's syndrome” has been described in which the child manipulates the catheter, causing it to migrate out of the vessel. Additionally, fluid leakage into surrounding tissue may initially go unnoticed owing to the distensibility of subcutaneous tissues in the very young.

TAP block after laparoscopic cholecystectomy may have some beneficial effect in reducing pain while coughing and on opioid requirements, but this effect is probably rather small.

One hundred seventy-one ASA physical status I and II children scheduled for BMT were randomized into 1 of 3 groups: group 1—nasal fentanyl 2 μg/kg with IV and IM saline placebo; group 2—IV morphine 0.1 mg/kg with nasal and IM placebo; or group 3—IM morphine 0.1 mg/kg with nasal and IV placebo.

**RESULTS:** There were no significant differences in peak FLACC pain among the 3 groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Assigned dose (mg/kg)</th>
<th>Trials (n)</th>
<th>Number of patients tested at assigned dose</th>
<th>Observed response rate</th>
<th>PAVA-adjusted response rate</th>
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</tbody>
</table>

**Ketamine the old wonder drug**

**Table 2.** Nonobese: Observed and Pooled-Adjacent-Violators Algorithm (PAVA)–Adjusted Response Rates with Propofol (Isotonic Regression Method).
Ketamine has found many applications in pediatric anesthetic practice. Insights into the mechanism of action and the pharmacokinetics and pharmacodynamics of its isomers have led to a re-evaluation of this drug, expanding the range of applications in children. Ketamine is a remarkably versatile drug that can be administered through almost any route. It can also be used for different purposes.


Most studies show improvement in pain scores and less opioid consumption in first 24 hours
No long term studies

Race and unequal burden of perioperative pain and opioid related adverse effects in children.

Results in adolescents are presented as results for a 70-kg person to allow comparison with adult parameters reported by others. Our study demonstrates that the PK of intranasal ketorolac in adolescents is similar to those reported in adults, assuming use of the same nasal administration device. Administration of ketorolac by the intranasal route resulted in a rapid increase in plasma concentration and may be a useful therapeutic alternative to IV injection in adolescents because plasma concentrations attained with the device are likely to be analgesic.
WHAT’S NEW IN OBSTETRIC ANESTHESIA FROM 2012?

Joy L. Hawkins, M.D.
University of Colorado SOM
(* I have no conflicts to disclose. *)

“If physicians would read two articles per day out of the six million medical articles published annually, in one year, they would fall 82 centuries behind in their reading.”

WF Miser, 1999

GOALS & OBJECTIVES
Participants will internalize and be able to discuss:
1. How emerging research is changing clinical practice and enhancing patient safety.
2. New developments in policies and guidelines, maternal and fetal effects of labor analgesia, and management of cesarean delivery.
4. Evaluation and care of the fetus and newborn.

POLICIES AND GUIDELINES

COST OF CESAREANS
Cesareans cost 50% more than vaginal birth due to longer hospital stay, ↑ maternal cx.
- Medicaid: $13,590 vs. $9,131
- Private insurers: $27,866 vs. $18,329
- Estimated U.S. loss of $5 billion / year
Pay physicians and hospitals to eliminate early deliveries, reduce unnecessary cesareans, prevent complications of birth.
The Hill’s Healthwatch, 1/7/13
CESAREAN MORBIDITY
Is cesarean associated with adverse outcomes in subsequent deliveries?
• ↑ anemia in subsequent births: OR 2.8
• ↑ abruption: OR 2.3
• ↑ uterine rupture: OR 268
• ↑ hysterectomy: OR 29
Counsel patients accordingly.
Am J Obstet Gynecol 2012;206:139

AVOIDING CESAREANS
If a woman expresses an antepartum preference for a cesarean, is she more likely to have one?
• If she preferred CD, 48% later had a cesarean.
• If she preferred VD, only 12% had a cesarean.
• OR 26 for elective cesarean if she expressed a cesarean vs. vaginal delivery preference.
Obstet Gynecol 2012;120:252

AVOIDING CESAREANS
Key points to reduce primary cesarean rate:
1. Inductions only for medical indications.
2. No elective inductions before 39 weeks.
3. Favorable cervix before induction.
4. Adequate time for latent and active labor before diagnosis of “failed induction”.
5. Operative vaginal delivery is acceptable.
Obstet Gynecol 2012;120:1181

AVOIDING CESAREANS
To reduce the rising cesarean rate:
1. Patience and active management of labor.
2. Payment reform (why less $ for VD?).
3. Tort reform (e.g. TOLAC).
4. Patient education about the value of SVD.
5. Reduce elective inductions.
Obstet Gynecol 2012;120:1194

VACCINATIONS
ACOG recommends influenza vaccine, but only 10-24% of pregnant women receive it. When vaccinated in the first trimester:
• No ↑ in malformations, preterm birth or fetal growth restriction.
• ↓ in overall stillbirth rate.
• Risk of Guillain-Barre’ 2/million doses.
JAMA 2012:308:184

VACCINATIONS
A review of 117,347 pregnancies during the 2009 H1N1 pandemic:
• 54% were vaccinated.
• Vaccination ↓ risk of influenza (RR 0.3).
• Risk of fetal death doubled if the mother was diagnosed with influenza.
• Vaccine was not associated with fetal death.
**CONTRACEPTION**

Study: Women received the reversible contraception method of their choice at no cost.
- Superior effectiveness of IUD and implants were emphasized to the patients.
- Abortion rates were less than half the regional and national rates.
- Rate of teen births was 6.3/1000 versus the U.S. rate of 34.3/1000.

Obstet Gynecol 2012;120:1291

**“NORMAL” LABOR**

- Compared to births in 1959-1966, primips in 2002-8 labored 2.6 hours longer
- Mothers are 2.7 years older and heavier (BMI of 24.6 vs 22.6).
- Use of oxytocin and epidurals are more common, while use of forceps is less.
  
  Am J Obstet Gynecol 2012;206:419

**POSTPARTUM STERILIZATION**

ACOG encourages improved access to PPTL for women requesting it; an “urgent” surgery.
- 50% rate of repeat pregnancy in the following year in women who request but do not receive PPTL.
- Limited time to perform the procedure.
- Medicaid has cumbersome consent process compared to private insurance.

Obstet Gynecol 2012;120:212

**“NORMAL” LABOR**

- Inductions vs. spontaneous labor: 2 hours longer until active phase (6 cm).
- Obesity > BMI 30: longer duration and slower progress from 4-6 cm.
- TOL after cesarean: no difference in first-stage labor curves or dilation rate.

Obstet Gynecol 2012;119:732 and 1114
Obstet Gynecol 2012;120:130

**LABOR ANALGESIA**

- Compared to births in 1959-1966, primips in 2002-8 labored 2.6 hours longer
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Obstet Gynecol 2012;120:1291

**NON-DRUG ANALGESIA**

- Methods that clearly work = epidural, CSE, inhaled analgesia, but also most side effects.
- Those that may work = water immersion, relaxation, acupuncture, massage, and LA nerve blocks, with few adverse effects.
- Methods lacking evidence = hypnosis, biofeedback, sterile water injection, aromatherapy, TENS, parenteral opioids

Cochrane Database 2012; CD009234
NITROUS OXIDE ANALGESIA

26 randomized studies of inhaled analgesia:
• Better analgesia with flurane derivatives than nitrous oxide (pain scale Δ 14.4 mm).
• More nausea with nitrous than fluranes (OR 6.6).
• Nitrous oxide more effective than placebo, but ↑ side effects such as N/V, dizziness.
  Cochrane Database 2012; CD009351

NITROUS OXIDE ANALGESIA

Overview of its use for labor analgesia:
• Currently used by 50% of women in the UK, Australia, Finland and Canada.
• Little effect on pain scores, but most women find benefit and wish to continue or use again.
• No adverse neonatal effects, no effect on uterine contractility.
• Neurotoxicity? Environmental pollution?
  www.soap.org / Summer 2012 Newsletter

REMITFENTANIL

Retrospective review of remifentail versus fentanyl IV PCA for labor (98 women):
• No difference in pain scores.
• No difference in side effects.
• More desaturation with R: 13% vs 2% (OR 7).
• More neonates needed resuscitation with F: 59% vs 25% (OR 4).
• Cost difference??
  Can J Anesth 2012;59:246

DEEXMEDETOMIDINE

Pregnant ewe study using 1 μg/kg/hour:
• Sedation but no respiratory depression.
• ↓ maternal BP and heart rate.
• No effect on fetal BP, heart rate or cerebral oxygenation.
• Maternal and fetal glucose increased.

FATHERS

84 couples were studied to see if partner presence reduced maternal anxiety during epidural placement (father-in vs. father-out).
• There was no difference in maternal anxiety scores at baseline.
• Pain scores during epidural placement were higher in the father-in group.
• After epidural placement, mothers in the father-in group had higher anxiety scores.
  Anesth Analg 2012;114:654

EPIDURAL FAILURES

Reasons for inadequate analgesia/anesthesia:
• Incorrect primary placement
• Secondary migration after correct placement
• Failure to use adequate LA concentration; choice of LA doesn’t matter.
• Inadequate use of adjuvants, especially opioids and epinephrine
• PCEA + background may be best for postop
  Br J Anaesth 2012;109:144
EPIDURAL FAILURES

Risk factors for failed conversion of labor analgesia to cesarean anesthesia:
1. More clinician top-ups during labor
2. Urgency of the cesarean (OR 40)
3. Non-obstetric anesthesiologist providing care (OR 4.6)
4. Not a risk: CSE vs. epidural, duration of epidural, dilation at placement, BMI


EVALUATING HEMOSTASIS

How does the TEG change during pregnancy and postpartum?

- Samples were taken from 45 healthy pregnant women in all 3 trimesters, at term, and 8 weeks postpartum.
- ↑ coagulability and ↓ fibrinolysis throughout pregnancy.
- ↓ R value, ↓ K, ↑ angle, ↑ MA

Anesth Analg 2012;115:890

“BEST” ASEPTIC PRACTICES

300 anesthesia providers were randomized to 3 hand-washing techniques:
1. Soap + sterile towel → 25% bacterial growth
2. Soap + sterile towel and alcohol gel → 16% bacterial growth
3. Alcohol gel alone → 4% bacterial growth

Can Anesth Society 2012; A1344599

“BEST” ASEPTIC PRACTICES

Chlorhexidine is not FDA-approved for use before neuraxial anesthesia for lack of safety evidence. BUT ASA and ASRA guidelines recommend its use.
- Review of 12,465 spinal anesthetics over 5 years that had chlorhexidine skin prep.
- 0.04% had neurologic complications felt related to the spinal anesthetic- all resolved.
- Incidence was no different than previous reports using Betadine.

Reg Anesth Pain Med 2012;37:139

CESAREAN ANESTHESIA

“NATURAL CESAREAN”

How can we make a cesarean (now 35% of deliveries) more “natural” and family-centered?
- Early skin-to-skin contact in the OR
- Slow delivery to mimic “vaginal squeeze”
- IV, oximeter, BP cuff on the non-dominant arm to facilitate holding her baby
- ECG leads on the back for breast-feeding
- Clear surgical drapes

Anesth Analg 2012;115:981
**SURGICAL INFECTION**

What interventions to prevent surgical site infections after cesarean are most effective?

- Administration of antibiotics within one hour of incision was associated with a 48% reduction in postop infections.
- ↑ BMI, ↑ hypertension, ↑ preeclampsia all ↑ infection rates.
- Banning artificial nails and improving O.R. cleaning had no effect on SSI.

Obstet Gynecol 2012;120:246

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**HYPOTENSION**

Do we miss hypotensive events using intermittent BP measurements? Does it matter to mother or fetus?

- Continuous non-invasive pressures were compared to BP cuff (N=888)
- Hypotension was detected in 91% of continuous and 55% of BP cuffs
- Cord pH was lower when BP < 100 mmHg

Br J Anaesth 2012;109:413

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**HYPOTENSION**

Does preop anxiety influence hypotension?

- 100 parturients were given anxiety scores prior to elective cesarean under spinal
- Patients scoring high on anxiety scales had significantly more hypotension and required more pressors
- No difference in neonatal outcomes

Br J Anaesth 2012;109:943

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**HYPOTENSION**

How does bolus phenylephrine (P) compare to continuous infusion (120 μg/min) after spinal?

- Non-invasive cardiac outputs were no different between groups.
- Infusions received more P: 1740 vs. 964 μg.
- Infusion group had lower BP’s in the first 6 minutes after spinal injection.
- No outcome benefits to using an infusion.

Anesth Analg 2012;115:1343
**PHENYLEPHRINE**

Two excellent reviews on the use of phenylephrine versus ephedrine for treatment of hypotension after regional anesthesia in obstetric patients:
- "Why Question Established Practice?" Anesthesiology 2012;117:1348-51

**DIFFICULT AIRWAY**

Comparison of awake fiberoptic intubation vs. awake video-laryngoscopy in 84 non-obstetric patients with anticipated difficult airways:
- Same topicalization and sedation used
- No difference in time to intubation, success on first attempt, ease of intubation, or patient assessment of discomfort.
- Good alternative for emergencies or when fiberoptic scope not available (most L&Ds?)
  Anesthesiology 2012;116:1210

**CONTINUOUS SPINAL**

*Case report:* During attempted epidural placement for cesarean and possible hysterectomy for placenta accreta, wet tap occurred. Converted to CSA. Placenta increta → hysterectomy → 8L blood loss → 37 units blood products → stable hemodynamics but conversion to GETA for pulmonary edema. Ventilated for 18 hours and did well.
  Can J Anesth 2012;59:473

**AIRWAY MANAGEMENT**

Healthy 44-yr old is NPO for termination of a 21-week pregnancy due to fatal anomalies. Is intubation mandatory?
- Pregnancy does not delay gastric emptying.
- LES pressure may be lower, but 2nd trimester similar to oral contraceptive effect.
- Pregnancy is not an independent risk factor for aspiration (J Clin Anesth 2006;18:102).

**DIFFICULT AIRWAY**

Review of obstetric tracheal intubations:
- 157/163 direct laryngoscopies successful on first attempt; 1 failure
- Failure rescued with video-laryngoscopy
- 18/18 video-laryngoscopies successful
- Providers chose the video-scope for emergencies, predicted difficult intubation.
  Anesth Analg 2012;115:904

**GENERAL ANESTHESIA**

A review of 533 term babies S/P emergent cesarean for fetal compromise:
- GA = more likely to have Apgar < 7 (OR 6.9), need bag/mask ventilation for > 60 seconds (OR 2.3), and to be admitted to neonatal ICU (OR 2.2)
- *Despite* 8 minutes faster incision-to-delivery times than regional techniques
  ANZJOG 2012;online 6/8/12
GENERAL ANESTHESIA
~ 80K cesarean deliveries analyzed for risk factors for postpartum hemorrhage:
• Emergency (3.2%) > planned (1.9%)
• General anesthesia ↑ risk (OR 2.7)
• Other risks as expected: twins, previa, macrosomia, failed induction or arrest of labor, abruption, anemia, HELLP.
   Am J Obstet Gynecol 2012;206:76

TAP BLOCKS
A series of 5 patients used TAP catheters for post-cesarean analgesia.
• Repeated boluses of local anesthetic maintained good analgesia
• Multi-modal when combined with oral acetaminophen and ibuprofen
• Labor-intensive, and high levels of local anesthetic are a potential concern

TAP BLOCKS
Defn: field block for abdominal surgery.
• Meta-analysis of 5 trials, 312 patients
• ↓ in IV morphine consumption by 24 mg over the first 24 hours postop
• ↓ opioid-related side effects
• No difference vs. spinal morphine
   Br J Anaesth 2012;109:679

TAP BLOCKS
Blind technique versus ultrasound-guided?
• After placement of TAP blocks using a landmark technique, US was used to record the needle position and spread of LA.
• Study terminated early due to high number of peritoneal needle placements (18%)
• Correct placement occurred in only 24%
   Br J Anaesth 2012;108:499

TAP BLOCKS
Randomized trial of TAP blocks versus intrathecal morphine 100 μg.
• TAP group required more morphine supplementation but had fewer opioid side effects
• Conclusion: Use TAP blocks when spinal morphine is contraindicated or unavailable.

WOUND INFUSION
Randomized trial of 48 hours of continuous infusion of ropivacaine in the wound vs. epidural morphine 2 mg every 12 hours.
• ↓ pain scores in the infusion group: 0 vs. 3
• Less nausea, vomiting, pruritus and urinary retention in the infusion group
• Fewer nurse visits for pain management in the infusion group: 1 versus 8
   Anesth Analg 2012;114:179
**HYPOTHERMIA**

Case report and review of 20 cases of severe hypothermia after spinal morphine:

- Patients complain of feeling warm, sweating, nausea
- Lowest temp 33-34 degrees C lasting 2-22 hours
- Reversed by lorazepam; mechanism?

Can J Anesth 2012;59:384

**METOCLOPRAMIDE**

Meta-analysis of 11 studies, 702 patients to prevent N/V after cesarean delivery:

- 10 mg given before block placement
- ↓ intraoperative nausea (RR 0.27) and vomiting (RR 0.14)
- ↓ postoperative nausea (RR 0.47) and vomiting (RR 0.45)
- No extra-pyramidal side effects seen

Br J Anaesth 2012;108:374

**DEXAMETHASONE**

Meta analysis of using dexamethasone to prevent nausea/vomiting in women undergoing laparoscopy for gyn surgery:

- 13 RCT with 1695 patients
- ↓ nausea (RR 0.56) and vomiting (RR 0.35)
- ↓ need for rescue anti-emetics
- ↓ time to meet discharge criteria
- No increase in adverse events

Obstet Gynecol 2012;120:1451

**ANESTHETIC COMPlications**

**DEXAMETHASONE**

Is dexamethasone effective at preventing N/V in women after neuraxial morphine?

- Meta analysis of 8 RCT, 768 patients
- Doses ranged from 2.5 mg to 10 mg
- ↓ nausea (RR 0.57), vomiting (RR 0.56), use of rescue anti-emetics (RR 0.47), but not pruritus
- ↓ pain scores and rescue analgesics (RR 0.72)

Anesth Analg 2012;114:813

**CPR IN PREGNANCY**

Simulated cardiac arrest exams for Board certification in Israel:

- Non-pregnancy related ACLS done well.
- Areas of deficiency related to pregnancy included LUD (performed by only 68%), cricoid pressure (48%), preparing for cesarean (40%).

Anesth Analg 2012;115:1122
CPR IN PREGNANCY

Protocols for L&D emergencies such as cardiac arrest should be specific to maternal-fetal issues.

- Obstetric providers are not trained to manage the specifics of maternal cardiac arrest.
- The Obstetric Life Support (OBLS) program is described as multidisciplinary, simulation-enhanced, obstetric crisis training.
- It may be comparable to development of NRP (the Neonatal Resuscitation Program).

Sem Perinatol 2011;35:74

Case report: Previously healthy 33 yr old woman at 20 weeks gestation suffered cardiac arrest at church. Bystander CPR was performed → spontaneous circulation after 25 minutes → transported to hospital with GCS 3 → therapeutic hypothermia instituted → recovery with mild amnesia, EF 25% → AICD.

- Uneventful delivery at 39 weeks.
- At 3 years of age her child has normal development and neurologic function.

Ann Emerg Med 2012

CARDIAC COMPROMISE

Case report: Induction at 37 weeks for cardiac decompensation due to bicuspid aortic valve and subaortic membrane. LV outflow gradient 80 mmHg. Uneventful low-dose epidural analgesia, but phenylephrine infusion needed to maintain BP. Cyclic variations of maternal heart rate developed with contractions while patient was supine, due to ↓ preload.

Anesthesiology 2012;117:879

HEADACHE

Using the Nationwide Inpatient Sample, 639 cases of subarachnoid hemorrhage associated with pregnancy were identified.

- Incidence: 5.8 per 100,000 deliveries
- 67% occurred postpartum, 10.3% died (low)
- Demographics: older mothers, AA race, higher rates of hypertensive disorders (40% of cases), coagulopathy, substance abuse, SS disease, intracranial venous thrombosis, hypercoagulability.

Anesthesiology 2012;116:324

Case report: Inadvertent dural puncture during epidural placement was followed by a positional PDPH. Blood patch provided only partial relief. Headache gradually became non-positional and associated with pain and paresthesias in her lower extremities. CT → bilateral subdural hematomas, managed conservatively with daily CT scans.

Can J Anesth 2012;59:389
HEADACHE

Case report: Labor epidural was complicated by dural puncture, and epidural placed at another interspace when intrathecal catheter would not pass. She had excellent analgesia for labor but complained of back and left lower extremity pain during and after labor. No motor, bowel or bladder deficits. MRI → acute spinal subdural hematoma. Resolved over 48 hours without surgery.

Anesthesiology 2012;117:178

HEADACHE

RCT of intrathecal catheter versus repeat epidural after wet tap (only 97 cases).
- No difference in incidence of PDPH
- 16g Tuohy doubled the risk over 18g
- SVD > risk than cesarean (RR 1.58)
- ↑ risk of difficult placement and 9% risk of second wet tap if epidural repeated – worth the risk?


HEADACHE

40 parturients with known wet tap using 17g Tuohy were followed at 12 and 24 months to assess headache and back pain. Compared to controls (no wet tap):
- 28% had chronic headache vs. 5%
- More likely to report chronic back pain (OR 7), but no association with blood patch.
- Pathophysiology and best treatment unknown.

Anesth Analg 2012;115:124

SURGERY IN PREGNANCY

Self-reported occupational exposures during pregnancy from 7482 nurses in the Nurses’ Health Study II were used to investigate the risk of spontaneous abortion:
- 10% had spontaneous abortions < 20 weeks
- Exposure to anti-neoplastic drugs and sterilizing agents was associated with doubled risk.
- There was no association of early or late abortion with x-ray radiation or anesthetic gases.

Am J Obstet Gynecol 2012;206:327
LOCAL ANESTHETIC TOXICITY

ASRA and APSF emphasize that treatment of LAST is different than other cardiac arrest scenarios:

- AVOID vasopressin, calcium channel blockers, beta blockers, local anesthetics
- REDUCE each epinephrine dose to < 1 μg/kg
- Use lipid emulsion 20% 1.5 ml/kg over 1 min

APSF Newsletter 2012;13

LOCAL ANESTHETIC TOXICITY

Lipid emulsion has been used to treat:

- Ropivacaine, bupivacaine toxicity
- Many other lipophilic drugs: haldol, tricyclics, beta-blockers, calcium channel blockers, and others
- Anesthesiologists should consider use of Intralipid in other resuscitation situations

Anesthesiology 2012;117:180

MATERNAL MORTALITY

10 “clinical diamonds” to prevent maternal death:

1. A pregnant patient reporting acute chest pain needs an immediate spiral CT.
2. A patient with preeclampsia and SOB needs an immediate chest x-ray + pulse oximetry.
3. A hospitalized patient with preeclampsia needs an IV anti-hypertensive within 15 minutes for BP > 160 systolic or 110 diastolic.

4. Uterine embolization is not meant to be used for acute, massive postpartum hemorrhage.
5. Any patient with structural or functional cardiac disease gets an MFM consult.
6. If more than 1 dose of medication is needed to treat uterine atony, go to the patient’s bedside until the atony has resolved.
7. Never treat “postpartum hemorrhage” without also pursuing an actual clinical diagnosis.

OBSTETRIC COMPLICATIONS
8. In the postpartum patient who is bleeding or recently stopped bleeding and is oliguric, furosemide is not the answer.
9. Any woman with placenta previa and 1 or more cesarean deliveries should be delivered at a tertiary care medical center.
10. If your labor and delivery unit does not have a recently updated massive transfusion protocol based on established trauma protocols, get one today.

Obstet Gynecol 2012;119:360

NEAR-MISSES
CDC review of severe morbidity rates for delivery and postpartum hospitalizations:
• Rates have ↑ over 10 years by 75% for delivery and 114% for postpartum events.
• ↑ rates of blood transfusion, acute renal failure, shock, acute MI, ARDS, aneurysms, and cardiac surgery.
• Overall mortality ↑ in U.S. vs. other countries.

Obstet Gynecol 2012;120:1029

MATERNAL MORTALITY
CDC compared causes of pregnancy-related mortality by race / ethnicity.
• Minority women are 41% of the population but 62% of the deaths.
• U.S.-born black women = 5.2 times higher.
• Foreign-born blacks = 3.6 times higher.
• Causes and timing of deaths were similar.

Obstet Gynecol 2012;120:261

NEAR-MISSES
As a surrogate for a near-miss, characteristics of mothers admitted to ICU were examined:
• 87% admitted postpartum
• African-American > other races, but no differences in outcomes.
• Leading diagnoses: cardiac disease (36%), hemorrhage (29%), sepsis (9%).

Obstet Gynecol 2012;119:250

HYPERTENSION
ACOG Practice Bulletin #125:
• ACE inhibitors and angiotensin receptor blockers are contraindicated in all trimesters of pregnancy → teratogenicity.
• Avoid atenolol (IUGR) and diuretics.
• Treat severe hypertension; labetalol is a good first-line option.
• Follow maternal end-organ involvement and fetal growth restriction by ultrasound.

Obstet Gynecol 2012;119:396
### HYPERTENSION

Does thyroid function affect incidence of hypertension? Incidence of HTN:
- Euthyroid → 8.5% had HTN
- Subclinical hyperthyroid → 6.2%
- Subclinical hypothyroid → 10.9%
- OR 1.6 for hypothyroidism and severe preeclampsia (p=.03).
  Obstet Gynecol 2012;119:315

### HYPERTENSION

What is the best route of delivery for eclampsia ≥ 34 weeks?
- 200 eclamptic patients were randomized to vaginal delivery or C/S; analyzed with intent-to-treat.
  - Maternal events: 11% C/S vs. 7% VD (NS)
  - Newborn events: 10% C/S vs. 19% VD (NS)
  Am J Obstet Gynecol 2012;206:484

### HYPERTENSION

Can ratios of sFlt-1 : PI GF identify women with preeclampsia who need to be delivered vs. other forms of HTN?
- Women with PEC had higher ratios than gestational HTN or chronic HTN.
- Highest sFlt-1 (anti-angiogenic) : PI GF (pro-angiogenic) ratios had significantly reduced time to delivery (p<.001)
  Am J Obstet Gynecol 2012;206:58

### HYPERTENSION

Case report: 25-year old G1 presented with severe preeclampsia and IUFD. Platelets 12K, Hct 23%, 4+ proteinuria, and ↑ LFTs. She was induced and delivered a stillborn vaginally. Postpartum she deteriorated with acidosis, hyperglycemia, and hypoxemia → cardiac arrest and death. Autopsy → acute necrotizing pancreatitis due to severe preeclampsia.
  Obstet Gynecol 2012;120:453

### HYPERTENSION

Method to diagnosis ↑ ICP in preeclampsia:
- 26 pre-eclamptic and 25 healthy pregnant women had ultrasound measurements of their optic nerve sheath diameter
  - Diameter was significantly greater in PEC but normalized after the 3rd PP day.
  - 20% of the pre-eclamptic patients had measurements compatible with ICP > 20.
  Anesthesiology 2012;116:1066

### HYPERTENSION

Hepatic rupture occurs in 2% of HELLP syndrome cases. A series of 9 cases:
- Hepatic artery embolization was used in 7(78%) vs. 6% in the literature.
- Maternal mortality 0%, fetal mortality 30% vs. 17% and 38% in the literature.
- Need early diagnosis; consider embolization.
  Obstet Gynecol 2012;119:617
**HYPERTENSION**

Review of the anesthesiologist’s role in co-managing patients with preeclampsia:
- IV labetalol or hydralazine if > 160/110
- MgSO4 to prevent and treat seizures
- Treat pulmonary edema no differently
- Regional analgesia/anesthesia is best
- Postpartum—analgesia, thromboprophylaxis

Anaesthesia 2012;67:1009

**HEMORRHAGE**

ACOG Committee Opinion: Placenta Accreta
- Greatest risk with previous cesarean plus placenta previa
- Ultrasound is sensitive (77-87%) and specific (96-98%)
- Consider transfer to a tertiary care center
- Delivery at 34 weeks after steroids, no amnio
- Planned hysterectomy with placenta left in situ

Obstet Gynecol 2012;120:207

**HYPERTENSION**

Risk factors for continued / chronic hypertension after preeclampsia:
- 17% continue to be hypertensive
- Related to obesity, ↑ insulin levels, ↑ LDL, micro-albuminuria, family history of hypertension (RR 3.7), and delivery before 34 weeks gestation.
- OR 4.3 for recurrence in pregnancy

Obstet Gynecol 2012;120:311

**HEMORRHAGE**

Trends of peripartum hysterectomy, 1994-2007:
- Overall rate ↑ 15%, largely explained by the increasing rates of 1st and repeat cesareans.
- Hyst for abnormal placentation ↑ 1.2-fold
- Hysterectomy for atony ↑ 4-fold after repeat CD, 2.5-fold after primary cesarean, and 1.5-fold after vaginal delivery.

Am J Obstet Gynecol 2012;206:63

**HEMORRHAGE**

What is the uterine pathology after hysterectomy for intractable atony?
- 1.7% rate of emergent peripartum hyst; 34% were for intractable atony
- Atony cases were more likely at term, had clinical chorioamnionitis, and had longer labors (8 hours vs. 2.5 hours)
- Path → acute inflammation and infection

Obstet Gynecol 2012;119:1137
HEMORRHAGE
What lab test(s) predict severity of bleeding?
• 738 women with PPH after VD
• Severe = drop in Hgb ≥ 4, transfusion of PRBC, embolization, ICU admit or death.
• Average fibrinogen at diagnosis of PPH=420
• OR=1.9 for severe PPH if fibrinogen 200-300 and OR=12 if fibrinogen < 200.
  Br J Anaesth 2012;108:984

HEMORRHAGE
What is the optimal dose of oxytocin to prevent hemorrhage after vaginal delivery?
• Blinded RCT compared 10, 40, 80 units in 500 ml over 1 hour after delivery.
• No difference in atony or hemorrhage.
• 80 unit group had less need for further oxytocin (RR 0.41) and fewer falls in Hct > 6% (RR 0.83)
  Obstet Gynecol 2012;119:293

HEMORRHAGE
Incidence of fever after misoprostol (Cytotec®) to prevent PPH:
• Sublingual 15%, oral 11%, rectal 4%
• Overall RR=5 compared with placebo or other oxytocics
• Highest incidence with high-dose sublingual route
  Obstet Gynecol 2012;120:1140

HEMORRHAGE
Case report: G8P2 had urgent cesarean for abruption → atony → transfusion but ongoing coagulopathy → 5 mg rFVIIa with resolution. Later that day she developed shortness of breath, tachycardia and oxygen saturation 80%. CT → pulmonary emboli, but no DVT on US so presumed due to the Factor VII. She recovered with anti-coagulation.
  J Clin Anesth 2012;508

HEMORRHAGE
Case report: G10P8 had emergency cesarean for previa, and increta was found. Massive transfusion → continued bleeding → emergency embolization of main iliac artery trunks using Gelfoam. Bleeding resolved. After extubation POD#2, she complained of buttock pain, incontinence and paraplegia. Required extensive debridement of buttock necrosis. Bilateral lumbosacral plexopathies with denervation partially resolved over 8 months.
  Obstet Gynecol 2012;120:468

HEMORRHAGE
Nationwide Inpatient Sample (NIS) database was searched for any association between race / ethnicity and the risk of PPH due to post-partum uterine atony. Relative to Caucasian:
• Hispanic had ↑ risk, OR 1.2.
• Asian / Pacific Islander had ↑ risk, OR 1.3.
• Gene expression or genetic polymorphisms?
  Anesth Analg 2012;115:1127
HEMORRHAGE
Use of a massive transfusion protocol in obstetrics; a 3-year review:
• Activated in 0.25% of deliveries
• 61% CD, 32% VD, 7% D&E
• Median EBL 2842 ml (800-8000 ml)
• Median 3 PRBC, 3 FFP, 1 U platelets
• 61% to ICU and 19% hysterectomy

UTERINE RUPTURE
What is the risk of rupture with induction in women attempting TOLAC?
• If cervical exam favorable for induction, no different than spontaneous labor.
• Initial unfavorable cervical exam associated with ↑ risk (RR 4).
• Restrict induction for TOLAC to patients with a favorable cervical exam.
  Am J Obstet Gynecol 2012;206:51

HEMORRHAGE
Cochrane evidence: Is a lower vs. higher Hgb transfusion threshold best to minimize transfusion and adverse outcomes in acute care settings?
• A Hgb threshold of 7-8 g/dl is associated with fewer PRBC transfused without adverse associations with mortality, cardiac morbidity, functional recovery or length of hospital stay.
  JAMA 2013;309:83

UTERINE RUPTURE
Is the rupture and accreta risk higher with prior myomectomy vs. classical cesarean delivery or low transverse incision?
• GA at delivery: 37.3 wks myomectomy, 35.8 wks prior classical vs. 38.6 wks LCT
• No ↑ risks after prior myomectomy
• Prior classical incision had ↑ rupture (OR 3.23) and ↑ accreta (OR 2.09)
  Obstet Gynecol 2012;120:1332

UTERINE RUPTURE
How does decision-to-delivery time affect neonatal outcome with uterine rupture?
• Frequency of rupture during TOLAC = 0.32%
• 75% presented with fetal signs, 25% with maternal signs only
• Good outcome: mean time to delivery = 16 min; no pH < 7 if delivered in < 18 minutes
• Bad longterm outcome if delivery > 30 min
  Obstet Gynecol 2012;119:725
**AMNIOTIC FLUID EMBOLISM**

**Case scenario:** G4P3 underwent several version attempts using epidural analgesia, followed by seizure, cardiac collapse, and uterine atony with hemorrhage and coagulopathy. She was successfully resuscitated, neuro intact.

- **Ddx:** Pathophysiology
- **Clinical course:** Diagnosis
- **Risk factors:** Management

**Anesthesiology 2012;116:186**

**INTRAOP EMBOLUS**

**Case report:** 40 yr old G7P1 for term elective repeat cesarean. PMH: Factor V Leiden mutation, on heparin until 36 hours preop. During uterine closure, asystole → CPR → TEE showed pulmonary embolus and RV strain and dilation → cath lab for clot lysis with tPA → successful clot removal but profuse vaginal and incisional bleeding → bilateral uterine embolization → hysterectomy → full recovery.

**J Clin Anesth 2012;24:582**

**AMNIOTIC FLUID EMBOLISM**

**Case record:** Multiparous woman with known previa was admitted at 36 weeks for bleeding. Emergency cesarean was uncomplicated, but 20 minutes postpartum she reported chest pain and had cardio-respiratory collapse with PEA. TEE → dilated RA, severe TR, D-shaped LV with small cavity. Placed on ECMO. Required dialysis. Discharged from ICU after 13 days. She and baby are healthy 1 year later.

**N Engl J Med 2012;367:2528**

**SEPTIC SHOCK**

**Clinical Expert Series:**
- Incidence: 0.01% of deliveries
- Etiology: pyelonephritis, septic abortion, chorioamnionitis or endometritis, pneumonia, necrotizing fasciitis
- 28% mortality
- Early goal-directed therapy: antibiotics, resuscitation, hemodynamic management.

**Obstet Gynecol 2012;120:689**

**SEPTIC SHOCK**

**Review article:** Sepsis in obstetrics.
- Resuscitation bundle: measure serum lactate, obtain cultures, administer broad-spectrum antibiotics in 1 hour, fluid resuscitate + pressors / inotropes as needed, CVP 8-12 mmHg, maintain oxygenation and ventilate as necessary.

**Int J Obstet Anesth 2012;21:56**
**SEPTIC SHOCK**

Case record: G1 had cesarean after 34 hours of labor with clinical chorio. Postpartum developed fever, dyspnea, tachycardia with EF 38%. Remained ill on broad-spectrum antibiotics with incisional drainage → endometrial abscess on CT → total hysterectomy → serial debridements for necrotizing soft tissue infection → Sweet’s Syndrome treated effectively with steroids.


**OBESITY**

RCT of 3 groups: exercise begun at 13 weeks, exercise begun at 20 weeks and control (no supervised exercise).
- Physical fitness improved in previously sedentary women.
- No difference in newborn birth weights.
- No association with preeclampsia, IUGR, SGA, or uterine blood flow.

Obstet Gynecol 2012;120:302

**CARDIOMYOPATHY**

State review of incidence and outcome:
- Incidence 1 in 2000-2800 live births
- Case fatality rate 16.5% (1 in 6 women died from their cardiomyopathy).
- Highest prevalence > age 35
- Black women 4x higher prevalence
- Main symptoms = dyspnea, fatigue

Obstet Gynecol 2012;120:1013

**OBESITY**

36% of adult women in the U.S. are obese.

JAMA 2012;307:491

Meta-analysis of interventions in pregnancy on maternal weight and obstetric outcomes:
- Both diet and exercise reduce weight gain.
- No differences in birth weights, SGA or LGA
- Dietary interventions → most effective, with improved pregnancy outcomes (e.g. ↓ PEC).

BMJ 2012;344:e2088

**CARDIOMYOPATHY**

Case report: Healthy G1 had uncomplicated cesarean under spinal anesthesia. 6 hours postpartum became hypotensive, tachycardic and febrile. TTE → well-filled LV with EF < 10%, no PE or evidence of MI. Changed management from fluid resuscitation to inotropes, diuresis, ACE therapy in the ICU. Recovered to NYHA class II by discharge.

Anesth Analg 2012;115:1033

**SLEEP APNEA**

Comparison of outcomes of pregnant women with OSA vs. without:
- More low birth weight babies, OR 1.76
- More preterm birth, OR 2.31
- More SGA babies, OR 1.34
- Higher C/S rate, OR 1.74
- Greater incidence of preeclampsia, OR 1.60

SLEEP APNEA
Prospective screening for OSA in obese pregnant women using overnight sleep studies:
• Prevalence 15.4%
• OSA group had higher BMI (47 vs. 38)
• More chronic hypertension (56% vs. 32%)
• ↑ incidence of cesarean (65 vs. 33%), pre-eclampsia (42 vs. 17%) and NICU admission (46 vs. 18%)
Obstet Gynecol 2012;120:1085

SLEEP APNEA
Does pregnancy-onset snoring predict hypertension vs. chronic snoring?
• 34% of women reported snoring, 25% had onset during pregnancy
• New onset snoring – not chronic - predicted gestational HTN (OR 2.36) and pre-eclampsia (OR 1.59)
Am J Obstet Gynecol 2012;207:487

CANCER TREATMENT
21-year review of L&D management of women with cancer in a tertiary center:
• Incidence 0.1%, equally diagnosed before and during pregnancy
• 75% received regional for labor, 22% received general for cesarean
• Life-threatening cx with mediastinal tumors or metastases
Int J Obstet Anesth 2012;24:524

CANCER TREATMENT
Should aggressive chemo be used when breast cancer is diagnosed during pregnancy?
• 10 women received dose-dense and 99 received conventional chemotherapy
• No difference in birth weight, GA at delivery, IUGR, anomalies, maternal or fetal neutropenia.
Obstet Gynecol 2012;120:1267

PREGNANT DIAGNOSIS
Several labs reported the ability to sequence the fetal genome from a maternal blood sample and to detect trisomy 21, 18, 13, and monosomy X cases with 100% sensitivity and specificity. No further need for amniocentesis or chorionic villus sampling?
Obstet Gynecol 2012;119:890
Nature 7/4/12
ASSISTED CONCEPTION
Should women over 40 have more embryos transferred than younger women?
- Odds of live birth were ↑ in women > 40 when 2 embryos were transferred (OR 3.12)
- OR was smaller for women < 40
- Livebirth rates did not ↑ with transfer of 3 embryos, but risk of adverse perinatal outcomes did increase.
Lancet 2012;379:521

TOLERANCE TO THE FETUS
- A possible cause of recurrent miscarriage is rejection of the fetus by the maternal immune system.
- In animal studies, pregnancy-induced regulatory T cells recognize paternal antigens and suppress maternal effector T cells.

FETAL SURGERY
Fetal endoscopic tracheal occlusion is used to treat severe CDH.
- ↑ survival: 54% vs. 5%
- Resulted in improvement in fetal lung size and pulmonary vascularity
- Response 4 weeks after occlusion can predict neonatal survival.
Obstet Gynecol 2012;119:93

FETAL SURGERY
Case report: Fetus with an oral teratoma required EXIT procedure at 25 weeks due to preterm labor. Under general anesthesia, fetus underwent bronchoscopy and tracheostomy while on placental circulation. Delivery and resection followed. The mother was discharged after 4 days.
Obstet Gynecol 2012;119:466
PRETERM LABOR

ACOG Practice Bulletin #127:
- Give steroids if 24-34 weeks gestation.
- Give magnesium sulfate < 32 weeks for fetal neuroprotection.
- Give β-agonist, calcium channel blockers or NSAIDs → allows 48 hours for steroids.
- Further tocolytics, antibiotics, bedrest and hydration are not effective.

Obstet Gynecol 2012;119:1308

Comparing nifedipine to placebo for maintenance tocolysis after first 48 hours:
- Blinded RCT of 406 women
- Average GA at randomization = 29 weeks
- No difference in any adverse perinatal outcome → no benefit to further tocolysis
  JAMA 2013;309:41

PRETERM LABOR

Comparing nifedipine to atosiban for tocolytic efficacy and tolerability:
- At 48 hours, 69% of atosiban and 52% of nifedipine patients were undelivered and did not require a rescue agent (P=.03)
- GA at delivery: 35.2 (A) vs. 36.4 (N), P=.01
- No difference in birth weight or morbidity

Obstet Gynecol 2012;120:1323

PRETERM LABOR

ACOG Practice Bulletin #127 (continued):
- Further tocolytics, antibiotics, bedrest and hydration are not effective.

Obstet Gynecol 2012;119:1308

PRETERM BIRTH

ACOG Practice Bulletin #130:
- Leading cause of neonatal mortality.
- More survivors on the cusp of viability (~24 weeks), but also more disabilities.
- Multiple births have ↑ risk.
- Vaginal progesterone for at-risk women is the main modern treatment – not tocolytics or cerclage.

Obstet Gynecol 2012;120:

PRETERM BIRTH

Which mode of delivery is best for preterm (< 34 weeks) SGA babies?
- Database review of singleton, live-born, vertex neonates 25-34 weeks with IUGR
- 42% delivered vaginally, 58% cesarean
- No difference in any outcome except ↑ RDS in cesarean babies.

Obstet Gynecol 2012;120:560
**PRETERM BIRTH**
Using data from the randomized magnesium neuro-protection study, 29 SNPs associated with neuroprotection were evaluated.
- Odds of CP were increased 2.5 times for each copy of VIP allele
- Odds of CP were increased 4.5 times for each copy of NMDA 3A allele
Obstet Gynecol 2012;120:542

**PRETERM BABIES**
• 90% drugs administered to preterm babies in the NICU are not approved by the FDA.
• NICU babies often receive > 60 drugs.
• No new meds have improved outcome since steroids and surfactant 20 years ago.
• How to create safe harbors for industry liability and engage them in studies of new and existing drugs?
JAMA 2012;308:1435

**PRETERM BABIES**
Follow-up to an early CPAP vs. surfactant and low versus high oxygen saturation study:
- 990 surviving infants were examined at 18-22 months of age
- Death or neuro disability in 29% of CPAP vs. 30% of surfactant (p=0.38)
- Death or disability in 30% of low oxygen vs. 27.5% of high oxygen (p=0.21)

**PRETERM BABIES**
Do fresh (<7 days) vs. older RBC’s affect infection or organ dysfunction in preterm NICU babies requiring transfusion?
- 77.7% vs. 77.2% had infection (NS)
- 67.5% vs. 64.0% had + cultures (NS)
- 52.7% vs. 52.9% had composite of other morbidities (NS)
JAMA 2012;308:1443

**TERATOGENICITY**
Database of women with singleton births who used SSRI’s during pregnancy, 1996-2007:
• No association with stillbirth, neonatal mortality or morbidity.
• There are still concerns about other adverse outcomes (birth defects).
• Must balance risk to the mother of untreated depression.
JAMA 2013;309:48

**TERATOGENICITY**
Database review of women taking NSAIDs during pregnancy:
• 22% used NSAIDs in first trimester; mainly ibuprofen, aspirin, naproxen
• No association with most defects
• Small ↑ risk of a few specific defects
Am J Obstet Gynecol 2012;206:228
TERATOGENICITY
Washington State database review of illicit and prescription maternal drug use:
- Rates ↑ from 2000→2008; mainly opioids
- Neonatal withdrawal 3.3 / 1000 births
- Newborns had lower birth weight, longer hospitalizations, more preterm births, feeding difficulties and respiratory issues.
  Obstet Gynecol 2012;119:924

TERATOGENICITY
A cost-benefit analysis for prenatal intervention to stop substance abuse in pregnancy (Early Start) was performed:
- Higher costs if screens positive without follow-up for mothers and infants.
- Early Start implementation = $670,000
- Net cost benefit = $5,946,741
  Obstet Gynecol 2012;119:102

TERATOGENICITY
Parental characteristics and risks to child:
- Maternal obesity → autism
  Pediatrics, May 2012
- Paternal job using solvents → anomalies
  Occup Envir Med, July 2012
- Maternal smoking → poor asthma control
  J Allergy Clin Immunol 2012

ANESTHETIC TOXICITY
Do children exposed to anesthesia in infancy have deficits in school performance?
- Mean composite scores on academic achievement tests did not appear different.
- However, 14% scored below 5th %ile, even when other CNS problems or risk factors during infancy could be ruled out.
- Negative association between duration of anesthesia and test scores (longer=lower).
  Anesthesiology 2012;117:494

ANESTHETIC TOXICITY
How do we interpret observational studies?
- What is the population receiving anesthesia?
- Who is actually included in the analysis?
- What is the definition of anesthetic exposure?
- What is the comparison group?
- What is the outcome measure?
- How are the data analyzed?
- What is the clinical relevance?
  Anesthesiology 2012;117:459

ANESTHETIC TOXICITY
Analysis comparing 321 children age 10 who were exposed to anesthesia under age 3:
- Battery of neuro-psych tests administered.
- ↑ language disability (RR 1.87)
- ↑ abstract reasoning deficits (RR 1.69)
- Disability in language and cognition (RR 2.41)
- Risks persisted even with only 1 exposure.
  Pediatrics 2012;130:476
ANESTHETIC TOXICITY

Summary of what we know:
• Single anesthetics may not have an effect.
• Repeated exposures do show an effect.
• Persists after adjustments for co-morbidity.
• Learning (reasoning), speech and language are affected but not behavior.
• Observational studies are prone to bias, confounding, etc. but RCTs for this question are not possible or ethical. Prospective trials are ongoing.
AAP 2012 Nat’l Conference / Medscape, 10/25/12

ANESTHETIC TOXICITY

What about exposure of the fetus in-utero?
• Non-obstetric surgery and fetal interventions often use GETA, high concentrations, longer than C/S, and all lipophilic anesthetics can be measured in the fetal brain.
• 2nd trimester: rapid fetal brain development
• Animal exposure → neuronal cell death and behavioral abnormalities.

AND WE’LL SEE WHAT’S NEW IN 2013!

THE END
Where Did All Our Drugs Go? Drug Shortages: What is the Current Situation?
Clark Lyda, PharmD
Clinical Pharmacist, Operating Room Pharmacy
Clinical Assistant Professor, CU School of Pharmacy
University of Colorado Hospital

Objectives
• Identify common medications affected by current drug shortages
• Delineate impact of drug shortages on anesthesia services
• List resources to identify up to date drug shortage information and resolution dates
• Discuss recent governmental actions to address the drug shortage crisis
• Discuss alternative therapies being used in clinical practice as a result of drug shortages

What is a Drug Shortage?
• American Society of Health-System Pharmacist
  – A supply issue that affects how the pharmacy prepares or dispenses a drug product or influences patient care when prescribers must use an alternative agent

Examples of shortages

FDA


ASHP


Disclosure Statement – no financial relationships to disclose

• Clark Lyda, PharmD

Statement of Disclosure
– I have no relevant financial relationships with commercial interests pertaining to the content presented in this program.
How are Drug Shortages Reported?

- drugshortages@fda.hhs.gov
- “Report a Drug Shortage to ASHP” link
- University of Utah Drug Information Services

Why Drug Shortages?

- Government- FDA, DEA
- Materials
- Manufacturing
- Distributors
- Business Decisions
- Inventory
- Recalls

Role of DEA

- Limits of yearly production of controlled medications, C-II – C-V
- Fill their allocated quantity of controlled drugs.
- Not able to make any more until the next January
- Recent shortages of fentanyl, morphine, hydromorphone

Supply Chain
New FDA Commissioner, 2009

- Margaret Hamburg, MD
- Aggressive campaign to increase the FDA inspections
- Contaminated Heparin 2008
- 1st year, FDA warning letters to MFR companies increased 42%
- Second year (2010), the letters increased 158%
- Spring 2012, generic production had decreased 30%

FDA Inspections

- From the US House of Representatives, Committee on Oversight and Government Reform report on the FDA’s contribution to the drug shortage crisis, June 2012,
- “the FDA field force does not believe that it is within the scope of their authority to worry about the implications of their actions, even if it means a manufacturer closing a manufacturing line or facility.”

FDA Findings

- Teva- Endotoxin in propofol (2009)
- Bedford Labs- lack of sterility, glass and stainless steel particles (2011)
- Hospira- stainless steel particle contamination propofol, morphine vials overfilled up to 2x volume (2009, 2010 and 2011)
- Sandoz – crystal formation in solutions, contaminated opioids (2011 and 2012)

Drug Shortages by Primary Reason

Medicare Modernization Act 2003

- Prescription benefit for seniors
- Government price cap for generic medications
- Changed the reimbursement rate for injectable drugs delivered in outpatient settings
- Limits price increases to 6% per year
- Low profit margins of generic injectables (6%) – change production lines to a more lucrative drug

Number of Drug shortages per Year

Lyda, Clark, PharmD

Drug Shortages: What is the Current Situation?

CRASH 2013
Group Purchasing Organizations

- Increased purchasing power
- 98% of US hospitals use GPO contracts
- Six GPO’s have 90% of market, 2 have 60%
- Intense competition, prices driven down
  - Intended goal
- Ultimately limits production to 1 or 2 companies
  - Contract losers, quit making the generic drug

Hospital Inventory Control

- “Just In Time Ordering”
- Order enough product for 2 or 3 days
- Delivery 1 to 2 times every day
- Limit inventory costs
- Maximize turnover and profits
- Limits ability to respond to any drug shortage

National Survey

- University of Michigan Health System (UMHS) distributed an online survey to directors of pharmacy
- Collected data from four domains
  - Demographics
  - Impact of drug shortages
  - Resource utilization to manage shortages
  - Adequacy of current resources

Less Drugs, More Frustrations

- Drug shortages have lead to increased:
  - Time spent managing shortages
  - Labor costs
  - Frustration
- Estimated annual labor cost of $216 million for all health systems nationwide

Is Everyone Affected?

- 99% of hospitals were affected by at least one drug shortage

A Change in Practice

- Alternatives
  - Using different or unfamiliar agents
  - Temporary guidelines/policies
- Assessment of inventory
  - Changing dispense location of medications
  - Changing strengths or concentrations stocked in Pyxis
Impact on Medication Safety

- ISMP released a special issue addressing the effects of drug shortages
- Drug shortages have lead to an increase in medication errors
  - One in three reported having a near miss
  - One in four reported having an actual error
  - One in five reported adverse patient outcomes

Alternative Therapy

- Problems with alternatives
  - Less effective
  - Increase side effects
  - Unfamiliar with alternative agent
- Hydromorphone 2 mg IV ordered by MD, verified by pharmacy and given by RN.
  - Patient to ICU after Naloxone

Unfamiliar Agents: A Patient Case

- A 47 year old female is admitted for an elective procedure
- Propofol shortage
- Unfamiliarity with Brevital® Sodium
- Serious dilution error, massive overdose
- Patient died despite resuscitation efforts

Compounding Error

- Shortage of Bupivacaine 0.5% w/epinephrine 1:200,000
- Pharmacy mixed small amount for anesthesia
- Added too much epinephrine
- Two patients: HTN, V-Fib, Pulmonary edema, extended stay in SICU

Changes in Supply

- Drug shortages have lead to changes in current supply
  - Different strengths
  - Different concentrations
  - Different packaging

Obama Becomes Involved

- On October 31, 2011 Obama issued an executive order
Executive Order

- Executive Order 13588
  - Required drug companies to report to the FDA when critical supplies were threatened
  - Required FDA to expedite regulatory reviews and increase staffing in its Drug Shortage Program

Obama Administration Acts

- Continued efforts by the Obama administration included
  - A letter to drug manufacturers reminding them of their legal responsibilities to report the discontinuation of certain drugs to the FDA
  - Encouraged manufacturers to voluntary report potential shortages when not required by law

FDA’s Role

- Has taken multiple steps to help prevent drug shortages
  - Asking other firms to increase production
  - Working with manufacturers to identify steps to prevent the dangers of manufacturing products with quality issues
  - Expediting review of regulatory submissions
  - Approved Import of propofol from Europe

FDA’s Actions to Prevent Shortages

- FDA has helped prevent several drug shortages
  - In 2010, prevented 38 drug shortages
  - In 2011, prevented 99 drug shortages
  - In 2012, prevented 128 drug shortages

FDA’s Response to Shortages

- (Based on 127 drug shortages between January 1, 2010 and August 28, 2011)
  - Exercised regulatory discretion regarding importation: 3%
  - Asked other firms to increase production: 31%
  - Expected review: 26%
  - Other: 1%
  - No action taken: 6%
  - Expected regulatory discretion regarding importation: 5%
  - Exercised flexibility through regulatory discretion: 28%

CRASH 2013
FDA Provides Resources

- Increased resources provided on their website regarding drug shortages
  - List of drugs on shortage
  - Report of the FDA’s actions in decreasing the number of shortages
  - Links to actions by the Obama administration on drug shortages

ASHP Provides Resources

- Increased resources provided on their website regarding drug shortages
  - List of drugs on shortage and the reason behind the shortages
  - ASHP’s actions involving drug shortages
  - Guidelines to managing drug shortages
  - Links to articles and news on drug shortages
- http://www.ashp.org/shortages

The FDA's Website


ASHP’s Website

- http://www.ashp.org/shortages

Lyda, Clark, PharmD
Drug Shortages: What is the Current Situation?

CRASH 2013
**ASHP’s Website**

- Nalbuphine Injection
  - [21 January 2013]
  - Products Affected - Description
    - Nalbuphine injection, Hospira
      - 10 mg/mL, 1 mL ampules (NDC 00409-1463-01)
      - 20 mg/mL, 1 mL ampules (NDC 00409-1465-01)
    - 10 mg/mL 10 mL vials (NDC 00409-1464-01)
    - 20 mg/mL, 1 mL Novaplus ampule (NDC 00409-1465-49) - discontinued
  - Reason for the Shortage
    - Teva discontinued all nalbuphine injections in July, 2010.
    - Hospira has nalbuphine on shortage due to manufacturing delays. Hospira discontinued the 20 mg/mL 1 mL Novaphase ampules in December 2012.

**Actions to Implement**

- Partner with other institutions
  - Different wholesale distributor
- Social media
- Collegial networks with professional organizations
- Professional list-serves and discussion groups
- Group Purchasing Organizations

---

**Hospital Action**

- Hospital developed Policy
  - 1. Transparent and open for review.
  - 2. Relevant to population of patients affected
  - 3. System by which patient can appeal a decision
  - 4. Institution implement policy so that everyone follows the rules

**Hospital Action**

- 5. Allocation must be fair, similar patients always treated similarly, no special people, physicians or patients
- 6. No gray market drugs
- 7. Prohibit use of drugs in short supply to be used in research studies.
- 8. Close inventory management and control

**Hospital Action**

- 9. Schedule patients to avoid waste of partial vials
- 10. Coin toss to decide between two equal patients
- 11. Protocol to update information systems, electronic POE systems

---

**Resources**

- ASHP http://www.ashp.org/DrugShortages/Current/
- ASA- Link to Drug shortages – http://www.asahq.org/
Propofol Shortage: Teva to Restart Production

- Continue Importation of Propoven
  - Fresnius/APP increased production & shipment
- Domestic production improved
- Teva expected to release product February 2013
  - Discontinued in 2010, now reentering market
- Etomidate production increasing

Trends in Drug Shortages

- Significantly increasing
- Generic, sterile injectables
- Critical drugs
- Older drugs
- Generic Pharmaceutical Association
- May Improve in 2014?

Conclusion

- Drug shortages caused by multiple factors
- FDA implemented some actions that may help
- Resources for information presented
- Future of drug shortages….
  - Politics, Medicare Modernization Act, Obama Care, etc.

Thank You

- Questions?
Drug Shortages and the FDA: What Does Sugammadex Teach Us?

Tod Sloan, MD, PhD
University of Colorado School of Medicine

Disclosures

- I have no current financial interests to disclose.
- I did participate in Phase III studies with Sugammadex which was supported by the Manufacturer. I received no funds personally with these studies.
- I have not received funds nor spoken on sugammadex sponsored by the manufacturer.
- I am not on any speakers bureaus.

Sugammadex - History

- Early studies of Rocuronium done to identify anatomic side effects.
- Sent to chemist in Scotland to assess effects in rat vas deferens.
- Needed to solubilize the drug separate from diluent to separate effects of each.
- Cyclodextrans traditional solvent for steroid molecules

Put 2 and 2 together:

- Molecular design to maximize binding efficiency.

FDA Approval Process

[Diagram showing the FDA approval process with phases and timelines]

Lexdon

The Business Library
U.S. Approval of Sugammadex, the First and Only Selective Relaxant Binding Agent

[Diagram showing the Lexdon approval process with timelines and milestones]

http://www.mainetoe.org/assets/Images/64_chart_centex_leo.jpg
Sloan, Tod, MD, PhD  Panel: Drug Shortages and the FDA

Schering-Plough gets not-approvable letter for sugammadex
By Michelle Donley

NEW YORK (MarketWatch) -- Schering-Plough Corp. said Friday that the U.S. Food and Drug Administration issued a "not-approvable" letter for its sugammadex sodium injection, used to reverse muscle relaxation during general anesthesia. The company said it will work with the FDA to address the issues, which are mostly related to allergic reactions, not efficacy.

European Union's CHMP Issues Positive Opinion on Sugammadex
Anesthesia update: New tool that works within minutes, open process approved

Hypersensitivity: Case Description

1/1973
- Subject had a first exposure to sugammadex in a volunteer study (Study 19.4.106)
- Infusion stopped after 6.4 mg/kg sugammadex due to:
  - Paresthesia
  - Visual disturbance
  - Rash
  - Stomach discomfort
- Reaction was self limiting, no treatment required
- A slight increase in serum trypase, suggestive for a possible allergy was found
- Follow-up skin tests:
  - Skin prick tests (SPT): Inconclusive
  - Intradermal skin test (IDT): The subject showed wheals > 50% of the wheal size of histamine (positive control) accompanied by flares at 1:1,000 dilution
- Conclusion skin tests: Subject probably hypersensitive to sugammadex

Follow-up Study

- Confirmed hypersensitivity in previously seen patient
- 182 subjects - some naive and some whom had previously had Sugammadex
- No new hypersensitivity reactions seen

Election to use experience in Europe where it is approved

Special Populations (cont.)

- Bronchospasm (study 19.4.308)
  - Two cases were reported as SAEs in asthmatic patients (considered possibly related by the investigator)
    1. Bronchospasm shortly after reversal, around the time of extubation, successfully treated with terbutaline
    2. Bronchospasm approximately one hour after reversal, close to the time of extubation, successfully treated with albuterol

Anaphylaxis During the Perioperative Period

<table>
<thead>
<tr>
<th>Substance</th>
<th>Incidence of perioperative anaphylaxis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhalation anaphylaxis</td>
<td>481</td>
</tr>
<tr>
<td>Inhalation anaphylaxis</td>
<td>123</td>
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<tr>
<td>Immediate anaphylaxis</td>
<td>27</td>
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<tr>
<td>Immediate anaphylaxis</td>
<td>1</td>
</tr>
<tr>
<td>Other anaphylaxis</td>
<td>24</td>
</tr>
<tr>
<td>Other anaphylaxis</td>
<td>20</td>
</tr>
<tr>
<td>Other anaphylaxis</td>
<td>19</td>
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<tr>
<td>Other anaphylaxis</td>
<td>18</td>
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<tr>
<th>Substances</th>
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<td>19</td>
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<td>Other anaphylaxis</td>
<td>18</td>
</tr>
</tbody>
</table>

FDA Under Fire

In early 2008, contaminated batches of Chinese-manufactured heparin, a widely used blood thinner, killed dozens of people in the United States. Since then, the U.S. Food and Drug Administration has taken its role much more seriously. While no one would fault the body for doing so, the switch in tactics in monitoring an industry full of potentially under-regulated factories has an impact.
The Federal Food and Drug Administration (FDA) has been stepping up its quality enforcement efforts — levying fines and forcing manufacturers to recall their products. Not only has this more rigorous regulatory oversight slowed down production, but the FDA’s “zero tolerance” policy is forcing manufacturers to abide by rules that are rigid, inflexible, and unforgiving. For example, a drug manufacturer must get approval for how much of a drug it plans to produce, as well as the timeframe. If a shortage develops (because, say, the FDA shuts down a competitor’s plant), a drug manufacturer cannot increase its output of that drug without another round of approvals. Nor can it alter its production schedule (producing a shortage drug earlier than planned) without FDA approval.

CMS rules contribute to drug shortages, hospital pharmacists say

An Institute for Safe Medication Practices survey concludes that strict expiration dates on drug labels, despite contrary evidence in national compendia, mean wasted medications.

Washington Federal guidance requiring strict adherence to manufacturer labels for injectable drugs has forced hospitals to throw away perfectly good drugs that are in short supply, according to a survey of pharmacy directors and managers.

One of the biggest reasons was the shutdown of the American retreat factory... It wasn’t who or what was going to our facility. The problem was the fact that the government regulations were designed to prevent the manufacture of other products...

Why Canada is at risk of chronic drug shortages

The Globe and Mail

*The Canadian market awards contracts to specific groups. The problem is global. But Canada's drug purchasing process, and the fact that manufacturers are not obliged to give advance notice of pending shortages, make a supply problem more likely to reach crisis level.*
**Shortage Consequences**

- > 80% Hospitals report a shortage
- In a 2011 survey, 35% of respondent hospitals reported:
  - a near miss as a result of one or more drug shortages,
  - mis-dosing of sufentanil due to fentanyl shortage
  - meningitis resulting from use of contaminated betamethasone
- In a 2004 survey, 65% of pharmacy directors experienced a delayed or canceled procedure,
  - 31% experienced a prolonged patient stay,
  - 10% experienced a significant dosing error,
  - 4% reported an adverse drug reaction and
  - 1% reported a sentinel event as a sequelae of medication
- Most respondents reported being forced to purchase drugs off contract from current vendors,
  - borrow drugs from other institutions or
  - purchase from alternative sources,


---

**Economics of Drug Shortage**

**Injectable Generic Drugs**

- Shortage and cost of raw materials
- Few manufacturers (1-3) 7 total in US
- Cost malpractice concerns
- Cost of regulatory compliance and good manufacturing practices
- High cost of specialized manufacturing equipment
- Unavailability of use manufacturing line for other drugs

- Supply chain problems / Natural Disasters
- Sale of drugs to outside US (Canada)
- Gray market availability
- Poor price responsiveness
- Cost of maintaining inventory
- Short supply
- Low cost of drug; pre-negotiated price of buying groups
- Low reimbursement rates for insurers and Medicare
- Unexpected increased demand, change in practice/usage

---

**Table 3. Type of Medication Errors Attributed to Medication Shortages Between 2004 and 2005**

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>No. of Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescribing error</td>
<td>274</td>
<td>34.1</td>
</tr>
<tr>
<td>Improper dose/quantity</td>
<td>204</td>
<td>25.7</td>
</tr>
<tr>
<td>Omission error</td>
<td>178</td>
<td>22.2</td>
</tr>
<tr>
<td>Wrong administration timing</td>
<td>84</td>
<td>10.6</td>
</tr>
<tr>
<td>Unauthorized/incorrect dosing</td>
<td>47</td>
<td>5.9</td>
</tr>
<tr>
<td>Wrong drug preparation</td>
<td>43</td>
<td>5.4</td>
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<tr>
<td>Wrong dosing form</td>
<td>21</td>
<td>2.6</td>
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<tr>
<td>Expired product</td>
<td>15</td>
<td>1.9</td>
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<tr>
<td>Expiration</td>
<td>11</td>
<td>1.4</td>
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<tr>
<td>Wrong patient</td>
<td>9</td>
<td>1.1</td>
</tr>
<tr>
<td>Wrong route</td>
<td>5</td>
<td>0.6</td>
</tr>
<tr>
<td>Discontinued product</td>
<td>3</td>
<td>0.4</td>
</tr>
<tr>
<td>Wrong administration technique</td>
<td>1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table was reproduced from Quantros_MEDMARX™ (https://www.quantros.com/medmarx.htm). Copyright permission to reproduce the table was obtained.

De Oliveira, Anesthesiology 2011;115:1429
Etiology of Shortages

- Limitation of raw materials (90% outside US)
- Manufacturing difficulties
- Regulatory limitations: FDA enforcement
- FDA facilitation (CDER)
- Drug Recalls
- Change in formulation
- Manufacturing business decisions (profitability, other drugs, selling drugs elsewhere)
- Distributor inventory (incl. non-US availability)
- Availability alternative sources, or agents

Summit 2010

- American Society of Health-System Pharmacists, American Society of Anesthesiologists, the Institute for Safe Medication Practices, pharmaceutical manufacturers, wholesalers, health care organizations, the federal government and others
- For the purpose of improving the supply of medications in our health care system.
- The summit produced recommendations in the four domains of regulation and legislation, raw material sourcing and manufacturing, business and marketing, and product distribution.

FDA Limitations to Respond

Report to Congress Nov 2011

- FDA responds to drug shortages
  - taking actions to address the underlying causes
  - enhance product availability, for example by providing assistance to manufacturers to resolve manufacturing or quality problems that can result in a shortage
- FDA is constrained in its ability to protect public health from drug shortages due to its lack of authority

FDA Resources

FDA enforcement actions are intended to protect the public from potentially unsafe drug products

- Advisory Panels
- DSAI: Division of Scientific Investigations conducts inspections of clinical investigators' study sites
- CDER: Center for Drug Evaluation and Research (responsible for response to shortages)(1987)
- CBER: Center for Biologics Evaluation and Research (blood and vaccines)(1987)
- PDUFA: Prescription Drug Users Fee Act Reauthorization (requires shortage tracking, expedited inspections and applications, user fees)(1992)
- FDASIA: Food and Drug Administration Safety and Innovation Act (requires reporting of shortages)(2012)

Center for Drug Evaluation and Research (CDER)

- Established 1987 by FDA to deal with shortages, charged with Biologics in 2002
- FDA's Drug Shortage Program
  - Provide awareness of shortages
  - Conduct medical necessity assessments
  - Consider appropriate action on inspection reports
  - Assess proposals of firms as they attempt to avoid supply disruption or increase production

FDA is primarily protective role
Prescription Drug User Fee Act


Thursday, May 31, 2012

On May 30, the U.S. House of Representatives, by a vote of 387-0, passed the Food and Drug Administration Safety and Innovation Act of 2012, H.R. 5601, commonly referred to as the Prescription Drug User Fee Act (PDUFA) reauthorization, a legislative package of important Food and Drug Administration (FDA) provisions including ones to prevent and mitigate national drug shortages. Last week, the U.S. Senate passed a separate PDUFA reauthorization that also addressed the drug shortage issue.

Title X of the House PDUFA reauthorization includes specific requirements for enhanced manufacturer notification to FDA that would enable the agency to use its existing authority to respond in a timely fashion to a manufacturer’s decision to halt or restrict production of a key drug.

Other provisions in Title X of the PDUFA reauthorization would authorize the Secretary of the Department of Health and Human Services (HHS) to process expedited inspections and audits of drug applications and manufacturing facilities if such actions could help identify or mitigate ongoing drug shortages. AWA was pleased to see that the Senate included language to “require the Drug Enforcement Administration (DEA) to provide timely approval of certain drug precursors in instances where such an increase could help address a drug shortage.” The legislation mandates a Government Accountability Office (GAO) study to examine the issue of drug shortages.

FDA Safety and Innovation Act

Title X of the Food and Drug Administration Safety and Innovation Act (FDASIA) of 2012

Regulatory Information

Fact Sheet: Drug Products in Shortage in the United States

On July 9, 2012, the President signed into law the Food and Drug Administration Safety and Innovation Act (FDASIA) of 2012. In the new law, Congress provided FDA with new authorities to combat shortages of drug products in the United States and imposed new requirements on manufacturers regarding early notification to FDA of issues that could lead to a potential shortage or discontinuation of supply in a product.

Manufacturers are required to:

- report information about shortages to FDA, and
- are required to report the reasons for shortages and
- the expected duration of shortages

News Release

FDA Rejects Blame for Drug Shortages

June 28, 2012

POLICY & MANAGEMENT

House committee on oversight and government reform report

- Trace problem to new FDA commissioner in 2009
- 200% increased warning letters resulting in reduced manufacturing (2009-2011)
- 4 of 5 largest manufacturers reduced injectable drug manufacturing
- Inspection office insufficiently concerned about public welfare
- FDA response: we are a major part of the resolution, not the cause of the problem.


FDA Actions

How does FDA fit?

- Patient care is our #1 concern
- We get involved when we are informed
  - Early notification is critical
- Seek ways to prevent & mitigate shortages
  - Secondary response to industry problem
  - Find root cause and get manufacturer on track
- Some shortages can be prevented, but not all
  - Unforeseen breakdown in manufacturing system
- Longstanding quality manufacturing problems
- Some can be addressed quickly, others not
  - Risks to the patient always considered

CRASH 2013

CRASH 2013
Sugammadex – Where are we?

**YAHOO! FINANCE**

**Merck Announces FDA Acceptance of Resubmission of New Drug Application for Sugammadex Sodium Injection**

**WHITEHOUSE STATION, N.J. (BUSINESS WIRE)**

Merck (NYSE:MRK), known as MSD outside the United States and Canada, today announced that the resubmission of the New Drug Application (NDA) for sugammadex sodium injection has been accepted for review by the U.S. Food and Drug Administration (FDA), allowing the company to be considered on the fourth of May.

Sugammadex sodium injection is the company’s investigational agent for the reversal of neuromuscular block (NMB) induced by neostigmine or vecuronium (formerly known as the ‘block’ agent). PDE is used in anesthesia to induce muscle relaxation during surgery. Sugammadex is designed to work by binding neostigmine or vecuronium molecules directly to neostigmine; it would be the first in a new class of medicine in the U.S. known as selective relaxant-binding agents to be used in the surgical setting.
Drug Shortages, Practical Considerations

Thomas A. Majcher, DO
Associate Professor, University of Colorado Department of Anesthesiology
Clinical Director Anesthesiology
Children’s Hospital Colorado

Disclosures

• No financial interests to disclose

Anesthesia Drug Shortages

• Midazolam
• Thiopental
• Propofol
• Ketamine
• Fentanyl
• Ondansetron
• Ketorolac
• Calcium Chloride
• Atropine

Children’s Hospital Colorado

• 318 + bed free standing children’s hospital located in Aurora, Colorado
• Approximately 30,000 anesthesics/year in 36 locations including fetal, neonatal and cardiac
• 45 anesthesiologists and 20 anesthetists
• Affiliated with the University of Colorado
• Complex network of care reaching from Broomfield to Colorado Springs

Pharmacy supply chain management via the Omnicell Anesthesia Workstation (AWS)

• Secure dispensing of intra-operative controlled and open stock anesthesia medications.
• Features:
  – Most medications immediately at hand
  – Securing of drawn up meds in-between cases
  – Documenting and disposing of controlled meds
  – Inventory management
  – At present, does not interface with AIMS systems
7 July 2012, we were notified by our pharmacy of a serious propofol shortage in the US with both APP and Hospira abruptly stopping production.

- Our use averaged about 130 vials per day.
- A 15-20 day supply was available in the pharmacy at the time.

1. Abrupt and severe shortage
2. 2,000 vials 20 ml propofol on hand
3. **Pharmedium** pharmacy compounding
4. Average use is about 130 vials per day
5. 15-20 day supply remaining
6. Thiopental, methohexital, ketamine, midazolam, dexmedetomidine, etomidate

1. Primary patients:
   - IV induction including RSI
   - TIVA cases, especially those requiring neuromonitoring
   - MH susceptible patients
   - Out of OR (off site) anesthetics (MRI, oncology)
   - Niche uses (anti-emetic, emergence modification)

2. Therapeutic alternatives: consider all

1. Dexmedetomidine and prolonged emergence, methohexital and nausea
2. No significant impact on prescribing process
3. Pharmedium propofol
   - requires refrigeration. 30 day shelf life (24 hours at room temp.)
   - too large to fit in Omnicell AWS
4. Mixing of methohexital
5. Cost of dexmedetomidine

---

**ASHP Guidelines on Managing Drug Product, Shortages in Hospitals and Health Systems**

Erin R. Fox, Annette Birt, Ken B., Heather Kokko, Sandra Salverson, Donna Soflin
• Communicate, communicate, communicate
• Reduce AWS PAR level from 20 to 2 and consolidate
• Investigate all therapeutic alternatives and implement as necessary
• Implement new workflow with Pharmedium refrigerated syringes
• Monitor AWS vial usage by provider

Summary

• Establish an excellent working relationship with your pharmacy.
  – Know the leadership
  – Establish quarterly meetings to discuss issues
  – Consider a pharmacy liaison to anesthesiology
• Open communication about upcoming shortages and strategize accordingly
• Consolidate shortage drugs in central location
• Over communicate with your department
Update on Cardiac Anesthesia

Glenn Gravlee, MD
University of Colorado School of Medicine
No conflicts of interest

Edwards SAPIEN Valve
Huffmeyer J, Semin CT Vasc Anes 2012;16:25

Medtronic CoreValve
Huffmeyer J, Semin CT Vasc Anes 2012;16:25

Transapical Approach
Fassl J, J Cardiothorac Vasc Anes 2010;24:496

TAVI Access
Percutaneous (>90% in most series)
• Predominantly transfemoral
• Trans-subclavian also possible
Surgical
• Predominantly transapical
• Trans-aortic also possible: abdominal or thoracic

Why the fuss? Nonsurg Candidates @ 1 yr
Leon MB, NEJM 2010;1597-1607

<table>
<thead>
<tr>
<th></th>
<th>TAVI</th>
<th>Med Mgmt</th>
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<tr>
<td>Mortality</td>
<td>31%</td>
<td>50%*</td>
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<tr>
<td>Vascular Cx (Major)</td>
<td>30%</td>
<td>4%*</td>
</tr>
<tr>
<td>3-4+ Para-valvular AI</td>
<td>10.5%</td>
<td>NA</td>
</tr>
<tr>
<td>Stroke</td>
<td>10%</td>
<td>5%*</td>
</tr>
</tbody>
</table>
Growth of TAVI
Binder RK, Heart 2012:98:i30

- Europe: 4500 in 2009, 16000 in 2011 (Ger >40%)
- Oct 2012: FDA approved TAVI for high-risk surgical candidates who are eligible for surgery
- Off-label: Failing surgical bioprostheses

TAVI: Better than surgical AVR? Meta-anal
Takagi H, Int J Cardiol 2011:153:207

- But only PARTNER was prospective, others observational with propensity matching
- Argues that Euroscore overestimates surgical mortality - STS score not so much

Transfemoral TAVI Anesthetic Considerations

- GA or sedation (TEE, technical precision tip us to GA)
- All report anesthesiologist presence
- HYBRID OPERATING ROOM RECOMMENDED
- If GA, ETT rather than LMA (risk of hemodynamic deterioration, pulm edema, use of TEE)
- A-line, CVP (less often PAC), temp, Foley
- Fassl J, JCTVA 2010;24:691

Sedation for Percutaneous TAVI
(Survey: Bufton KA, JTCVA 2013:27:46)

<table>
<thead>
<tr>
<th>Anesthetic Procedures</th>
<th>North America</th>
<th>Europe</th>
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<tbody>
<tr>
<td>GA</td>
<td>69*</td>
<td>61</td>
</tr>
<tr>
<td>Sedation with transesophageal echocardiography</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sedation without transesophageal echocardiography</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>No sedation with local anaesthesia</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No anesthesiologist present</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>20</td>
</tr>
</tbody>
</table>

*Six North American institutions switched to GA from sedation after experiencing complications. Three other centers using GA had plans to try sedation in light of the European experience.
†Two European centers using GA recently had switched from using predominantly sedation after a series of emergent intubations. A total
Incidence and Predictors of Early and Late Mortality After Transcatheter Aortic Valve Implantation in 663 Patients With Severe Aortic Stenosis

Circulation 2011;123:299
Corrado Tamburino, MD, PhD; Davide Capodanno, MD; Angelo Ramonino, MD;

• Registry “Real world” – more than just nonsurgical candidates
• 663 consecutive patients, all with Medtronic CoreValve, 14 centers in Italy
• Anesthesia and procedural mortality
  – Died: GA 37%, “local” 63%
  – Overall population: GA 28%, “local” 72%
  – P=0.02
  – Dropped out in stepwise regression
  – Intraprocedural stroke was biggest risk factor (HR 15.7)

Transapical TAVI
Anesthetic Considerations
Fassl J, JCTVA 2010;24;691

• GA for sure
  – Lung isolation? (Optional)
• Hybrid OR
• A-line, CVP or PAC, Temp, Foley
• Various anesthetic techniques reported:
  – Usually des or sevo with muscle relaxant
  – Often remifentanil
  – 1 case report of pure thoracic epidural

TEE for Transcatheter AVR
Fassl J, JCTVA 2010;24;691

Usual AVR considerations with special attention to
• Post-deployment new Reg. Wall Motion Abnormalities (coronary ostia obstruction)
• Post-deployment paravalvular leak, maybe at multiple sites
• Live 3D Images often helpful

TAVI Anesthesia: Wake-up

• Assuming GA, typically extubate at end of procedure
• Hypertension/tachycardia avoidance important – be ready to treat either
• Immediate extubation: Lower likelihood with the usual suspects:
  – Low pre-op LVEF
  – High comorbidity (renal, pulmonary)
  – Slow recovery after rapid pacing
  – Need for inotropes

TAVI Time-out topic

What is the rescue plan?
• If a life-threatening complication occurs that can only be salvaged with surgery, is that the plan?
• Does the patient agree?
• Does the surgeon agree?
• Are you prepared to proceed quickly?
  – hybrid OR, surgeon and perfusionist present
**TAVI Peri-procedural Complications**  
Stortecky S, Heart 2012;98,iv52  
- Aortic insufficiency (>50% in most)  
- Acute kidney injury (12–28%)  
- Vascular access/bleeding/dissection  
- Stroke (5%+)  
- Sluggish recovery from rapid vent pacing/deployment (undefined)  
- Conduction disturbance/LBBB  
- Valve misplacement (MI/ischemia, LVOT obstruction) or embolization (!)

**Reducing Al with TAVI**  
- Biggest valve possible  
  - Trend: Annular sizing via CT reconstruction because TTE and TEE tend to underestimate  
- Avoid TAVI with bulky eccentric valve calcium  
- Postimplant dilation (another RVP run)  
  - 40% incidence in some centers  
  - Trade-off? Central vs paravalvular Al  
  - Immediate valve-in-valve also possible

**TAVI Vascular Complications**  
Stortecky S, Heart 2012;98,iv52  
- Injury eligibility: Fem access site to aortic valve  
- Mortality doubles to triples  
- Bleeding: Occult or obvious  
- Rupture, dissection, retroperitoneal hemorrhage, hemothorax, AV fistula, pseudoaneurysm, local access bleeding  
- Index of suspicion: Unexpected hypotension during technical access difficulty  
- Response: Crystalloid bolus up to transfuse/open abdomen or chest  
  - Covered stent may suffice  
  - (Suggest another day for the TAVI)

**TAVI and (new) AI**

<table>
<thead>
<tr>
<th>Box 1 Causes of postprocedure aortic regurgitation</th>
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<tbody>
<tr>
<td>Paravalvular</td>
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<tr>
<td>▶ Valve placement too low</td>
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<tr>
<td>▶ Valve placement too high</td>
</tr>
<tr>
<td>▶ Annular-valve ‘discongruence’ — valve too small</td>
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<tr>
<td>▶ Incomplete stent expansion</td>
</tr>
<tr>
<td>▶ Bulky, eccentric calcification</td>
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<tr>
<td>Transvalvular</td>
</tr>
<tr>
<td>▶ Leaflet damage</td>
</tr>
<tr>
<td>▶ Leaflet stuck open</td>
</tr>
<tr>
<td>▶ Incomplete stent expansion causing leaflet malcoaptation</td>
</tr>
<tr>
<td>▶ Calcium overhang of stent preventing back pressure for closing</td>
</tr>
</tbody>
</table>

> 2+ quadruples long-term mortality  
Even mild Al significantly increases

**TAVI Vascular Complications**

- Reported incidence 0–31%  
- Size matters

**New LBBB is common after TAVI**

Houthuisen P, Circulation 2012;126: 720  

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*Gravlee, Glenn, MD*  
Update on Cardiac Anesthesia

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CRASH 2013
TAVI future possibilities

In addition to lower risk with primary AS:
• Combined with coronary stent
• Deploy inside malfunctioning existing bioprosthetic aortic (or mitral) valve
• Highly selected AI patients (intrinsic leaflet pathology)
• Also: Several different valves under development

TAVI Summary

• Expanding rapidly: Typically octogenarians with predicted operative mortality >10%
• Transfemoral>transapical by substantial margin
• GA or sedation (transfem), A-line and CVP – TEE integral to procedure
• Be prepared for major Cx: bleeding (may be occult: dissection), heart block, new AI, coronary ostial obstruction

Prohemostatic Drugs in Cardiac Surgery

• Not much new info: rVIIa, DDAVP, antifibrinolytics
• New but unimpressive: F XIII concentrate

New and promising: Fibrinogen concentrates:
• Increasing use in Europe, available in US
  • FDA-approved for congenital fibrinogen deficiency
  • Off-label use hasn’t discouraged us in the past: IV nitroglycerin, DDAVP, FVIIa, aminocaproic acid

Some facts about fibrinogen

• Critical importance to plasma>“cell-based” clotting process
• Several studies show [fib] is first to diminish in consumptive processes (others say Va)
• FFP: 300-400 mg/U @ 2 mg/mL
• Cryo: 2.5-4 gm/10 bags (2-300 mL)
• Fibrinogen concentrate (Riastap, Behring, Marburg, Ger): About 1 gm/50 mL vial

rVIIa vs Fibrinogen

rVIIa
• Genetically engineered
• Fluid phase
• Exorbitant (platinum)
• Generates thrombin
• Procoagulant

Fibrinogen
• Pooled human product
• Lyophilized: reconstitute
• Expensive (silver)
• Requires thrombin
• Supports clotting only?

Levy JH Anesth Analg 2012;114:261
Is “normal” fibrinogen too low?
Blome M, Thromb Haemost 2005;93:1101
• Low normal fibrinogen was a strong post-CPB (T2) predictor of highest blood loss group (Group 3)
• Plt count and aPTT also were quite good

Fibrinogen: Sufficient by itself in hemodilution?
• Conventional recommendations suggest 75-100 mg/dL as intervention threshold
• In vitro study on hemodiluted WB: Bollinger D, BJA 2009;102:793
• 80% dilution:

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<th>Control</th>
<th>70 mg/dL</th>
<th>81 mg/dL</th>
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<tr>
<td>Fibrinogen (mg dl⁻¹)</td>
<td>384 (75)</td>
<td>70 (11)*</td>
<td>81 (4)</td>
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<tr>
<td>Antithrombin III (%)</td>
<td>106 (14)</td>
<td>18 (2)*</td>
<td>82 (3)</td>
</tr>
<tr>
<td>Factor II (%)</td>
<td>113 (17)</td>
<td>25 (1)*</td>
<td>78 (4)</td>
</tr>
<tr>
<td>Factor VII (%)</td>
<td>107 (25)</td>
<td>16 (4)*</td>
<td>85 (3)</td>
</tr>
<tr>
<td>Factor IX (%)</td>
<td>90 (18)</td>
<td>23 (5)*</td>
<td>74 (5)</td>
</tr>
<tr>
<td>Factor X (%)</td>
<td>113 (16)</td>
<td>19 (4)*</td>
<td>83 (3)</td>
</tr>
</tbody>
</table>

Bollinger D, BJA 2009;102:793
• Hemodilution effect

Authors suggest 200 mg/dL as target (2 g/L)
• Note that ONLY fibrinogen was replenished
  – Surprising and instructive that this would work

YET: Seems likely that 100-150 mg/dL would suffice if FFP/Plts also replenished
Fibrinogen: Selected Studies in CT Surg

  - Prophylactic fibrinogen 2 gms p-CPB in CABG decreases 12-hr blood loss 20% despite ND in (normal) coag tests

Fibrinogen conc: Recent Editorial
Manucci R, JTCVA 2013;27:1-4

- Hot topic: Std of care (vs cryoppt) for fibrinogen in several European countries
- Prolonged CPB: Lower [fib] approaching critical levels
- Dose-finding study needed, but improved outcomes to date associated with ≥6 gms
  - Would require over 20 u FFP
- 5 prospective studies in progress

Fibrinogen Recommendations

- For higher risk Pts (e.g., long CPB time, pre-op clopidogrel, circ arrest, redo), include [fibrinogen] in late CPB or post-protamine screening tests
  - Can substitute ROTEM FIBTEM or maybe TEG α-angle
- If [fib] < 200 mg/dL (roughly FIBTEM<15) and bleeding after heparin neutralization, strongly consider fibrinogen concentrate 4(+) gms or cryoprecipitate 10 bags as first intervention

Fibrinogen: Recent Studies in CT Surg

  - Fibrinogen concentrate as 1st intervention associated with much lower transfusion of other components
  - Not randomized, ND in blood loss

Bilecen S, JCTVA 2013;27:12
  - In database of 1075 CPB Pts, 264 received fibrinogen concentrate 2 gms: ND in blood loss, transfusion, or other outcomes
  - Speculate that dose was too low, but study clearly was very uncontrolled

Lariat Procedure
Lariat: Anesthetic Considerations

- TEE typically done real-time with live 3D
- General anesthesia is the norm
- Atrial fibrillation – assess pre-procedure rate control
- Potential for rupture/tamponade
  - Solid IV access
  - Arterial catheter seems wise
  - We are using perfusion/CT surgeon back-up at present, but typically not a hybrid OR

Other Nonsurgical LAA closure approaches: WATCHMAN Device

Other LAA Space Occupiers

Nonsurgical LAA Closure Devices

- Lariat Complications: Too soon to say
- “Space occupying” devices: Acute complication rates (mainly rupture/pericardial effusion) 4-8%
  - Improves with experience
  - Sedation/MAC feasible? Our cardiologists want GA
  - vs Lariat: Must continue anticoagulation

Lariat Indications: Atrial fibrillation

With contraindication to/ intolerance of anticoagulants

Other factors supporting procedure

- Low tolerance to or success with antiarrhythmics
- Failed atrial fib ablation and/or cardioversions
Touted as 95% successful: Randomized studies?
- Rapidly spreading
Comeback for CABG (vs PCI)?

Gravlee, Glenn, MD Update on Cardiac Anesthesia
CRASH 2013

SYNTAX Score Implications

Diabetics With Multivessel Disease
Farkouh ME, NEJM 2012;367;2375
• Consistent with multiple previous trials, yet PCI continues to grow vs CABG: Why?
• “many cardiologists simply have dismissed the results of earlier randomized studies as outdated...This is a catch-22, since long-term studies are needed...but evidence from long-term studies may be ignored if therapies are evolving.”
• “the comparative effectiveness of CABG and PCI...remains similar whether PCI is performed without stents, with bare-metal stents, or with drug-eluting stents...Mortality has been consistently reduced by CABG....The controversy should finally be settled.”

Hlatky MA, NEJM 2012;367:2437

Many PCIs today are ad hoc procedures, performed at the time of diagnostic coronary angiography, with the same physician making the diagnosis, recommending the treatment, and performing the procedure. There is little time for informed discussion about alternative treatment options, either medical therapy on the one hand or CABG on the other. Well-informed patients

Will ACOs address issues like CABG vs PCI with objectivity (and teeth)?

Time will tell...
Other countries do

Fast-tracking in Cardiac Anesthesia

• Several different approaches and definitions
• Trend toward extubation on OR table?
• Advantages of fast-tracking: depends on definition. If extubation within 6-12 hrs
  – Not a determinant for hospital or ICU LOS unless ICU LOS is defined to exclude a step-down unit
  – Respiratory or cardiac Cx: No convincing data
  – So why extubate in OR? You CAN do it in stable, lower risk Pts

Fast-tracking in Cardiac Anesthesia

If defined as extubation within 6 hours, consider it for
• Off-pump cases, pump times < 120 min, hypothermia minimum temp ≥ 32 °C, no or low-dose inotropes
• Age: Go with “physiologic” age, but if > 75 they should look REALLY good
• Minimal co-morbidity outside CV system (COPD, hepatic, renal, neurologic)

Recent study looking at 3 sufentanil targeted-infusion rates

El Tahan MR, JTCVA 2013;27:63-70
• Valve surgery, 3 groups of 16 Pts each
• Low risk: mean age high 30s, normal LVEF, Mean EuroSCORE low 4’s, mean weight 70 kg, MS>AS>MR=AI>double valve
• Surgical Duration 4-5 hrs, CPB 2 hrs, Crossclamp usually < 1 hr, “standardized hypothermic CPB”
Anesthesia Protocol
El Tahan MR, JTCVA 2013;27:63-70

• TIVA with targeted infusions of sufentanil and propofol - cisatracurium bolus + infusion thru CPB
• Sufentanil target effect-site concentrations @ 0.2, 0.3, and 0.4 ng/mL
  – My (crude) calculation: doses approximately 0.33, 0.50, and 0.55 ug/kg/hr
  – D/C infusion @ sternal closure
• Propofol titrated to state entropy < 50, response entropy minus state entropy < 10
  – Same crude calc: doses approx 140, 82, and 75 ug/kg/min
  – D/C at skin closure

Sufentanil Targeted Infusion Results
El Tahan MR, JTCVA 2013;27:63-70

• No diffs in hemodynamics, rescue vasoactive drugs (underpowered perhaps)
• Eye opening time range 25±8 to 86±10
• Extubation time 112±17 to 271±27
• ND in ICU or hospital LOS (standardized, common in fast-track studies)

Thoughts on El Tahan study

• Higher-risk, older Pts would need lower doses
• Sufentanil and cardiac fast-tracking in US: Probably underutilized
  – Dosing of 0.2-0.4 ug/kg/hr D/C’d at sternal closure
    is compatible with extubation within 2 hours
• Why not a volatile agent rather than propofol?
• BIS or other CNS monitor rather than entropy should be OK (none if volatile > 0.5 MAC)

CNS Autoregulation: Lower Limit

• Classically thought to be 50 mmHg
• Now recognized as likely higher and quite variable
• Age may increase it, poorly controlled hypertension clearly does, severe CVD regionally
  does so (Circle of Willis is overrated)
• And yet, CPB has some unique aspects
  – Flow is controlled
  – Hemodilution “left shifts” flow-pressure relationship

Predicting the Limits of Cerebral Autoregulation During Cardiopulmonary Bypass
Erijn Joshi, MD,⁎ Masahiro Ono, MD,† Charles Brown, MD,⁎ Kenneth Brady, MD,⁎ R. Blaine Easley, MD,⁎ Gayane Yenokyan, PhD,⁎ Rebecca F. Gottesman, MD, PhD,⁎ and Charles W. Hogue, MD⁎

232 CABG or Valve Pts monitored with TCD and NIRS during CPB, LLA using TCD vs MAP relationship: Observational

Demographics:
• Age 66±11, Males 78.9%, Substantial incidence of comorbidity: HTN 67%, Prev MI 31%, and pre-existing Carotid Dz (>50% narrowing) in over 80%

TCD/MAP Lower Limit of Autoreg
Joshi B, Anesth Analg 2012;114:503-10

Anesth Analg 2012;114:503-10
Other Findings
Joshi B, Anesth Analg 2012;114:503-10

• Only associations found with LLA were pre-op SBP (if < 160) and avg cbr oximetry index >0.5
• Efforts to construct a Receiver Operant Curve at various MAP decrements from baseline failed to find a “sweet spot” optimizing sensitivity and specificity
• No relationship between stroke and either LLA or time below LLA

Comments about Joshi et al. LLA study
Anesth Analg 2012;114:503-10

Observational: Varying ongoing conditions with possible confounders: [iso], [Hgb], Flow (2-2.4 index), PaCO₂, possibly drugs (vasodilators not recorded), TCD use assumes constant MCA diameter
  • Hgb especially concerning: Mgmt not controlled, data not given

• Promising, impact on outcomes unclear
• Emboli vs hypoperfusion as stroke etiology (impacting CBF mgmt “philosophy”)
• Brain as the index organ: Defining LLA based on CNS may miss gut, kidney LLAs

MAP during CPB

• Multiple observational studies are inconclusive
• Appears likely that MAPs should be higher with age > 70, DM, poorly controlled HT, CVD, and severe aortic atherosclerosis
  – How high? Realistically, > 60 mmHg (witness Gold’s experience)
“It came from the ICU...”
CRASH 2013
Breandan L. Sullivan MD

Disclosures
• No financial disclosures at this time...

Goals
• Case
• Attack common problems in critically ill surgical patients
• Management decisions
• Discuss the role of the anesthesiologist in critically ill

Goals Continued
• Controversy
  – Etomidate
  – Vasopressor use
  – Hemodynamic Monitoring

Urgent Phone call from the ER
• 54 y/o obese male
• Chief Complaint in ED
  – Feeling dizzy at home
  – Scrapped his shin two weeks ago
  – Wife “encouraging” him to get it checked out

Are you kidding me!
• It’s 3AM!
• Emergency Surgery
• Concern for necrotizing fasciitis
• “Send him to the damn ICU, he is under-resuscitated!”
More Details

- 39.5
- Sat’s 88% on NRB
- HR 142 irregular
- BP 75/50
  - Improved to 90/60 with 2 liters of fluid

Medical History

- Medical History
  - Diabetes
  - CAD
  - Renal Dysfunction
  - Seizure Disorder
    - Stopped drinking last month had a seizure

General Surgeon

- Gotta go now!

Surviving Sepsis Guidelines

Induction

- Etomidate of course

Fluid Management

- Crystalloid vs Colloid
- What is our end goal?
- What are standard monitors in the patient with septic shock?
Paralytics

- Load ‘em up for the ride over
- APRV
- Bi-Level
- ABCDE

Back and forth to the operating room

- Can you extubate a patient
  - Open belly?
  - On vasopressors?
  - On inotropes?
  - Coming back for surgery in 2 days?

Conclusions

- Anesthesiologists
  - Major Role in management
- Practicing good medicine
  - Best Chance of Survival
ANESTHETIC CHOICES FOR THE OCCASIONAL NEUROANESTHESIOLOGIST

Paul D Mongan MD

Outline – Common Questions
• Which anesthetic agent is the best?
• How much blood loss will there be?
• Will there be neuromonitoring?
• What is the ICP?
• Craniotomy – Is there a magic recipe?
• You want me to do what in IR?

IDEAL NEUROANESTHETIC AGENT
• 1. Rapid onset and rapid offset
• 2. Maintains hemodynamic stability
• 3. Does not increase CBF
• 4. Does not alter CSF production or reabsorption
• 5. Decrease ICP
• 6. Maintains CO2 reactivity
• 7. Maintains cerebral autoregulation
• 8. Allows EEG/EP monitoring
• 9. Does not increase cerebral metabolic rate
• 10. Anticonvulsant
• 11. Decrease edema
• 12. “Protects” the brain

Anesthetic Drugs of Interest
• Drugs
• Propofol
• Desflurane
• Sevoflurane
• Fentanyl
• Sufentanil
• Remifentanil
• Dexmedetomidine

Disclosure
• None

Rapid onset and recovery

<table>
<thead>
<tr>
<th>Anesthetic Agent</th>
<th>Rapid onset (Y)</th>
<th>Desflurane (Y)</th>
<th>Sevoflurane (Y)</th>
<th>Sufentanil (+/-)</th>
<th>Remifentanil (Y)</th>
<th>Dexmedetomidine (+/-)</th>
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</thead>
<tbody>
<tr>
<td>Propofol</td>
<td>+/-</td>
<td>Y</td>
<td>Y</td>
<td>+/-</td>
<td>Y</td>
<td>+/-</td>
</tr>
</tbody>
</table>
Clinical Experience: Functional Neurosurgery

- Dexmedetomidine infusion at 0.1 – 0.2 μg/kg/hr achieves a tranquil state sufficient to complete neuropsychiatric testing required for mapping of the cortical speech area, as well as to perform an awake tumor resection
- A lack of respiratory depression offers an advantage over other techniques

Clinical Experience: Carotid Endarterectomy

- A combination of superficial and deep cervical plexus blocks is the most common regional anesthetic technique in the NYU medical center
- Sedation with dexmedetomidine (0.2-0.4 mcg/kg/hr) offers a comfortable and cooperative patient during the operation
- Less agitation and respiratory depression than with a continuous infusion of propofol or repeated doses of fentanyl and/or midazolam

Rapid onset and recovery

<table>
<thead>
<tr>
<th>Anesthetic</th>
<th>Propofol</th>
<th>Desflurane</th>
<th>Sevoflurane</th>
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<th>Remifentanil</th>
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<tbody>
<tr>
<td>Y</td>
<td>+/-</td>
<td>Y</td>
<td>+/-</td>
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Does Not Increase CBF

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Maintains Autoregulation

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<tr>
<td>Y</td>
<td>+/-</td>
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Effects of Subanesthetic Dose of Nitrous Oxide on Cerebral Blood Flow and Metabolism: A Multimodal Magnetic Resonance Imaging Study in Healthy Volunteers

Nitrous oxide in 40% oxygen, but not 40% oxygen alone, significantly increased gray matter cerebral blood flow (22%; P < 0.05) and arterial blood volume (41%; P < 0.05).
**Effects of Intravenous Agents**

- Propofol
- Desflurane
- Sevoflurane
- Sufentanil
- Remifentanil
- Dex

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<td>Maintains CO2 reactivity</td>
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<td>Allows EEG/EP monitoring</td>
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<td>Does not increase CMRO2</td>
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<td>&quot;Protects&quot; the brain</td>
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<td>+/-</td>
<td>+/-</td>
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</tbody>
</table>

**Hemodynamic Stability**


**Ideal Neuroanesthetic Agent**

Gelb AW Can J Anesth 2003; 50:946

- Remifentanil
- Fentanyl
What’s Important for a Procedure

- What’s the diagnosis and the operation?
- What position?
- **How much blood loss?**
- Do you anticipate any ischemia?
- Will there be neuromonitoring?
- Is the ICP elevated?
- Where will the patient go afterwards?

How much blood loss will there be?

What’s Important for Procedure

- What’s the diagnosis and the operation?
- What position?
- **How much blood loss?**
- **Do you anticipate any ischemia?**
- Will there be neuromonitoring?
- Is the ICP elevated?
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What’s Important for Procedure

- What’s the diagnosis and the operation?
- What position?
- How much blood loss?
- Do you anticipate any ischemia?
- Will there be neuromonitoring?
- Is the ICP elevated?
- Where will the patient go afterwards?

Neurophysiologic Monitoring

- Electromyography (EMG)
- Somatosensory (SSEP)
- Motor Evoked Potentials (MEP)
- Brainstem Auditory Evoked Potentials (BAER)
Anesthetic Issues

- Anesthetic agents suppress
  - MEPs in patients with Myelopathy:
- Harder to obtain
- Greater suppression by anesthesia

Anesthesia

<table>
<thead>
<tr>
<th>SSEP</th>
<th>MEP</th>
</tr>
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<tbody>
<tr>
<td>0.75% MAC</td>
<td>0.5% MAC</td>
</tr>
<tr>
<td>Propofol infusion</td>
<td>Propofol infusion</td>
</tr>
<tr>
<td>Narcotic infusion</td>
<td>Narcotic infusion</td>
</tr>
<tr>
<td>Ketamine</td>
<td>Ketamine</td>
</tr>
<tr>
<td>Etomidate</td>
<td>Etomidate</td>
</tr>
<tr>
<td>Dexmedetomidine</td>
<td>Dexmedetomidine</td>
</tr>
</tbody>
</table>

What’s Important for Procedure

- What’s the diagnosis and the operation?
- What position?
- How much blood loss?
- Do you anticipate any ischemia?
- Will there be neuromonitoring?
- Is the ICP elevated?
- Where will the patient go afterwards?
Is the ICP elevated

Determinants of ICP (What We Can Control)
- Brain tissue
- Intra- and extracellular fluid (edema)
- CSF
- Blood (arterial/venous)
- Airway or intrathoracic pressure
- Jugular venous pressure
- P_{CO2}
- P_{O2}
- Anesthetics
- Vasodilators
- Seizures
- Temperature
- Arousal
- Pain

ICP

It is a change in VOLUME that causes a change in ICP

Major Constituents of ICP

Reduction of ICP
- Intravenous anesthetics
- Hyperventilation (30-35 mmHg)
- Mannitol (0.5-1.0 gm/kg, 320 mOsm/kg), (hypernatremia, hypokalemia, hypovolemia)
- Hypertonic saline
- Lasix
- CSF drainage
- Avoid hypoxia, hypovolemia
- Head position (venous drainage)
- Increase MAP
Head Elevation

- Decrease PaCO2 from 40-25

-Same change in CBV and ICP

- Decrease CVP 3 mmHg

ICP Control

- Mild controlled hypertension
  - MAP maintained around 100 mm Hg in order to decrease CBV and ICP
  - Normovolemia; no vasodilators
- Together with:
  - Adequate head-up positioning
  - Free venous drainage; no compression of the jugular veins
  - No PEEP, no ventilator fight (myorelaxants)
  - CSF drainage

ICP Control

- Mild hyperosmolality
  - NaCl 0.9% (304 mOsm) as baseline infusion
  - Mannitol (1319 mOsm) 0.5 to 1.0 g/kg
  - Hypertonic saline
    - 23.4% (4000 mEq/L) 30 ml
    - 7.5% (1282 mEq/L) 3 to 5 ml/kg
    - 3% infusion (514 mEq/L) 75ml/hr

Tight Brain

- Hyperventilate (ET CO2 25-30 mmHg)
- Venous drainage (head up, head position)
- Relaxation (Intrathoracic pressure low)
  - Mannitol (320 mOsm/kg) (lasix ?, HTS?)
  - Propofol bolus
  - Delete N2O (if you even tried to use it)
  - Turn inhalation agents off (propofol/oxygen)
  - Ventilation (oxygenation)
  - MAP > 100 mmHg
  - CSF drainage

Hypertonic Saline

- 0.9% to 3% to 23.8% NaCl solutions
- Shown to be effective in neurotrauma by shrinking brain and thus reduce ICP
  - can do so and maintain intravascular volume
  - Goal is to increase osmolarity not dehydrate
- May not be effective in stroke


Hypertonic Saline - Clinical Approach

- Establish central venous access
- Bolus 30ml to 23.8% NaCl solution
- Initiate therapy with 3% saline at 75 cc/hr (or higher if requiring fluid resuscitation)
  - use 50% chloride/50% acetate to minimize risk of hyperchloremia
- Infuse to a goal Na (ex. 145-150)
- Check serum Na frequently (q 4-6 hrs)
  - "ballpark" serum osm will be double serum Na
### Craniotomy Basics

- **Induction**
  - Prevent coughing
  - Prevent hypertension
- **Maintenance**
  - Position
  - Brain bulk management
  - Cerebral perfusion pressure (CPP 60-70 mmHg)
  - Glucose management
  - Fluid management
- **Emergence**
  - Prevent/minimize coughing
  - Prevent hypertension
  - Neuro exam capacity
    - Delayed awakening >30 min may result into a trip to CT scanner.

### Preop

- One IV
- Premedicate with up to 2 mg of midazolam if normal mental status.
- No premed if altered mental status/risk of increased ICP

### Induction

- Routine monitors
- Propofol 1-1.5mg/kg
- Fentanyl 3-5 ug/kg in divided doses prior to intubation
- Muscle relaxant (rocuronium or vecuronium).
- Hyperventilate spontaneously prior to induction if ICP high. Mild hyperventilation immediately after induction.
- More drugs for pinning

### Anesthetics

- Intravenous anesthetics (not ketamine) are cerebral vasoconstrictors
  - Reduce CMR
  - CO₂ reactivity intact
- Volatile anesthetics are cerebral vasodilators
  - Increase ICP
  - Reduce CMR
  - CO₂ reactivity intact (offsets ICP increases)

### Procedures and Adjuncts

- 4-10 mg dexamethasone, 0.5 gm/kg mannitol, +/- lasix
- Levetiracetam 1gm (Keppra)
- Tape eyes with tegaderms (prep solution)
- Temp probe, Foley
- A-line (ABG, CPP)
- Additional IV (limited access, 300 cc blood loss)
- Bair Hugger
- Compression stockings
Positioning

- Complications:
  - Ventilatory & Hemodynamic Changes
  - Loss of Airway, Monitors, Catheters
  - Venous Air Embolism
  - Injury to Eyes, Nose, Ear
  - Injury to Neurovascular Bundle

Maintenance

- Control CMR, CBF
- Good depth of anesthesia
  - Volatile (0.5-0.75 MAC) (too much-slow awakening, brain swelling)
  - Narcotics
    - Fentanyl infusion (2ug/kg/hr) (too much-slow awakening)
    - Remifentanil infusion 0.05-0.1 mcg/kg/min
    - Dexmedetomidine 0.4-7 mcg/kg/hr
  - Muscle relaxation (vecuronium, rocuronium)
  - Adequate CPP (MAP > 90mmHg)
  - Mild hyperventilation (ETCO2 30-35 mmHg)
  - Aim for rapid awakening

Awakening

- Neurosurgical awakening should avoid:
  - Coughing (opioids/dexmedetomidine)
  - Attenuate stress response (autoregulation impaired/labetalol, opioids/dexmedetomidine)
  - Tracheal suctioning
  - Airway overpressure during extubation
  - Hypercarbia, hypoxia (opioids)
- Neurosurgical awakening should provide:
  - Optimal conditions for neurologic examination (opioids, CT)

Recovery

- Wake patient up as soon as possible
- Extubate if possible
- Prevent post op hypertension (bleed)
  - Labetalol, pain control
- Transport to ICU with monitor and oxygen
- Head up position
- Pain Management

Potential Complications

- Postop seizures
- Delayed awakening from anesthesia
- Intracranial bleeding
- Brain swelling

Neuroendovascular Procedures

- Brain aneurysm coiling
- Carotid artery stenting
- Intracranial stent placement
- Clot-dissolving drugs
- Clot removal
- Embolization for arteriovenous malformation (AVM)
- Tumor embolization
Neuroendovascular Concerns

- Maintain Physiological Stability
- Manage Anticoagulation
- Manipulate Systemic or Regional Blood Pressures
- Treat Unexpected Complications
  - ICP
  - Bleed
- Rapid Recovery (neuro evaluation)

Disasters

- Vasospasm
- Occlusion
- Dissection
- Thromboembolism
- Stent misplacement
- Vessel rupture and hemorrhage
- Access site hematoma
- Arrhythmia
- Death

Room Size

- General surgical procedure rooms
  - commonly sized at 500 to 650 sf
- Cardiothoracic surgery procedure rooms
  - typically 650 to 800 sf
- Interventional radiography (angiography) and cardiology (catheterization and electrophysiology labs)
  - commonly sized at 500 to 650 sf.
- Hybrid procedure rooms
  - designed to accommodate (a) open procedures, (b) closed procedures, and/or (c) hybrid open and closed procedures
  - frequently sized within a range of 800 to 1000 sf, or even larger.

CEA vs. BMT

<table>
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<tr>
<th>Trial</th>
<th>Ipsilateral stroke, periop stroke, death</th>
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<tbody>
<tr>
<td></td>
<td>CEA</td>
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<tr>
<td>Nascet 70-99% (1991)</td>
<td>9%</td>
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<tr>
<td>ECST 70-99% (1991)</td>
<td>9.5%</td>
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</table>

Asymptomatic Carotid Atherosclerosis Study

- 1662 patients, 60-99% stenosis
- 1993-2002 with 10 year follow-up
- BMT vs BMT +CEA
- Study stopped after 2.7 years of follow-up
  - Ipsilateral stroke (5 year projected rate)
    - CEA vs BMT 5.1%
    - BMT 11%
GALA TRIAL

<table>
<thead>
<tr>
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<tr>
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<tr>
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<td>11</td>
</tr>
<tr>
<td>non-fatal</td>
<td>55</td>
<td>55</td>
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<tr>
<td>Modified Rankin 6 months after stroke</td>
<td>0-2</td>
<td>41</td>
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<tr>
<td></td>
<td>3-5</td>
<td>14</td>
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<tr>
<td>dead</td>
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<td>12</td>
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</table>

GALA Trial Lancet, 2008: 372:2132

CEA vs Carotid Artery Stent

Specialties Performing Carotid Stenting

<table>
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<tr>
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<td>2</td>
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<tr>
<td>Interventional Medicine</td>
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</tr>
</tbody>
</table>

Anesthesia for CAS

- Minimal to moderate sedation
  - Propofol infusion
  - Dexmedetomidine infusion

- ACT monitoring

- Balloon dilation
  - Neck pain, cough
  - Bradycardia (25%)
  - Labile BP (20-50%)

Questions???
Objectives

- Understand controversies in fluid management for lung resections and how they apply to specific types of patients and resections.
- Be able to identify and discuss common problems in positioning double-lumen endobronchial tubes.
- Understand the anatomy and physiology of esophagectomy
- Explain anesthetic techniques for esophagectomy
- Understand pros and cons of different anesthetic techniques for one lung ventilation.
- Compare risks and benefits of paravertebral blocks versus thoracic epidural analgesia

Update on Thoracic Anesthesia

Speaker Recommendation: Recent SCA Workshop

F. Indication for lung isolation
1. Absolute
   - a) Minimizing cross contamination due to:
     - (1) Blood
     - (2) Pus
     - (3) Protein
     - (4) Disruption of the bronchial tree with inadequate ventilation (bronchopleural fistula)
2. Relatively absolute:
   - a) Thoracic surgery, excluding:
     - (1) Purely elective, rare
     - (2) Surgeon able to operate using lung retraction, rare

Lung Isolation
- Indications, techniques, hypoxemia
- Fluid Management
- Esophagectomy Considerations
- Analgesia: Paravertebral Block vs TEA
- Robotic Thoracotomy

Double Lumen Tube Modifiers
- Open thoracotomy (vs VATS)
  - Pulmonary retraction is plausible in some open thoracotomies – incision size an issue
- Difficult intubation: Consider bronchial blocker + SLT
- Pre-existing severe shunt/hypoxemia
  - Medical ICU patients defying Dx, not responding to Rx, on ventilator for advanced hypoxemia with severe infiltrates
  - Consider intermittent apnea with SLT
  - May need ICU ventilator in OR: TIVA

Difficult DLT Placement: Unexpected
- Follow ASA Algorithm to maintain gas exchange and place single-lumen ETT
- Now what? Several options:
  - One lung ventilation for case if feasible (our surgeons dislike)
  - Bronchial blocker (our surgeons dislike)
  - Use tube-changer to place DLT
Tube Changer for DLT

- Tube changer depth key: generally assume past carina in R mainstem: Hence will need FOB-guided reposition of bronchial lumen into L side if L sided DLT
- Often hangs up at larynx: DL may help even if you can’t see cords
- Consider 2 tube changers (11 F rather than 14), one in each lumen of DLT, then DL with video laryngoscope during tube advancement through larynx

DLT vs Bronchial Blocker

DLT
- Ease of suction
- Rapid Lung collapse
- Positioning usually easy
- Greater airway rupture incidence (still low)
- Lesser chance of migration once positioned

Blocker
- Difficult airway advantage
- Slow Lung collapse
- Marginal suction capability
- Reduced chance of bronchial rupture
- Facilitates post-op ventilation
- Positioning can be a challenge
- Selective lobar blockade possible

Bronchial Blocker Options

<table>
<thead>
<tr>
<th>Blocker</th>
<th>Arndt</th>
<th>Cohen</th>
<th>Fuji</th>
<th>EZ</th>
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<tbody>
<tr>
<td>Size</td>
<td>3F, 4F, 5F</td>
<td>5F</td>
<td>4F, 4 1/2F</td>
<td>5F</td>
</tr>
<tr>
<td>Balloon shape</td>
<td>Spherical or elliptical</td>
<td>Spherical</td>
<td>Spherical</td>
<td>Spherical or elliptical</td>
</tr>
<tr>
<td>Guide wire</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Number of blockers</td>
<td>2 + 2 blockers</td>
<td>2 blockers in 1</td>
<td>2 blockers in 1</td>
<td>2 blockers in 1</td>
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<td>Recommended style</td>
<td>9 French (5.0 EETT), 11 French (5.0 EETT)</td>
<td>9 French (9.0 EETT)</td>
<td>9 French (9.0 EETT)</td>
<td>7 French</td>
</tr>
</tbody>
</table>


Bronchial Blocker Positioning

Right
- Proximal Cuff ~ 1 cm distal to carina
- But still CAN be over RUL orifice

Left
- Proximal cuff 1-2 cm distal to carina
- Harder to place, easier to stabilize

Campos JH, SCA Thoracic Workshop Syllabus 2012
Generally OK, but presumes knee-jerk transfer of lung protective ventilation from ARDS setting to OLV setting

Concerns:
1. Permissive hypercapnia in the context of RV afterload and it may increase Q to nondependent lung
2. PEEP in setting of emphysema/elevated dependent lung FRC may increase Q to nondependent lung and auto-PEEP to ventilated lung

Lohser J, Anes Clinics 2012;30:683

Higher L-R ETCO2 Difference during 2LV in lateral position predicts higher PaO2 during OLV

- Makes sense:
  - Higher ETCO2 in dep lung from higher blood flow
  - Another predictor of higher PaO2: L lung is collapsed and “up”

- Sense: Higher ETCO2 in dep lung from higher blood flow

Yamamoto Y, J Anesth 2009;23:192

How much hypoxemia should you tolerate during OLV?
No definitive answer, but SpO2 > 90% seems reasonable

- Modifiers: Surgical field (risk vs benefit of re-expansion of lung), Pt baseline SpO2, coronary artery disease /ECG ischemia
- Zebra: CONSIDER low CO as a contributor to OLV hypoxemia (via low SVO2): In which case volume bolus or inotrope infusion could help

Anesthesia Information Systems: Blessing vs Curse
Ehrenfeld JM, JCTVA 2010;24:598-601

- One lung anesthesia database reviewed for 196 Pts
- Findings: SpO2 < 90% in 24%
  - Mean lowest SpO2 79% and 83% (2 groups)
  - Duration means 5-10 min
- Mean highest ETCO2 54±5 mmHg
- PIP > 35 cm H2O in 34%
  - Mean highest PIP 45+6

How much hypoxemia should you tolerate during OLV?
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OLV Hypoxemia: Respect the DLT

- Cases of neurologic injury and cardiac arrest do occur – not a time for timidity
- Call for help early
- Engage the surgeon early
- Malposition of the tube is the most common malady, but stat simultaneous application of two maneuvers will “save” you
  - 1. RE-EXPAND OF COLLAPSED LUNG
  - 2. DEFLATION OF BRONCHIAL CUFF
  - IF SPO2 < 80, DO BOTH BEFORE REACHING FOR THE BRONCHOSCOPE

Could head down position with venous congestion explain?
Subtleties of OLV Management

- Pre-existing lung disease: More hyperinflation (emphysema, increased FRC, breath stacking) vs more hypo-inflation (restrictive/infiltrative Dz) – the latter responds well to recruitment maneuvers/PEEP to ventilated lung
- Surgeon capacity to help with hypoxemia varies with exposure and procedure:
  - Distortion or pressure to “crimp” a lobar PA, early exposure and clamping of PA in lobectomy or pneumonectomy

Advanced Hypoxemia Management

Update on Thoracic Anesthesia

- Lung Isolation
- Fluid Management
  - Philosophical shift, goal-directed Rx, Postpneumonectomy Pulmonary Edema, hypotension management
- Esophagectomy Considerations
- Analgesia: Paravertebral Block vs TEA
- Robotic Thoracotomy
Fluid Options in Thoracic Anesthesia

Progression of Thinking

1970s
- Replace NPO deficit
- 3rd Space 6-8 mL/kg/hr
- Blood loss: replace with BSS 4/1 ratio
- Crystalloid is good

2010s
- No deficit exists
- No 3rd space exists
- Replace with BSS 1-2/1 ratio
- Colloid is good

Clinical Result

- Practitioners are afraid to give fluids during major abdominal and thoracic procedures
- Previous anathema of masking hypovolemia or CV depression with alpha-agonists is now embraced
- Several hours of phenylephrine “pops” or infusion without consideration of adverse effects
  - Variation on theme: vasopressin

Granted

- Too much fluid was given in past: The direction of change has been good
- But has pendulum swung too far?
- Example: 8 hour Whipple with epidural – after 4 ml 0.25% bupiv, BP in 60s. Total crystalloid 2.0 L, 1 U RBCs, 1000 mL 5% albumin, Hgb 8, EBL 1500.
  - Surgeon happy with fluid management, tendency to micromanage
  - Surgeon notes that bladder is empty, advises fluid
  - 3 L of plasmalyte in 15 min, Pt responds well

Pulmonary Surgery: Fluids

Higher risk patients likely to reside at top of this pyramid, i.e., narrower span:
- Bilobectomy and Pneumonectomy
- Advanced COPD
- Known CVD
- DM, Renal impairment

Searl CP, Anes Clinics 2012;30:641
Postpneumonectomy Pulm Edema and Intra-op Fluids

- Statistical relationship to Positive Fluid Balance is anecdotal at best, no randomized trials
- Much is made of 1 retrospective study of 10 cases of which 4 suggested a possible fluid mgmt connection (Zeldin RA, JTCVS 1984;87:359)
- Subsequent studies: No such connection (Turnage WS Chest 1993;103:1646; Waller DA ATS 1993;55:140)

High-risk Pts undergoing Major Pulmonary Resections
(Bilobectomy, Pneumonectomy, maybe Decort)
Best fluid mgmt? Consider Goal-directed even in absence of controlled studies
- Invasive or noninvasive CO has the most support
- PAC? Out of favor, but consider
- Esophageal Doppler, TEE: Reasonable alternatives
- Goal? CI>3, DO2>600, MAP>65 (70?) using fluids, RBCs, inotropes
- Focusing 1° on SBP/MAP using vasoconstrictors lacks evidence-based support

Considerations re Phenylephrine
- What if Pt is indeed hypovolemic?
- What if Pt is too deep?
- What if Pt has reduced myocardial contractility? LV afterload implications
- What if Pt has increased pulmonary vascular resistance? RV afterload implications
- What is the minimal acceptable BP for any given Pt?

If we are to embrace restrictive fluid strategy, we should do it strategically
- Tenuous science gleaned from low-risk colon resection and pneumonectomy Pts is being extrapolated into one-size fits all for open and closed laparotomies and all thoracotomies including VATS wedge resections in ASA I Pts
- We need to consider adverse consequences of hypovolemia/ low cardiac output/high SVR states
  - Likely OK in ASA I-II Pts for short periods
  - Likely not OK in ASA II-IV Pts for multiple hours

How do we assess when fluid restriction is not OK?
Monitoring of Circulatory system “happiness”
- CVP? “Random number generator”
- PA catheter with CI/CO? Passe – in need of a “comeback” award?
- TEE for preload/SV assessment? Selectively OK
- Pulse or Pletth volume/contour? Tends to fail when “stressed”
- Doppler cardiac output? Promising, but would love to have preload assessment as well
A Systematic Review and Meta-Analysis on the Use of Preemptive Hemodynamic Intervention to Improve Postoperative Outcomes in Moderate and High-Risk Surgical Patients

Mark A. Hamilton, FRCP. FRCNA, Maurizio Cocconi, MD, and Andrew Rhodes, FRCP. FRCNA

- 29 studies, 2420 Pts, most interventions were fluids/inotropes (not pressors), goals were a mix dominated by CI and DO₂
- Types of surgery not given, no known trials in thoracotomy Pts (Abdominal>Total hip>>others)
- Mortality OR 0.48 (0.33-0.70) unless isolated to higher Jadad (quality) scores, then 0.62 (0.39-1.01=NS). But Cx reduced either way (OR 0.43-0.44, CI 0.28-0.59)

Can Changes in Arterial Pressure be Used to Detect Changes in Cardiac Output during Volume Expansion in the Perioperative Period?

Kerrick Le Manach, MD, Ph.D.; Christopher K. Healy, M.D., Ph.D.

- Anesthesiology 2012;117:1165-74
- Looked at 500-mL colloid bolus effects on various intra-arterial pressure permutations in 402 surgical Pts
- Measured CO with one of four (l) methods

Le Manach Y, Anes 2012;117:1165

- Decrease in Resp PPV >3% detects an increase in CO of >15% with Sens 90%, Spec 77%, “gray zone” of only 14% of population (Ooh BABY, how great is that?)
- No mention of vent settings, CO measurement reliability/variability

More benefit ascribed to PA Cath, CI/DO₂, and supranormal targets

Hamilton MA Anesth Analg 2011;112:1392

Table 2. Subgroup Analysis for Mortality

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>No. of studies</th>
<th>No. at follow-up</th>
<th>Odds ratio (95% CI)</th>
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<td>UGIB</td>
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<td>Thoracic</td>
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<td>720</td>
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<tr>
<td>Isolated</td>
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<td>1510</td>
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Hypotension: Are thigh-high SCDs an answer?

Sequential compression device inflate with air to acceleurate venous return

CRASH 2013

200
Update on Thoracic Anesthesia

- Lung Isolation
- Fluid Management
- Esophagectomy Considerations
  - Analgesia: Paravertebral Block vs TEA
  - Robotic Thoracotomy

Speaking of High-risk Procedures:
Esophagectomy

- Depending on stage, 5-year survival 3-49%
- Operative mortality 8-9% (higher at lower volume centers)
- Morbidities: PULMONARY, Anastomotic leaks (leading to PULMONARY)
- Anastomotic viability aided by epidural/sympathectomy, but compromised by vasoconstrictor Rx

— Jaeger JM, Anes Clin 2012;30:731-47

Esophagectomy: Resp Cx Multifactorial: But few have benefit of prospective trials

Anesthetic
- Absence of Epidural
- XS Fluids (> 4 L?): Maybe targeted CD/SV helps
- Transfusion
- OLV duration
- Delayed extubation
- High Tidal Volumes: Maybe (inflammation evidence)
- DLT Cx/hypoxemia

— McKevith JM, Curr Opin Anaesth 2010;23:34-40

Surgical/Oncologic
- Blood Loss
- Procedure duration
- Recurrent Lat N Injury (Aspiration: may be higher with min invasive)
- Anastomotic Leaks
- Induction chemo-rad prep-op (increases colonization of Resp tree)

— McKevith JM, Curr Opin Anaesth 2010;23:34-40

Impact of a multidisciplinary standardized clinical pathway on perioperative outcomes in patients with esophageal cancer

N. R. Preston1, S. R. Markert1, G. R. Baker3, Y. Soto1, S. Smith1 and D. F. Low1

1Department of Surgery, University of Virginia, Charlottesville, VA, USA
2Department of Thoracic Surgery, University of Virginia, Charlottesville, VA, USA
3University of Virginia, School of Medicine, Department of Thoracic Surgery, Charlottesville, VA, USA

Impact of a multidisciplinary standardized clinical pathway on perioperative outcomes in patients with esophageal cancer

2 institutions, not randomized, mix of simultaneous and historical controls, large variation in group sizes (12,12,12,74)
- Slightly different protocols, main focus post-op
- Key elements: same-day extubation, sits up DOS, epidural to Day 5, sit day 1, walk day 2, jejunal feedings day 2
Impact of a multidisciplinary standardized clinical pathway on perioperative outcomes in patients with oesophageal cancer

K. R. Forrest1, S. R. Marques1, C. R. Truex2, V. Soar1, S. Singh1 and D. M. Love1

1Surgery-Gastroenterology, University of Florida Health College of Medicine, Jacksonville, Florida, USA and 2Department of Thoracic Surgery, Mayo Clinic, Rochester, Minnesota, USA

Email: kforrest@ufhealth.org

- Largest group also had LIDCO goal-directed fluid Rx for first 6 hrs post-op
- Principal outcome improvements other than protocol per se: Decreased ICU LOS (1 vs 3 D), decreased hospital LOS (mean 13-17 vs 7-8)

Association of No Epidural Analgesia with Postoperative Morbidity and Mortality after Transsthoracic Esophageal Cancer Resection


J Am Coll Surg 2006;202:393

- Peculiar epidural vs non-epidural groupings inadequately explained
- Yet: biggest risk factor for pneumonia was absence of epidural (41% vs 25%, N=185 total)
- Absence of epidural almost doubled reintubation (15% vs 29%) and ICU LOS (2.8 vs 5.8 D)

Observational Esophagectomy Multimodal Approach

Neal JM et al., Reg Anes Pain Med 2003;28:328

- Key elements: TEA intra- and post-op 5-6 d, “conservative” fluids (but median 650 mL/hr intra-op), vasopressors prn for SBP w/in 20%, U/O goal 0.3-0.5 mL/kg/hr
- N=56, 0 mortality, all extubated in OR, CV Cx 9% (arrhythmia #1), Resp Cx 15% (Pneumonia #1)
- Vasopressor frequency/dosing not given

Esophagectomy anastomotic blood flow (laser) and epidural

Thoracic epidural bolus 0.1 mg/kg bupiv 0.25%, 30 min later epi infusion titrated to baseline BP

- Epidural decreased MAP, SVR, and CI
- Epid bolus: No change in HR, but epi (dose?) increased HR and CI to above baseline (NS)
- Al-Rawi OY, Anesth Analg 2008;106:884

Update on Thoracic Anesthesia

- Lung Isolation
- Fluid Management
- Esophagectomy Considerations
- Analgesia: Paravertebral Block vs TEA
- Robotic Thoracotomy

Post-thoracotomy Analgesia Questions

Fact: Thoracic Epidural Analgesia = Gold Std Question: Are Paravertebral or Intercostal Blocks underutilized? Subqueries:
- Is PVB as effective as TEA?
- Does PVB technique matter?
- Does PVB offer greater safety than TEA?
- Does VATS merit regional analgesia?
- Are Pt expectations about chronic post-thoracotomy pain realistic?
Distressing Aspects of Post-thoracotomy Pain

- Multimodal therapy: Added benefit unproven
- IV opioid PCA: Helps a little, no better than RN-controlled IV opioids in ICU/stepdown setting
- “Complete” post-op analgesia uncommon
- Chronic pain is common (50% plus)
  - Pre-emptive analgesia benefit? Unproven to date

Paravertebral Space Anatomy

Source: Ultrasound for Regional Anesthesia, Toronto Western Hosp

Paravertebral Block Techniques

- Traditional “blind”
- Nerve stimulator-guided
- Ultrasound guided
- Direct vision (surgeon placed)
  
  Prospective comparisons lacking, greatest number of reports use direct vision

PVB Complications vs TEA

Daly DJ, Curr Opin Anes 2009;22:38-43

- Less hypotension: Decidedly
- Lower hematoma risk? Probably, but ASRA guidelines re anticoag are the same
- Less itching for sure: Virtually nil with PVB
- Less urinary retention? Probably, but most often moot
- LOS: ND

Table 1 Summary of findings from a systematic review and meta-analysis of trials comparing paravertebral block with opioid analgesia on side-effects associated with analgesic therapy

<table>
<thead>
<tr>
<th>Outcome</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumothorax</td>
<td>0.36 (0.14-0.92)</td>
</tr>
<tr>
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<td>0.20 (0.10-0.39)</td>
</tr>
<tr>
<td>Nausea or vomiting</td>
<td>0.47 (0.25-0.91)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>0.12 (0.04-0.34)</td>
</tr>
</tbody>
</table>

Respiratory Cx and Function: PVB vs TEA

Davies RG, BJA 2006;96:418-26

Table 2: Comparison of two methods of paravertebral block and traditional epidural analgesia for thoracic surgery in 186 patients.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>PVB</th>
<th>TEA</th>
<th>OR (95% CI)</th>
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<td></td>
</tr>
</tbody>
</table>
Rare Prospective 3-group comparison of TEA (LA vs LA+O) and PVB (LA)

Best Analgesia: TEA LA+O

Grider JS, JCTVA 2012;26:83

Spirometry: TEA LA=O by a hair

Metaregress: Higher doses of PVB bupiv may better relieve pain

Higher dose calculates to 0.5% @ 8 mL/hr or 0.25% @ 15 mL/hr

Update on Thoracic Anesthesia

- Lung Isolation
- Fluid Management
- Esophagectomy Considerations
- Analgesia: Paravertebral Block vs TEA

Robotic-Assisted Thoracotomy

Steenwyck B; Anes Clinic 2012;30:699

Robotic-Assisted Thoracotomy (RATS)

Offers some advantages to surgeon over VATS
- Principally more instrument control, degrees of freedom, rotational capability (360°)
- Learning curve issues
- Positioning quirks depending upon specific procedure: Slightly more intense “field avoidance” issues than VATS
FIBEROPTIC AIRWAY MANAGEMENT

Geoffrey Lane, MB, FRCA
The Children’s Colorado Hospital

TOPICS

1. Selection and care of equipment
   - Choice of fiberoptic endoscope
   - Video systems
   - Avoiding damage
   - Cleaning and sterilization

2. Navigation skills
   - Introduction
   - Rotation
   - Flexion (control lever)
   - Anatomic deflection and direction

3. Decisions
   - Awake vs. asleep
   - Oral vs. nasal
   - Nasal: tube first or scope first?

4. Problem solving
   a. The tongue is in the way!
   b. The larynx is hidden because the epiglottis is stuck to the back of the pharynx!
   c. Laryngeal impaction and the S bend!
   d. The scope is always misting up!
   e. The view seems all wrong (upside down?)

5. Advanced applications
   - Pediatric intubations
   - Single lung ventilation – double lumen tubes and blockers.
   - Intubation through the LMA.
   - Intra-operative diagnosis of ventilation problems
   - The extreme airway

(Revised January 2012)
Section 1: Selection and care of equipment

Choice of fiberoptic endoscope.

With the publication of the ASA difficult airway guidelines, hospitals should have appropriate fiberoptic scope(s) for use by anesthesia. With the availability of relatively cheap, disposable Pentax scopes, fiberoptic intubation may be available in smaller ambulatory facilities, though other devices such as video-laryngoscopes may also be suitable. The selection of fiberoptic scopes is complicated, and should be designed to fit logically with other difficult airway equipment including video-laryngoscopy.

Desirable features include:
- Insertion tube length 50 – 60 cm
- Appropriate diameter - for the target patient population and hence the ETT’s most likely to be used (including double lumen tubes)
- Flexible tip (cannot maneuver much without it)
- Suction channel – useful though not essential - for local anesthetics, guide wires etc.
- Ease of cleaning and sterilization
- Compatibility with light sources and signal processing equipment.
- Digital bronchoscopes have much better resolution, and should be less easily damaged
- Durability, Durability, Durability!!!
- Price

The scopes that are designed for intubation are usually cheaper (approximately $1000) than corresponding diagnostic bronchoscopes, and have a thickened sheath covering the insertion tube to protect them from abuse by anesthesiologists (other than you, of course!) They lack some of the electronic photography exposure features of diagnostic scopes, but can still be used with a video camera, and are generally the best choice for anesthesiologists.

Some new scopes have a small video-screen built into the system. These are cheaper than purchasing video towers, but the screen is a little small and more difficult to orient. They represent good value for places that use fiberoptic intubation less often.

Fiberoptic scopes designed and marketed for anesthesia/intubation present a compromise regarding size or diameter. As the diameter is reduced, the bronchoscope can be introduced through smaller endotracheal tubes and thus extended to pediatric use, and for examining placement of double lumen tubes. The disadvantage with smaller scopes is that when passed through large adult sized endotracheal tubes, there is a greater tendency for the tube to become caught on the laryngeal inlet. This can be very frustrating, but there are several methods to avoid or manage this problem (see section 4c, page 10.)

Ultra thin pediatric scopes are available and can be used inside 3.0 mm tubes. They are soft, flimsy and more difficult to use. Though valuable for pediatric use, they are not suitable for
routine intubations with endotracheal tubes larger than 4.5 mm. Ultra thin scopes may be required when examining the placement of small double lumen tubes and blockers.

Price is obviously a major consideration, but repairs are so expensive that durability is even more important. Heavy use in an academic teaching center with inevitable damage to the scopes may warrant investment in a maintenance/repair contract.

Olympus has digital bronchoscopes which use a video chip mounted on the distal end of the bronchoscope; the image is then transmitted electronically instead of using glass fibers to transmit an analogue picture. This improves the resolution dramatically, and the scopes should be less prone to damage because the image is transmitted electrically rather than by fragile glass fibers.

Storz has new scopes with good optical resolution. They have an integral camera head mounted on the scope, the video output produces an excellent large image compared with older systems. The Storz video systems can also be used with their video laryngoscopes.

**Video Systems**

The purchase of a camera and video equipment significantly enhances a fiberoptic intubation system. (When did you last see your friendly orthopod doing an arthroscopy without an expensive video tower?) If the anesthesia scope does not include a camera/video system, you can usually connect to the OR system using the digital video cameras that clip onto the rigid surgical endoscopes.

It is much easier to teach and supervise when you can see what the student is doing. The video system is also valuable in difficult airways, when an assistant is needed to retract the tongue and soft tissues, or to help thread a guide wire through the scope. When the assistant can see the results of his efforts on the screen, the assistance is more effective.

The output from the digital processor can also be exported to a Mac computer using a Firewire cable, and edited in iMovie. We are using this to improve instruction by replaying the (edited) video to provide “feedback,” and can also generate a simple evaluation score to track progress and guide further instruction. Keeping a video recording of extremely difficult intubations can be helpful for the next intubation, and to provide a record for the patient/family.

Video use can involve the OR team; when the surgeons and OR nurses can share your fiberoptic exploits on the screen, they are much more likely to offer support and encouragement than when your endeavors are seen only as an irritating delay before they can have their fun!
Avoiding damage

Success in fiberoptic intubation requires continued access to a satisfactory fiberoptic system. There are several easy but expensive ways to damage the scope and render it unusable. We teach our staff and residents this mnemonic:

“Please Don’t Damage This Thin Scope!”

Petroleum based lubricants such as Vaseline and lacrilube can penetrate the cover of the scope and cause separation of the fibers; use aqueous lubricants such as KY jelly or silicone spray (as used by GI endoscopy)

drawe Don't leave the scope in the drawer of the endoscopy cart while connected to the light source; shutting the drawer will crush the glass fibers.

door Don't leave the scope plugged into the light source when removing the endoscopy cart from the room - the light cable can easily be smashed on the door frame!

teeth A good bite can crush the scope - if the patient is awake, protect the scope with a bite block or airway.

tube Advancing the tube down over the scope while bending the tip may damage the vulnerable, flexible tip section - always remove pressure from the control lever and keep the tip straight while advancing the tube.

S - Bend The scope can be forced into an S-bend when the tube tries to continue passing down the esophagus while the scope remains in the trachea. If you encounter resistance when advancing the scope through the larynx, DO NOT FORCE IT! Try rotating the tube 90 or 180 degrees, or use an introducer. (See section 4c, page 10)

Cleaning and sterilization

There are several reports of disease transmission attributable to faulty preparation of endoscopes, including episodes of hepatitis, tuberculosis and more recently, pseudomonas. Ease of cleaning and sterilization is therefore essential.

Most modern scopes may be immersed in cleaning fluids or be subjected to gas sterilization. The use of automated sterilization machines such as the Steris system has simplified processing, but the use of Steris has recently been challenged by withdrawal of FDA support
after some changes that were not approved. We now use a more complicated endoscope processing system.

Section 2: Navigation Skills

Introduction

The simplest approach to intubation with a fiberscope is to point the scope so that the target (larynx) is in view, and then try to advance the scope towards the target or through it. This "point and shoot" approach works in many adult patients, and is the method most people use initially. The skillful operator develops more advanced navigation skills with experience, intuition and manual dexterity. These skills will be demonstrated in the workshops, but understanding the basic principles can enable the student to advance more quickly.

Though the distal tip of the bronchoscope can be manipulated by the control lever, most of the insertion tube is deflected passively by the airway tissues. Learning how to pass the bronchoscope skillfully through the mouth or nose to the larynx requires recognition of how to use this deflection by the anatomic structures to one’s advantage.

There are three different types of maneuvers that can be used to control the scope; the expert is able to advance and navigate the scope smoothly through the airway by combining these controls effortlessly – just like a teenager operating a video game!

(1) Rotation

The bronchoscope can be rotated around its long axis by turning both hands together. The effects on the image are different when using observed through the eyepiece of an analogue bronchoscope compared with use a camera or a digital system.

The image transmission pathway in the insertion tube of an analogue bronchoscope is constructed of bundles of parallel glass fibers. The 12 o’clock position is marked by an indent or black triangle to assist in orientation. Rotating the scope through 90 degrees will cause the 12 o’clock marker to rotate correspondingly, but so long as the observer is viewing the target through the eyepiece, the target will not change position. (The image will be carried through different fibers, but the spatial relations between target and observer are the same.)

When using a digital bronchoscope, or when a camera is placed on the eyepiece, the image displayed on the screen will rotate as the insertion tube is rotated.

When using rotation to control the scope, it is easier for novices to keep the scope relatively straight by keeping both hands as far apart as possible, otherwise a big loop may develop, and the tip may flex in unexpected directions.

(2) Flexion (control lever)
The distal tip section of the scope bends up or down with light pressure on the control lever. The flexible (or bending) part of the scope is short, and flexing it does not necessarily control the remainder of the insertion tube. It is also the most fragile part of the scope, since it has to be covered with a thin, flexible covering, and can be damaged by excessive force and by sliding the endotracheal tube down and into the flexed tip.

Since intubation scopes are only flexible in one plane, it may be necessary to combine flexion and rotation when navigating difficult or ‘tortuous’ airways.

(3) Anatomic deflection and direction

The greater part of the length of the insertion tube is not controlled directly by the control lever, but responds indirectly to pressure against anatomic features as the scope is advanced. The operator can aim the scope as it enters the mouth or nose, and by directing it against structures (e.g. the palate), can encourage the scope to assume an optimum trajectory. This type of control is demonstrated more easily than it can be described, but should be mastered if the operator is to exploit the full potentials of fiberoptic intubation.

The chances of success improve when the endoscopist has good manual control of the scope and can keep the scope in the mid-line all the way to the trachea. Recognition of the mid-line landmarks facilitates navigation, for oral intubation they include:

**Posterior:**
- Raphe (fine white line) in palate, that leads to the -
- Uvula

**Anterior**
- Furrow, or groove, down mid-line of tongue, leading to the -
- Epiglottis

Failure to understand these navigation principles is the reason for the scope passing into the esophagus, even though the operator may have visualized the larynx clearly. The problem occurs during oral intubation when the scope is introduced directly backwards (see below, A) and the tip is flexed acutely upwards to see the cords. As the scope is pushed down the airway, the tip may still lie behind the arytenoids so that the scope enters the esophagus rather than the larynx (B.) This problem is more likely to occur in small patients; adults tend to be more forgiving because the larger distances involved allow the scope to bend more towards the intended direction.
**Section 3: Decisions**

**Awake vs. Asleep**

In adults, the difficult adult airway is usually managed safely and more easily awake, using good topical anesthesia and with judicious (if any) sedation. Dexmedetomidine may be helpful.

Children seldom cooperate well under topical anesthesia, and sedation for difficult pediatric airways can quickly lead to obstruction and hypoxia. I generally recommend an inhalation anesthetic for children between 12 months and 10 years, but the ability to maintain an adequate airway using a chin thrust maneuver is essential, and relaxants should be avoided.

There are many ways to achieve good topical anesthesia. I prefer to use viscous lidocaine first, and will then inject lidocaine through the suction channel of the scope into the larynx. Inhaling a nebulized solution of lidocaine is also effective if administered until the airway is anesthetized. It is easy to exceed therapeutic doses of local anesthetics and cause toxicity especially in smaller patients; the safe dose should be estimated before use.
Oral vs. Nasal

Nasal intubation is technically easier than oral intubation because the intranasal structures support the scope and facilitate a smooth advance. The convexity of the cervical spine helps to direct the scope forwards and away from the posterior pharyngeal wall towards the laryngeal inlet.

There are situations where oral intubation may be preferred for surgical access, e.g. for cleft palate surgery. There is also a risk of bleeding with nasal intubation despite the use of vasoconstrictors, and is of sufficient concern in the most precarious airways that oral intubation may be the first choice.

Oral intubation requires more dexterity and skill in keeping the scope towards the mid-line, and in small patients it may even be necessary to press the scope against the palate to achieve enough curvature to enter the larynx.

Nasal: tube first or scope first?

Passing the endotracheal tube through the nose before advancing the scope may appear easier than threading the scope through the nose first, but can cause severe bleeding and jeopardize the intubation. The tube is stiff enough to penetrate the posterior wall of the pharynx, causing a false passage, or it may perform a partial adenoidectomy.

With a little practice, the scope can be directed through the nose without tearing the mucosa and adenoids, and it will make the turn at the back of the nose more easily.

Section 4: Problem Solving

a.) The tongue is in the way!

The tongue often presents a major visual obstruction when intubating difficult airways, especially when the patient is unconscious.

Maneuvers to pull it forwards include use of a chin thrust, pulling the tongue out of the mouth with a dry sponge, and mechanical devices. Of these, I find that a narrow, malleable surgical retractor can be shaped and used successfully in some of the most difficult pediatric airways. Using a regular laryngoscope to lift the tongue forwards is seldom helpful as the tip of the blade usually covers the glottis; a video laryngoscope may be more helpful.

b.) The larynx is hidden, because the epiglottis is touching the back of the pharynx!
This is what difficult airways are all about! In the awake patient, a deep breath will often lift the tip of the epiglottis off the posterior wall of the pharynx enough to allow the scope to be advanced.

The anesthetized patient is more of a challenge. A chin thrust by an assistant is often sufficient, but in extreme airways, it may be necessary to pull the tongue forwards using a dry sponge, or by using a malleable ribbon retractor bent to an appropriate shape.

c.) Laryngeal impaction and the S-Bend – or- ‘the tube won’t go down the larynx!’

Very frustrating! This happens when the ETT is much wider than the scope, and the tip of the ETT impacts on the ary-epiglottic folds or on the arytenoids. Once this has occurred, the situation can often be resolved by (1) pulling the ETT back over the scope a short distance and then (2) rotating it 90 or 180 degrees. The tube is then advanced again, this time with the tip of the ETT above the scope so the tip enters the glottis between the anterior commissure and the scope without impacting the ary-epiglottic folds. The problem may be anticipated and avoided by several strategies:

1. Selecting a fiberscope whose diameter is as close to that of the endotracheal tube as possible will usually prevent the problem.

2. The new endotracheal tubes manufactured by Parker Medical Systems have a special tip that bends inwards to reduce trauma to the mucosa as the tube is advanced. The tip will remain in touch with a fiberscope passing through the laryngeal inlet and should help to avoid the “S-bend problem.”

4. An introducer can be placed between the fiberscope and the endotracheal tube just as we use a dilator or introducer between the guide wire and catheter/sheath during central venous cannulation. Suitable devices include a straight chest tube, a small uncuffed endotracheal tube, or an Aintree Intubation Catheter (Cook Catheters.) The chest tube and Aintree have the advantage of being longer; an uncuffed endotracheal tube is so short that the larger ETT may have to be shortened by 4 to 6 cms.
The appropriate sizes when using an Olympus LF2 scope are:

<table>
<thead>
<tr>
<th>Outer ETT (mm, ID)</th>
<th>Introducer: A: Chest Tube</th>
<th>Introducer: B: Uncuffed ETT</th>
<th>(length)</th>
<th>(ext diam)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5 mm</td>
<td>-</td>
<td>5.0 mm</td>
<td>24.5 cm</td>
<td>6.9 mm</td>
</tr>
<tr>
<td>8.0 mm</td>
<td>-</td>
<td>5.5 mm</td>
<td>27.5 cm</td>
<td>7.5 mm</td>
</tr>
<tr>
<td>8.5 mm</td>
<td>24 FG</td>
<td>6.0 mm</td>
<td>28.5 cm</td>
<td>8.2 mm</td>
</tr>
<tr>
<td>9.0 mm</td>
<td>24 FG</td>
<td>6.0 mm</td>
<td>28.5 cm</td>
<td>8.2 mm</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>28 FG</td>
<td>6.5 mm</td>
<td>29 cm</td>
<td>8.9 mm</td>
</tr>
</tbody>
</table>

**The scope is always misting up!**

This problem is usually caused by allowing the tip of the scope to touch the mucosa. Careful navigation, keeping to the lumen of the airway, will eliminate this problem, but if it does occur, clean the end with an alcohol wipe. When using a video camera, a 'white out' is a warning that you are almost touching the mucosa - retreat and find the lumen before advancing!

**Section 5: Advanced Applications**

**Pediatric intubations**

1. **Guide wire method:** a regular intubation scope can be used to intubate infants (when an ultra thin scope is not available,) by threading a long (125 cms) guide wire through the suction channel into the trachea. Suitable J wires can be ordered (or “appropriated” from the cath. lab in an emergency), a 0.032” to 0.036” diameter wire is usually appropriate. The scope is then withdrawn over the wire, and an appropriate ETT advanced, using a small suction catheter inside the ETT to facilitate the advance.

2. **Ultra thin fiberscopes:** Pediatric fiberscopes such as the Olympus LFP, with a 2.8 mm diameter that fits inside 3.0 mm ETT’s have extended routine fiberoptic intubation abilities to neonates. These scopes are much softer and are more difficult to control, but can be life saving.

**Single lung ventilation - double lumen tubes and blockers**

Fiberoptic scopes may be used to place and verify correct positioning of double lumen tubes. Confusion regarding which lumen to use is simplified if you remember that the scope may be used for two distinct purposes.
First, the scope can be inserted through the *distal, bronchial* lumen to direct the tube from the lower trachea into the selected mainstem bronchus.

Second, it can be used to confirm and adjust the position of the bronchial cuff, to ensure that the endobronchial cuff is just inside the bronchus, and that when inflated, the cuff does not extend beyond the carina to obstruct the trachea. Place the scope through the *tracheal* lumen to observe the cuff.

The practical sequence is therefore:

1. Place the tube into the trachea by conventional direct laryngoscopy.
2. Advance the tube into the main stem bronchus either directly, by simply pushing and turning it in the traditional manner, or endoscopically by inserting the scope through the *bronchial lumen* and then into the selected main bronchus.
3. The position of the bronchial cuff in relation to the carina is inspected by inserting the scope through the *tracheal* lumen. The scope should emerge just above the carina, and the bronchial cuff should be entirely within the bronchus - to avoid obstruction of the trachea. Correct inflation of the cuff can be observed directly to avoid hyperinflation.

Bronchial blockers can be used to provide single lung ventilation, especially in smaller patients. Cook® have the Arndt Endobronchial blocker sets in a range of pediatric and adult sizes. These are designed for placement using a fiberoptic scope, using a nylon guide loop that slips over the scope for insertion and positioning.

**Intubation via the LMA**

A fiberscope can be placed through an LMA (or other supraglottic airway) to facilitate intubation in patients who cannot be intubated directly for anatomical or neurologic reasons. The Fastrach LMA can serve as a conduit for intubation without using a fiberscope, but is not available for small children.

When using a fiberscope through the LMA, the ETT can be passed over the scope and into the trachea, but the ETT is usually too short to allow the LMA to be removed. If this is necessary, then a second smaller ETT can be wedged inside the proximal end of the first ETT until the LMA is removed. Alternatively, a long guide wire can be placed through the suction channel of the fiberscope. The LMA is then withdrawn, and an appropriate size ETT is then advanced over the wire, using a suction catheter inside the ETT to support the wire and facilitate passage through the glottis.
Intra-operative diagnosis of ventilation problems.

The fiberoptic scope can be an asset in the diagnosis and management of a variety of intra-operative ventilation problems, for example:

1. The surgeon claims the left lung is not moving as you come off by-pass. You can try pulling the tube back - but risk extubating the patient. Passing the scope down the tube allows you to confirm the position (or improve it) and turns your attention to shifting the mucous plug obstructing the left bronchus.

2. Difficult ventilation in the neurosurgical patient in the sphinx or prone position: the tube may be kinked, blocked or positioned incorrectly - use of the scope may facilitate resolution of the problem.

3. Reintubation. The scope may be used to reintubate either electively, or sometimes in emergency situations (e.g. the infant accidentally extubated coming off by-pass, when direct laryngoscopy interferes with the aortic cannula)

The “extreme” airway

Difficult airways may be defined as those that cannot be intubated by direct laryngoscopy (amongst other definitions.) Most of them can be managed by airway devices currently available, including fiberoptic intubation, video-laryngoscopy, and supra-glottic airways.

There are some airways that are even more difficult, that cannot be ventilated by bag/mask nor intubated with standard airway devices by reasonably skilled operators. Some of these airways cannot be intubated using video-laryngoscopy. These are the “life-threatening” airways that can develop into severe hypoxic situations all too quickly.

These airways require awake intubation, usually fiberoptic. The skill and experience of the “intubator” and assistants is obviously a prime factor in their outcomes. A definitive management plan that includes alternative strategies can be helpful. When fiberoptic intubation fails, placing an LMA may provide a conduit for fiberoptic intubation, and may also permit oxygenation. In an emergency, LMAs can be placed awake, with some topical anesthesia (spray the mouth, topical anesthetic gel on the LMA.)

When the tongue is blocking the view of the glottis, using a malleable surgical retractor (see section 4a, page 9)) may help provide a view, and nasal intubation may be better than oral.

Suggested Reading

2. Ovassapian, A: Fiberoptic Endoscopy and the Difficult Airway (2nd Edn); 1996, Lippincott Williams & Wilkins.
Introduction to Intraoperative 3D Valve Evaluation

Dan Beck, M.D., M.S.
VA Eastern Colorado Health Care
University of Colorado

I have no disclosures or conflicts of interest to report.

3D Valvular Imaging

3D Valve Evaluation Objectives

• Understand basics of 3D technology
• Discuss limitations and advantages of 3D Valve Imaging
• Introduce various 3D modes and applications
• Knobology for 3D image acquisition
• Tips for image acquisition and image cropping

3D Technology

• 3000 pizoelectric crystals in matrix configuration
• Matrix array produces pyramidal volume
• Multiple imaging modalities available
  – X-plane 2D imaging – 2 images real time 90° apart
  – 3D Live or real time imaging
  – 3D ECG gated multiple beat imaging

3D Limitations

• Data derived by basic ultrasound principles
  – Poor 2D images will lead to poor 3D images
  – Far Field images crossing multiple tissue planes
  – Calcified valves or annulus with image dropout
• Frame rate limitations well below 2D
  – Visualizing complex valvular movement limited
• Learning Curve for acquisition
### 3D Valvular Imaging Advantages

- Teaches scanning planes from standardized TEE views
- Helps in location of valvular pathology for less experienced users
- Easy to display image improves communicating information to surgeons

### Live or Real Time Imaging

- Live 3D Mode
  - Real time, narrow sector
  - Preserves temporal and spatial resolution
  - Trade off is volume of sector
- Typically can’t fit full MV in one image
- Can rotate image using track ball
- Continue to manipulate probe to optimize image

### Live 3D Aortic Valve

![3D Aortic Valve Image]

### Other Live Imaging Modes

- 3D Zoom Mode
  - Wide Sector
  - Decreased spatial and temporal resolution
  - Region is adjustable
  - Larger ROI will further decrease resolution
  - Image is rotational in 3D space during live imaging

### 3D Zoom Mode

![3D Zoom Mode Image]

### Gated Multi-Beat Imaging

- Largest sector available in 3D imaging
- With and without Doppler color flow
- 4+ beats required for full volume
- ECG gating
  - Regular rhythm necessary
- Apnea required to prevent heart translation
- Optimal spatial resolution for detecting complex pathology
Beck, Dan, MD, MS

Introduction to Intraoperative 3D Valve Evaluation

3D Volume Set

3D Gating Artifacts

Current Guidelines

GUIDELINES AND STANDARDS

EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography

(J Am Soc Echocardiogr 2012;25:3-46.)

Standardized Imaging

Table 3: Protocol for three-dimensional echocardiography

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<th>Patient's Month</th>
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(J Am Soc Echocardiogr 2012;25:3-46.)

Mitral Valve Imaging

Aortic Valve Imaging

Mitral Valve

Aortic Valve

Mitral Valve

Aortic Valve
Aortic Valve

- Motion artifacts
  - Regular rhythm and gating essential
- Aortic Valves highly calcified
  - Dropout artifacts limiting visualization
- Aortic perspective most helpful for valvular anatomy
  - Subvalvular view may improve color insufficiency evaluation

Mitral Valve Full Volume

1. 4 Chamber optimized 2D Image of MV
2. Decrease depth to top of papillary muscle
3. Adjust Focus to level of mitral valve
4. Set Gain to 50 and optimize image with TGC while in Live 3D or 3D Zoom real time mode

Knobology

Image Optimization

Mitral Valve Full Volume

1. 4 Chamber optimized 2D Image of MV
2. Decrease depth to top of papillary muscle
3. Adjust Focus to level of mitral valve
4. Set Gain to 50 and optimize image with TGC while in Live 3D or 3D Zoom real time mode
5. Select Full Volume
6. Adjust Your Line Density based on image
   - Hold Respiartions
7. Acquire Image

Post Acquisition Processing

- Review Image
- Adjust gain to optimize image
- Crop image to visualize item of interest
3D touch controls

Cropping Green Plane

Post Acquisition Processing
- Review Image
- Adjust gain to optimize image
- Crop image to visualize item of interest
- Rotate around Z axis (base of heart) to orient valve to surgeon-enface view

Rotate the Image

Mitral Valve Surgeon’s View

Save Your Changes
Summary

• 3D can’t show you anything 2D won’t
  – Optimize your 2D images before trying 3D
• 3D matrix probe has multiple viewing options
  – Orthogonal 2D imaging
  – Live Mode and ECG gated multi-beat modes
• Exchange spatial and temporal resolution
• Unlimited post processing options
Transesophageal Echocardiographic Image Acquisition and Recognition of 20 Standard Views

Bryan Ahlgren DO

Objectives:

- To understand TEE probe manipulations and their impact on scan planes
- To be able to recognize the 2D standard views fundamental to a complete examination
- To be able to identify key cardiac structures from the above views

TEE probe manipulation

There are five possible manipulations of the TEE probe. These include moving the probe up or down within the esophagus to obtain different levels of imaging, termed advancing or withdrawing. The probe may be rotated counterclockwise (to the patient’s left) or clockwise (to the patients right). The tip of the probe can be flexed anteriorly or posteriorly using the large control wheel termed anteflexion and retroflexion, and also to the right or left using the small control wheel termed right or left probe flexion. Finally the the transducer within the probe can rotate from 0 to 180 degrees, termed omniplaning.

The SCA and ASE have produced guidelines for performing an intraoperative TEE examination and have standardized the nomenclature in order to ensure a common language and completeness of examinations. They have defined 20 cross sectional views which are fundamental in the performance of a complete examination.

Anesth Analg 1999;89:870-884
Ahlgren, Bryan, DO  
TEE for the General Anesthesiologist

Anesth Analg 1999; 89: 870-884
Doppler Modalities

Bryan Ahlgren DO

Objectives:

- Understand the Doppler equation and its use in clinical echocardiography
- Understand the benefits and limitations of commonly used Doppler modalities including pulse wave, continuous wave, and color flow
- Be able to apply, and accurately interpret appropriate Doppler modality in commonly used echocardiographic scenarios

Doppler ultrasonography allows us to visualize and assess velocity and direction of blood flow in the cardiovascular system. Doppler technology is based on measuring the change in frequency of ultrasound waves reflected from red blood cells.

The Doppler Equation

\[
F_d = \frac{2F_t V \cos \Theta}{C}
\]

Where \( F_d \) is the change in frequency or frequency shift, \( F_t \) is the transmitted frequency, \( V \) is the velocity of blood flow, \( C \) is the speed of sound through tissues, and \( \cos \Theta \) is the incident angle of the ultrasound wave and direction of blood flow.

Pulse wave Doppler- The pulsed wave transducer uses a single crystal as both the emitter and the receiver of ultrasound waves. It switches from emitter to receiver, because the speed of sound in tissue is constant (C), the time delay for the signal to reach its target and return to the transducer is based solely on the distance (d) to the target. Using this principle the ultrasound machine can time gate the returning signals and subsequently determine the exact location of those Doppler shifts and therefore directional velocities. Unfortunately because the Doppler data is collected intermittently and the transducer must wait for returning signals, the maximal blood flow velocity that can be measured is limited. The limitation of the measurement of maximal velocity is determined by the aliasing phenomenon. The maximum velocity can be measured by pulse wave Doppler is about 1.9 m/s.

Continuous wave Doppler- The continuous wave Doppler technique avoids the maximal velocity limitation of the pulsed wave system, though loses the ability to accurately determine the exact location of the returning Doppler shifts. The transducer of a continuous wave system uses two crystals, one continuously emitting and one continuously receiving signals. Because it does not use time gating, returning velocities are measured along the entire beam path, not relegated to the sample volume as in pulse wave, this is referred to as range ambiguity.

Color Flow Mapping- Color flow Doppler displays both direction and velocity of blood flow superimposed upon a 2D ultrasound picture of cardiac anatomy. Color flow uses pulsed wave Doppler technology with a few caveats. Instead of selecting a single sample volume, multiple sample volumes
along multiple sector scan lines are measured in rapid succession. The returning signals are analyzed and assigned a specific color based on the direction and magnitude of blood flow. By convention red shades indicate blood flow moving toward the transducer and blue shades indicate blood flow away from the transducer. Because the transducer is using pulse wave technology in order to display the color flow, it is subject to the same limitations. In fact because multiple samples are being taken at different depths and there is also a superimposed 2D picture, color flow is subject to aliasing artifacts at a lower velocity than traditional pulse wave technology.
A Brief History of 3D Echocardiography and How We Can Currently Use This Technology in Left Ventricular Measurements

Bryan Ahlgren DO

Objectives:
- Understand how the ultrasound machine creates a 3D image
- Understand what information can be gathered from a left ventricular full volume loop

The first 3D ultrasound employed a 2D transducer moved freehand across the chest wall. It was tracked in three dimensions with a spatial tracking. Reconstructing the 3D volume from a 2D image series was difficult and took a lot of computer horsepower but these reconstructions accurately assessed ventricular volumes and ejection fraction.

The next step was the volume-rendered reconstruction using 2D multiplane transducers capable of axially rotating the imaging plane in steps over a full 180 degrees. The resulting data consisted of a 3D cone with known x, y, z coordinates for each ‘voxel’. Axially scanned voxel data sets are reconstructed after the fact, usually offline. These systems allowed better visualization of cardiac structures. However, intra-operative use was hampered by data acquisition requiring up to 60 heartbeats, arrhythmias, and artifacts introduced if the heart's center of mass moves from one beat to another.

The latest 3D TEE technology utilizes fully sampled matrix array transducers, streamlining data acquisition and allowing real-time 3D imaging. A 2–7 MHz transducer incorporates 2500 elements that simultaneously acquire data in a 3D pyramidal fashion, with the ability to focus in on a small region of interest (ROI). In addition to 2D imaging, this transducer has three different 3D acquisition modes. The live 3D mode displays a small pyramidal segment in real time. The 3D zoom mode displays a ROI using a larger pyramidal segment, which is also in real time. The non-real-time ‘full-volume’ mode acquires a wider segment with the greatest spatial and temporal resolution. Full-volume data combine 4–7 subvolumes, acquired over 4–7 cardiac cycles. Color Doppler can be added in the full-volume mode.

**Left Ventricular Functional Measurements Using Real Time 3D TEE: How We Can Get Away From “Eyeballing” It.**

Because the LV is a large structure, 3D full-volume acquisition is the only imaging modality that can capture the entire LV volume at sufficient frame rate (25 Hz) allowing dynamic assessment. After optimizing a 2D image, the full volume function is employed and the ultrasound machine gathers 3D data sets over a set amount of EKG triggered cardiac cycles. Analysis is then done by exporting the dataset into analytical software that enables semi-automated volumetric and dynamic quantification of global and regional LV function.

**Measuring Left Ventricular Volumes:** In a process called direct volumetric analysis the ultrasound machine renders a cast of the LV cavity to measure its volume throughout a cardiac cycle.
cycle. This process requires the initial identification of 4 LV walls and the apex from 2D LV views derived from the full-volume 3D dataset. Semi-automated endocardial border detection then creates a dynamic cast of the LV endocardial cavity. The end-diastolic volume and end-systolic volume are measured, and the stroke volume and ejection fraction are calculated. Although there is little data comparing this method using TEE, the same method using TTE has shown good correlation with cardiac MRI.

**LV Mass** can be similarly measured using the above technique with the difference being that the 3D direct volumetric analysis calculates the difference in end-diastolic volumes from rendered endocardial and epicardial LV casts to estimate the volume of LV myocardium.

**Detection of Wall Motion Abnormalities:** For the assessment of regional LV wall motion, the 3D LV cast is automatically divided into 16 wedges plus an apical cap, resembling the 17 segments of the American Heart Association/American Society of Echocardiography model. Examination of each of the 17 subvolumes allows rapid detection of abnormalities in systolic endocardial motion, (wall motion abnormalities).

**Measurement of LV Dyssynchrony:** Because each of the subvolumes is computed and displayed as volume change over time, the 17 segments can be easily graphed. The standard deviation (SD) of the time to minimal systolic volume of all 17 LV segments is a measure of LV dyssynchrony. The time to minimal systolic volume is the time from the ECG R wave to the minimal systolic volume. The mean and SD are calculated as a percentage of a single cardiac cycle. Although 3D TEE for the assessment of LV dyssynchrony has not yet been investigated, 3D TTE (using the same method) has correlated well with single positron emission CT in the assessment of LV dyssynchrony.
Quantitative Echocardiography

Tamas Seres MD, PhD.

University of Colorado Denver

Transesophageal echocardiography (TEE) is an important monitoring and diagnostic modality in the field of cardiac anesthesia. Due to its reliability and safety its application is extending into other areas of anesthesiology as well. This chapter will provide an overview of the application of TEE to evaluate systolic and diastolic function. Furthermore this chapter provides tools to evaluate pressure gradients through stenotic valves.

The sections are:

I. Systolic Function

Evaluation of systolic function includes the measurement of:

1. Left ventricular end-diastolic and end-systolic volume
2. Ejection fraction (EF)
3. Stroke volume (SV)
4. Cardiac output (CO), cardiac index (CI)
5. Myocardial wall thickness
7. Additional measurements:
   a. LV short axis area measurement and fractional area change
   b. LV internal diameter measurement in M-mode and fractional shortening

II. Diastolic Function

The Phases of Diastole:

1. Isovolumic relaxation time (IVRT)
2. Rapid filling
3. Diastasis  
4. Atrial contraction  

Evaluation of diastolic function with TEE:
1. Mitral Doppler Inflow Velocity  
2. Pulmonary Vein Flow  
3. Tissue Doppler Velocity Measurement  

Evaluation of the Severity of LV Diastolic Dysfunction:
1. Grade I: Impaired relaxation  
2. Grade II: Pseudonormal pattern  
3. Grade III: Restrictive pattern  

Hemodynamic Measurements Using the Diastolic Parameters:
1. High LA Pressure with Depressed EF  
2. High LA pressure with normal EF  

III. Doppler Measurements of Pressure Gradients  
1. Measurement of pressure gradients  
2. Evaluation of LV contractility by measuring pressure gradients in MR
I. Systolic Function

One of the most common indications for a TEE exam in the regular OR is to evaluate left ventricular (LV) systolic function. It is the most important part of the intra-operative exam in cardiac anesthesia before and after cardiopulmonary bypass. The TEE measurements provide parameters to evaluate the remodeling process of the LV and the LV systolic function in patients with chronic or acute heart failure (HF).

Myocardial Remodeling

Myocardial remodeling is thought to be an important aspect of disease progression in heart failure regardless of cause. It is manifested clinically by changes in cardiac size, shape, and function in response to increased load or myocardial injury.

The cause of pathologic myocardial remodeling can be:

1. Pressure overload (eg, aortic stenosis, hypertension)
2. Volume overload (eg, valvular regurgitation)
3. Altered myocardial contractility:
   - Myocardial infarction
   - Inflammatory myocardial disease (myocarditis)
   - Idiopathic dilated cardiomyopathy

1. Pressure overload results in concentric myocardial hypertrophy or remodeling with normal heart volumes and EF.
2. Volume overload results in eccentric myocardial hypertrophy or remodeling with large LVEDV, LVESV, decreased EF and normal or altered SV and CO depending on the functional status of the disease and the effectiveness of the treatment.
3. Altered myocardial contractility is characterized by decreased SV, increased LVESV and LVEDV and decreased EF. The SV can be normal depending on the stage of the remodeling process and the treatment of the heart disease.¹

Systolic function of the Left Ventricle

*Principle*: A heart with normal systolic function generates appropriate CO with low filling pressures for appropriate oxygen delivery to the body to cover the oxygen consumption in rest
or during exercise. Pathological remodeling results in increased myocardial oxygen consumption and LV filling pressures at the same increase in CO, which may manifest in symptoms of HF. The stage of the remodeling is characterized by LVEDV, LVESV and EF and the actual functional capacity is characterized by the SV and CO. For example, a patient with dilated cardiomyopathy has enlarged LVEDV, LVESV and low EF but in compensated stage the SV, CO and LV filling pressures can be normal so the patient does not have symptoms in rest or at mild to moderate exercise. The symptoms of HF derived either from low CO for the actual demand of the body (fatigue) or high LV filling pressures (dyspnea, pulmonary edema). LV remodeling is a complex process with changing functional status of the patient. For example, patients with good exercise tolerance might have dilated heart and low EF. Sometimes patients with normal heart volumes and EF have symptoms of HF suggesting diastolic dysfunction with high filling pressures. To evaluate a heart disease the stage of HF and the functional status of the patient should be determined:

Stages of HF:
Stage A: Patient has a disease (diabetes, hypertension), which potentially progresses to HF.
Stage B: Patient has signs of remodeling (dilated heart, low EF) without symptoms of HF.
Stage C: Patient has a remodeling heart with symptoms or history of HF.
Stage D: Remodeled heart with symptoms of HF in rest with maximum medical therapy.

The functional status of the patient graded by the New York Heart Association classification:
NYHA I: no symptoms of HF at exercise.
NYHA II: symptoms of HF at moderate exercise.
NYHA III: symptoms of HF at mild exercise.
NYHA IV: symptoms of HF at rest.

For anesthesia practice patient with stage C HF can be problematic because the patient can be in NYHA III-IV functional status but with medical therapy can go back to NYHA II status and can tolerate different type of surgeries. Patient with stage D HF is waiting for assist device or heart transplantation in a NYHA IV functional status. With the assist device the patient is still in stage D HF but the functional status can go back to NYHA II-III and can tolerate surgeries.
Image planes: For the evaluation of the LV volumes and systolic function the following ME image planes are considered:\textsuperscript{3, 4}

1. ME 4-chamber view
2. ME 2-chamber view
3. ME long axis (LAX) view

Transgastric (TG) views are used for diameter, area change and direct Doppler measurements:

1. TG mid short axis (SAX) view
2. Deep TG view
3. TG LAX

Evaluation of systolic function includes the measurement of:

1. Left ventricular end-diastolic and end-systolic volume (LVEDV and LVESV)
2. Ejection fraction (EF)
3. Stroke volume (SV)
4. Cardiac output (CO), cardiac index (CI)
5. Myocardial wall thickness
7. Additional measurements:
   a. LV short axis area measurement and fractional area change
   b. LV internal diameter measurement in M-mode and fractional shortening

1. LVEDV and LVESV Measurement using 2D Images

*Principle:* When the left ventricle (LV) contracts it shortens the left ventricle's long axis, short axis, and there is a twisting effect where the base and the apex rotate around the long axis of the left ventricle. During systolic contraction the longitudinally oriented subendocardial and subepicardial fibers cause the shortening of the long axis and the circumferentially running midwall fibers contribute to the shortening of the short axis of the LV and to the major portion (80\%) of the SV. The twisting effect is mostly due to the spiral arrangement of the cardiac musculature. Based on the complex pattern of the LV systolic contraction the midesophageal (ME) LV views are the most appropriate to evaluate the long and short axis changes as well as segmental motion.\textsuperscript{5} To localize the end-diastolic and end-systolic phase, the ECG can be used.
End-systole occurs at the peak of the T wave and end-diastole occurs at the peak of the QRS wave.

LVEDV and LVESV are measured by using the method of discs (MOD) or Simpson’s method by using two ME views. The Simpson’s method slices the LV into several discs and measures the volume of each disc. Aberrations in LV shape will not introduce as much error into the result compared to other standard measurements.\(^6\)

*Image planes:* ME 4-chamber and 2-chamber views

*Measurement:* The measurement is performed by tracing the endocardial border of the LV in 4-chamber and 2-chamber views in end-diastole and end-systole. After tracing the endocardial border under the option of MOD the computer automatically calculates the volumes (Figure 1). Normal values can be seen in Table 1.

**LVEDV and LVESV Measurement by Using M-mode Images**

*Principle:* The measurement of left ventricular internal diameter at end-diastole (LVIDd) and end-systole (LVIDs) can be used for mathematical assumption of the LV volume using the Teicholtz method.

*Image planes:* TG SAX mid-papillary view

*Measurement:* The diameter can be measured by caliper under the M-mode measurement option and the volume will be calculated by the computer of the echo machine using the Teicholz method: \(V = \left[ \frac{7}{2.4 + \text{LVID}} \right] \times \text{LVID}^3\)

*Comment:* The measurement of LVEDV, LVESV and EF with the Teicholz method requires absence of regional wall motion abnormalities and normal shape of the LV (Figure 1).\(^7\)

2. **Ejection Fraction**

*Principle:* EF can be calculated quantitatively by using the volumes measured by the Simpson’s or Teicholz methods (Figure 1):

\[ \text{EF} = \frac{(\text{EDV-ESV})}{\text{EDV}} \times 100 \]

*Normal values:* 55-75%

*Comment:* The advantage of ejection fraction is the uniformity among patients. While the patient’s size, body habitus, and sex may be different, ejection fraction represents systolic function that is comparable between patients and comparable in a single patient under
different conditions. Preload, afterload and contractility can affect the EF. An increase in preload or contractility as well as a decrease in afterload will increase the EF.


Volumetric Measurement:

*Principle:* SV can be measured by using the volume data of the Simpson’s or Teicholz methods (Figure 1).

\[ SV = EDV - ESV \]

*Normal values:* 70-100 ml

Doppler Measurement:

*Principle:* There is a direct way to measure SV by using pulsed wave Doppler in LV outflow track (LVOT). The SV measurement is based on the concept that the blood is flowing through the LVOT cross sectional area (CSA\textsubscript{LVOT}) with changing velocity during systole. The time integral of the velocity curve (VTI) or the area under the curve is the distance what the blood travels during systole through the CSA\textsubscript{LVOT}. The SV is the product of the CSA\textsubscript{LVOT} x VTI\textsubscript{LVOT}. The velocity curve should be obtained at the level of the measurement of the CSA to get exact result.

*Image plane:* ME LAX view, deep TG view or TG LAX view

*Measurement:* The calculation of CSA\textsubscript{LVOT} is based on the measurement of the diameter (D) of the LVOT in the ME LAX view (Figure 2). Assuming that the LVOT area is a circle, the area is:

\[ CSA_{LVOT} = r^2 \times \pi = (D/2)^2 \times \pi = D^2 \times \pi/4 = D^2 \times 0.785 \]

The measurement of the velocity time integral (VTI\textsubscript{LVOT}) is performed by placing the pulsed wave Doppler (PWD) cursor at the site of the measurement of the diameter of the CSA\textsubscript{LVOT} in deep TG or TG LAX view (Figure 2 and 3). The velocity curve can be traced and the peak and mean velocity as well as the VTI\textsubscript{LVOT} can be obtained.

The SV is calculated as follows:

\[ SV = CSA_{LVOT} \times VTI_{LVOT} \] (Figure 3)

*Comment:* The SV derived from volumetric measurements can be different from Doppler SV measurement in the LVOT. For example in a patient with mitral regurgitation or ventricular septal defect the volumetric SV is bigger than the Doppler SV. The difference is the regurgitant or the shunt volume, respectively.
SV can be measured at the level of the pulmonary artery (PA), the mitral and tricuspid valve. These measurements are less reliable because of difficulty to measure the diameters of these structures. The shunt volume can be measured in ASD or VSD comparing the SV at LVOT to SV at the PA. Shunt volume = SV at the PA – SV at LVOT

4. Cardiac Output and Cardiac Index

*Principle:* The measured SV is multiplied with the heart rate (HR) to obtain the CO:

\[ \text{CO} = \text{SV} \times \text{HR} \]

Cardiac Index (CI): CO/Body Surface Area (BSA)

*Normal values:* 2.5-4.2 l/min/m²

*Comment:* LV systolic function and CO are dynamic, responding rapidly to metabolic demands. CO increases from 6 l/min to 18 l/min with exercise. Most of the increase in CO is mediated by an increase in heart rate. The increase in SV is 20-35%. With exercise, LVEDV is unchanged, EF and SV increases and LVESV decreases.

5. Myocardial wall thickness:

*Principle:* The left ventricular wall has similar thickness in the different walls. If the ventricle becomes hypertrophied, the wall thickness will increase. The heart can hypertrophy symmetrically or asymmetrically. Symmetrical hypertrophy occurs when the walls thicken proportionally. In asymmetrical hypertrophy, the posterior wall remains unaffected, while other walls may increase in thickness. Therefore, in asymmetrical hypertrophy, the septal or other wall and posterior wall thickness ratio is increased.

*Image plane:* TG SAX view, ME LV views

*Measurement:* The wall thickness is measured from endocardial to epicardial border, except the septum, which is measured from right ventricular to left ventricular endocardial border.

*Normal values:* <1.1 cm

*Comments:* These measurements are important to evaluate patients with hypertension, aortic stenosis, and hypertrophic cardiomyopathy.⁹

6. Evaluation of regional wall motion abnormality (RWMA):

*Principle:* The LV is divided to 16 segments to describe the wall motion of different areas supplied by different coronary arteries. There are basal, mid and apical segments. There are 6
segments in the basal and mid level (anterior, anteroseptal, septal, inferior, posterior, lateral) and 4 segments at apical level (anterior, septal, inferior, lateral).

*Image planes:* To evaluate the different segments multiple views should be used: ME 4-chamber, ME 2-chamber, ME LAX views. TG SAX views are frequently used to evaluate the short axis movement of the segments.

*Measurement of wall motion:* During systole, the myocardial wall thickens and the endocardial wall moves towards the center of the heart (wall motion). In current clinical practice, analysis of LV segmental function is based on a qualitative visual assessment of the motion and thickening of a segment during systole. The recommended qualitative grading scale for wall motion is:

1. normal (>30% movement of the endocardium to the center of the LV)
2. mildly hypokinetic (10% to 30% movement of the endocardium)
3. severely hypokinetic (<10% movement of the endocardium)
4. akinetic (does not thicken)
5. dyskinetic (moves paradoxically during systole).

*Comments:* RWMA represents segmental systolic dysfunction and alters long-term morbidity and mortality in ischemic heart disease. The causes of RWMA include ischemia, infarction, hibernation, stunning, bundle branch block, pacemaker or artifact. Myocardial ischemia can be detected early by monitoring wall motion in intraoperative setting.

**7/a. LV Short Axis Area Measurement**

*Principle:* More than 80% of the SV is due to the shortening of the short axis. Therefore, the change in area during systole in LV short axis view at mid papillary level may represent the systolic volume change of the LV.

*Image planes:* TG mid SAX

*Measurement:* The LV Left ventricular areas are measured by manual planimetry of the area of the LV at end-diastole (EDA) and end-systole (ESA) excluding the papillary muscles (Figure 4).

*Normal values:* EDA: 9.5-22 cm², ESA: 4-11.6 cm²

*Comments:* Volume administration will increase the preload and the EDA of the LV. Changes of ESA may reflect the changes in contractility (increased contractility decreases ESA) or afterload (increased afterload increases ESA). Qualitatively, if the papillary muscles are seen "kissing" or
making contact during systole, then hypovolemia (most frequent), low peripheral resistance, or increased contractility can be present.¹¹

**Fractional area change**

*Principle:* The area change during systole compared to the EDA is the fractional area change (FAC), which correlates well with EF (Figure 4).

\[
FAC = \frac{EDA-ESA}{EDA} \times 100
\]

*Normal values:* 40-75%

*Comment:* Although the value of FAC is generally used for off-line quantitative analysis, a qualitative assessment of ESA, EDA and FAC is important in evaluating the etiology of hemodynamic instability. ³

7/b. LV Internal Diameter Measurements in 2D or M-mode Images

*Principle:* LV internal diameters in diastole (LVIDd) and systole (LVIDs) can be measured either in 2D or M-mode images. Internal diameters can be obtained easily and they are characteristic in different remodeling conditions.

*Image planes:* TG mid SAX view

*Measurement:* After obtaining the TG mid SAX view the diameter of the LV can be measured in diastole (LVIDd) or in systole (LVIDs) by using a caliper in the M-mode option of the echo software (Figure 1).

*Normal values:* Table I.

*Comments:* The papillary muscles should be excluded from the measurement. The LVIDd and LVIDs can be used to evaluate eccentric remodeling in regurgitation of mitral or aortic valve.¹²

**Fractional shortening (FS)**

*Principle:* Percentage change in the LV internal diameter during systole compared to end-diastole. It can be used to evaluate LV systolic function.

\[
FS = \frac{LVIDd-LVIDs}{LVIDd} \times 100
\]

*Normal values:* 28-44%.

*Measurement:* Under the M-mode option after the measurement of LVIDd and LVIDs the echo machine calculates the FS (Figure 1).
Comments: FS has restricted value in evaluating systolic function because it measures changes only in a narrow segment of the LV in one dimension.\textsuperscript{3}
II. Diastolic Function

*Principle:* The optimal performance of the left ventricle depends on its ability to cycle between two states:

1. A compliant chamber in diastole that allows the left ventricle to fill with low left atrial (LA) pressure
2. A stiff chamber with rapidly rising pressure in systole that ejects the stroke volume at arterial pressures.

Furthermore, the stroke volume must increase in response to demand, such as exercise, without much increase in LA pressure. Elevated filling pressures are the main physiologic consequence of diastolic dysfunction. Filling pressures are considered elevated when the mean pulmonary capillary wedge pressure (PCWP) is >12 mmHg or when the LVEDP is >16 mmHg. Impaired left ventricular relaxation and/or poor left ventricular compliance may lead to elevated filling pressures with or without the clinical symptoms of heart failure. Diastolic HF represents patients with abnormal diastolic function and normal EF. The staging and functional classes of diastolic HF are the same as it was described for systolic HF. ²

The Phases of Diastole:

1. **Isovolumic relaxation time (IVRT)**
2. **Rapid filling**
3. **Diastasis**
4. **Atrial contraction**

1. **IVRT:** The time from the aortic valve closure to mitral valve opening. During isovolumic relaxation the volume of the left ventricle is constant but the pressure falls. The period of IVRT ends when the mitral valve opens. The period of IVRT is an active, ATP burning phase. The mitral valve will open when the LAP exceeds the LV pressure. If the LA pressure is elevated the IVRT will be shortened. Conversely, if the relaxation of the left ventricle is decreased, then the IVRT will be increased. If the LA pressure is increased with decreased relaxation, then the IVRT can become normal, or if the LA pressure is markedly increased, the IVRT can even be decreased.
2. **Rapid filling phase:** The rapid filling phase accounts for most of the filling of the left ventricle (80%). The factors that account for the amount of filling during this phase are the left ventricular suction, pressure difference between the left atrium and the left ventricle, the left ventricular compliance, and the left atrial volume.

3. **Diastasis:** During diastasis the LA-LV pressure difference is small. Filling of the left ventricle (5%) is mostly due to pulmonary venous flow with the LA acting as a conduit. Left ventricular compliance is the main determinant of filling during diastasis.

4. **Atrial contraction:** Factors determining the filling of the left ventricle (15-20%) from an atrial contraction are ventricular compliance, pericardial restraint, atrial contractility, and electrical synchrony (PR interval). ², ¹³

**Evaluation of diastolic function with TEE:**

1. **Mitral Doppler Inflow Velocity**
2. **Pulmonary Vein Flow**
3. **Tissue Doppler Velocity Measurement**

**1. Mitral Doppler Inflow Velocity**

*Principle:* Pulsed wave Doppler is used to visualize the flow through the mitral valve. The early diastolic wave of the mitral inflow is the E wave. In normal patients the LV relaxation and untwisting generate negative pressure in the LV at the time of the opening of the MV. This suctioning effect is even more effective during exercise in normal condition avoiding significant increase in LA pressure during early diastole. The second wave or A wave is generated by the atrial contraction.

The velocity of E and A, their ratio, deceleration time (DT) of E, and duration of A are used to characterize the diastolic function (Figure 5).

*Image plane:* ME 4-chamber view

*Measurements:* The PWD cursor is positioned at the tip of the mitral leaflets to gain the best possible velocity curve. Maximum velocity of the E and A wave is measured by using the velocity scale. Deceleration time of the E wave can be measured by using the slope
measurement tool, which calculates the time from the maximum velocity to zero velocity. The duration of the A wave can be measured by time measurement options (Figure 5).

**Comments:** Decreased relaxation accompanies decreased E wave, E/A ratio and increased A wave. Increased LA pressure increases the PG during early diastole resulting in high E wave and E/A ratio. Increased LV end-diastolic pressure causes decreased A wave velocity and duration (Table 2).

### 2. Pulmonary Vein Flow

**Principle:** Pulsed wave Doppler is used to measure the velocity of the flow through the left upper or other pulmonary veins. The wave during LV systole is the S wave, which has two components. The S1 wave represents the relaxation of the LA after atrial contraction. The S2 wave is more prominent than S1 and represents the flow from the pulmonary vein into the LA during LV systole due to the movement of the closed MV toward the LV apex. The D wave represents the flow from the pulmonary vein into the LA during early diastole after the opening of the MV. The A reversal (Ar) is a flow from the LA into the pulmonary vein during the atrial contraction (Figure 5).

**Image plane:** ME 2-chamber view focusing on the area of left atrial appendage and the left upper pulmonary vein running close to it.

**Measurement:** The PWD cursor is placed into the pulmonary vein and the velocity curve is registered. The velocities of S2, D and Ar waves, the S/D ratio as well as the duration of the Ar wave are measured and used to characterize the diastolic function in addition to the parameters of the mitral inflow.

**Comments:** Increased LA pressure decreases the S wave velocity. Relaxation abnormality decreases the velocity of the D wave. Increased LV end-diastolic pressure may increase the velocity and duration of Ar (Table 2).

### 3. Tissue Doppler Velocity Measurement:

**Principle:** Eliminating high velocity low amplitude signals in color Doppler the low velocity high amplitude movements of the myocardium during systole and diastole can be visualized and measured. The MV annulus is moving toward the apex during systole (S wave). During diastole the MV annulus moves away from the apex during the early and late diastole. The early
diastolic annular velocity has been expressed as $E'$ and the late diastolic velocity as $A'$. The peak velocity of these diastolic movements and their ratio are measured for characterization of the diastolic function parallel with the flow evaluation through the MV and pulmonary vein. For the assessment of global LV diastolic function, it is recommended to acquire and measure tissue Doppler signals at least at the septal and lateral sides of the mitral annulus and their average, given the influence of regional function on these velocities and time intervals (Figure 6).

**Image plane:** ME 4-chamber view using tissue Doppler image.

**Measurement:** For obtaining the velocity curve of the MV annulus the PWD cursor is placed on the septal or lateral edge of the MV annulus in tissue Doppler mode.

**Comments:** Tissue Doppler parameters are important for full evaluation of diastolic function and LV filling pressures. Low $E'$ (<8 cm/s) represents impaired relaxation. The MV inflow $E/ E'$ average tissue Doppler ratio < 8 is usually associated with normal LV filling pressures, whereas a ratio > 13 is associated with increased filling pressures (Table 2).

**Evaluation of the Severity of LV Diastolic Dysfunction:**

Three grades of diastolic dysfunction are identified by Doppler echocardiography:

1. **Grade I: Impaired relaxation**
2. **Grade II: Pseudonormal pattern**
3. **Grade III: Restrictive pattern**

**1. Grade I**

In patients with mild diastolic dysfunction, the mitral $E/A$ ratio is <0.8, DT is >200 ms, IVRT is ≥100 ms, predominant systolic flow is seen in pulmonary venous flow ($S/D \geq 1$), annular $E'$ septal is <8 cm/s and $E'$ lateral is <10 cm/s, and the $E/E'$ average ratio is <8 (Table 2). Patients with mild diastolic function or impaired relaxation have reduced diastolic reserve that can be uncovered by stress testing. These patients usually are in NYHA II functional status. Importantly, even in asymptomatic patients, grade I diastolic dysfunction was associated with a 5-fold higher 3-year to 5-year mortality in comparison with subjects with normal diastolic function. Because the majority of subjects aged >60 years without histories of cardiovascular disease have $E/A$ ratios <1 and DTs >200 ms, such values in the absence of further indicators of cardiovascular disease (eg, LV hypertrophy) can be considered normal for age. Reduced mitral $E/A$ ratio in the
presence of normal annular tissue Doppler velocities can be seen in volume-depleted normal subjects, so an E/A ratio <0.8 should not be universally used to infer the presence of grade I diastolic dysfunction.

2. Grade II

In patients with moderate diastolic dysfunction (pseudonormal pattern), the mitral E/A ratio is 0.8 to 1.5 (pseudonormal) and decreases by >50% during the Valsalva maneuver. DT is 160-200 ms and IVRT is 60-100 ms. E’ septal is <8 cm/s and E’ lateral is <10 cm, the E/E’ average ratio is 9 to 12. Other supporting data include an Ar velocity >30 cm/s and an S/D ratio <1 (Table 2). In some patients with moderate diastolic dysfunction, LV end-diastolic pressure is the only pressure that is increased (mean LA pressure is normal) and it is recognized by Ar duration-A duration (Ar-A) >30 ms. Grade II diastolic dysfunction represents impaired myocardial relaxation with mild to moderate elevation of LV filling pressures due to moderately decreased LV compliance. These patients may have symptoms of HF with NYHA II-III functional status.

3. Grade III

Severe diastolic dysfunction or restrictive LV filling occurs with an E/A ratio >2, DT <160 ms, IVRT <60 ms, E/E’ average ratio >13, S/D <<1, Ar-A >30 ms (Table 2). LV filling may revert to pseudonormal or impaired relaxation pattern with successful therapy in some patients (grade IIIa), whereas in others, LV filling remains restrictive (grade IIIb). The later predicts a high risk for cardiac morbidity and mortality. However, grade IIIb dysfunction should not be determined by a single examination and requires serial studies after treatment is optimized. LA volume is increased in grades II and III of diastolic dysfunction, but can be within normal limits in grade I. Patients with grade III diastolic function may have symptoms of heart failure with NYHA III-IV functional status.

Hemodynamic Measurements Using the Diastolic Parameters

Besides the diastolic patterns elevated LV filling pressures are important characteristics of clinically significant systolic and diastolic dysfunction. The increased filling pressures represent elevated preload. A clinical scenario of elevated preload with small SV and EF suggests significant systolic dysfunction. However, elevated preload with normal SV and EF may
represent significant diastolic dysfunction. Elevated LV filling pressures in the OR might suggest high risk for pulmonary edema in cases with significant fluid shifts and volume changes.

1. High LA Pressure with Depressed EF

Patients with depressed EF but compensated with medications show normal filling pressures and acceptable exercise tolerance. Increasing filling pressures in rest suggest low functional status and symptoms even in rest.

High filling pressures with depressed EF can be present when the E/A ratio ≥2, and DT <160 ms. In case of the E/A ratio between 1 and 2 high filling pressure might present when the E/E’ average >15, the E/Vp ratio ≥2.5, S/D<1, and Ar -A ≥30 ms (Table 3).

2. High LA pressure with normal EF

Patients with normal EF but high filling pressure represent symptomatic diastolic dysfunction.

High filling pressures with normal EF characterized by the E/E’ average is >13. In case the average E/E’ ratio is 9-13 the Ar -A ≥30 ms suggests high LV end-diastolic pressure (Table 3).
III. Doppler Measurements of Pressure Gradients

1. Measurement of pressure gradients

2. Evaluation of LV contractility by measuring pressure gradients in MR

1. Measurement of pressure gradients (PG)

*Principle:* The PG through stenotic valves needs to be evaluated to determine the severity of the valve disease. Based on the physical principle of flow continuity in a closed system wherever the area of the flow is decreasing the velocity is increasing. The velocity is highest at the point where the area is the smallest. In the case of aortic stenosis (AS) or mitral stenosis (MS) the velocity of the flow is highest at the site of the stenosis. Measurement of the peak velocity allows calculating the peak PG at the site of the stenosis by using the simplified Bernoulli equation.

\[ \text{Peak PG} = 4 \times V^2 \]

*V* = the peak velocity of the flow through the stenotic valve

*Image planes:* deep TG or TG long axis view for AS and ME 4-chamber view for MS.\(^8\)

*Measurement:* Continuous wave Doppler (CWD) aligned to the blood flow through the stenotic valve is used to measure the highest velocity in the direction of the flow. After obtaining the velocity curve the curve is traced and the peak and mean PG are determined by the computer of the echo machine. In clinical practice the mean PG gradient is used to determine the severity of the stenosis (Figure 3).

2. Evaluation of LV contractility by measuring pressure gradients in MR

*Principle:* Contractility is described as the change of pressure in the LV over time (dP/dt). The highest dP/dt can be measured during the isovolumetric contraction. The isovolumetric contraction becomes visible for TEE measurement in patients with MR. The MR jet can be used for the measurement of contractility using CWD.

*Image plane:* ME 4-chamber view

*Measurement:* A velocity measurement, early in the flow acceleration phase of systolic ejection, is used to calculate an early pressure, using the Simplified Bernoulli Equation \((\text{PG} = 4 \times V^2)\). Another velocity, later in the flow acceleration phase is used to calculate another pressure. The difference in pressures is the dP part of the dP/dt value. The difference in time between the last
and first velocity measurements make the dt part of the formula. The typical values used are the time difference, in seconds, between the velocity values of 3 m/sec and 1 m/sec. The pressures are $4 \times 3^2 = 36 \text{ mmHg}$ and $4 \times 1^2 = 4 \text{ mmHg}$ with a difference of 32 mmHg divided by the seconds between the velocity measurements (Figure 7).

*Normal value*: 1200 mmHg/sec, abnormal value is <1000 mmHg/sec.

*Comment*: One study found that $dP/dT < 600 \text{ mmHg/sec}$ identified a high risk group with a reduced event-free survival after myocardial infarction.¹⁴
# Table 1.

## LV Systolic Function

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDV (ml):</td>
<td>62-170</td>
<td>55-101</td>
</tr>
<tr>
<td>LVESV (ml):</td>
<td>14-76</td>
<td>13-60</td>
</tr>
<tr>
<td>LVIDd (cm):</td>
<td>4.2-5.9</td>
<td>3.9-5.3</td>
</tr>
<tr>
<td>LVIDs (cm):</td>
<td>2.6-4.0</td>
<td>2.3-3.5</td>
</tr>
<tr>
<td>SV (ml):</td>
<td></td>
<td>70-100</td>
</tr>
<tr>
<td>CO (L/min):</td>
<td>4 - 8</td>
<td></td>
</tr>
<tr>
<td>CI (L/min/m²):</td>
<td>2.5-4.2</td>
<td></td>
</tr>
<tr>
<td>EF (%):</td>
<td>55-70</td>
<td></td>
</tr>
<tr>
<td>FS (%):</td>
<td>28-44</td>
<td></td>
</tr>
<tr>
<td>FAC (%):</td>
<td>40-75</td>
<td></td>
</tr>
<tr>
<td>Wall thickness:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior wall (cm):</td>
<td>0.6-1.1</td>
<td></td>
</tr>
<tr>
<td>Septum (cm):</td>
<td>0.6-1.1</td>
<td></td>
</tr>
<tr>
<td>Contractility (dP/dt)(mmHg):</td>
<td>&gt;1200 (normal)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;1000 (abnormal)</td>
<td></td>
</tr>
</tbody>
</table>
Table 2.

**LV Diastolic Function:**

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased realaxation:</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Increased LV-EDP:</td>
<td></td>
<td>+</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Decreased Compliance:</td>
<td>+</td>
<td>++</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYHA Functional Class:</td>
<td>I</td>
<td>I-II</td>
<td>II-III</td>
<td>III-IV</td>
</tr>
</tbody>
</table>

**Mitral Inflow:**

<table>
<thead>
<tr>
<th></th>
<th>1-2</th>
<th>&lt;0.8</th>
<th>0.8-1.5</th>
<th>≥2</th>
</tr>
</thead>
<tbody>
<tr>
<td>E/A ratio:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DT (msec):</td>
<td>160-200</td>
<td>&gt;200</td>
<td>160-200</td>
<td>&lt;160</td>
</tr>
<tr>
<td>IVRT (msec):</td>
<td>60-100</td>
<td>&gt;100</td>
<td>60-100</td>
<td>&lt;60</td>
</tr>
</tbody>
</table>

**Pulmonary Vein Flow:**

<table>
<thead>
<tr>
<th></th>
<th>≥1</th>
<th>&gt;1</th>
<th>&lt;1</th>
<th>&lt;&lt;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>S/D:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ar(m/s):</td>
<td>&lt;0.35</td>
<td>&lt;0.35</td>
<td>≥0.35</td>
<td>≥0.35</td>
</tr>
<tr>
<td>Ar-A (msec):</td>
<td>&lt;0</td>
<td>&lt;0</td>
<td>≥30</td>
<td>≥30</td>
</tr>
</tbody>
</table>

**Tissue Doppler Velocity of the MV annulus:**

<table>
<thead>
<tr>
<th></th>
<th>&gt;10</th>
<th>&lt;8</th>
<th>&lt;8</th>
<th>&lt;8</th>
</tr>
</thead>
<tbody>
<tr>
<td>E’ (cm/s):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E’/A’ ratio:</td>
<td>1-2</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>E/E’ average ratio:</td>
<td>≤8</td>
<td>≤8</td>
<td>9-12</td>
<td>≥13</td>
</tr>
</tbody>
</table>

**Flow Propagation Velocity:**

<table>
<thead>
<tr>
<th></th>
<th>&gt;50</th>
<th>&lt;50</th>
<th>&lt;50</th>
<th>&lt;50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vp(cm/s):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.

Increased filling pressures suggested by diastolic parameters:

Patient with depressed EF and LA pressure > 12 mmHg:
1. E/A ratio ≥2 and DT < 160 ms
2. E/A ratio 1-2: E′/E′ average > 15
   - E/Vp ratio ≥ 2.5
   - S/D < 1
   - Ar - A ≥ 30 ms

Patient with normal EF and LA pressure > 12 mmHg:
1. E/E′ average > 13
2. E/E′ average 9-13: Ar - A ≥ 30 ms
Figure 1.

Examples for systolic function determined by Simpson’s method and M-mode

Panel A

Simpson’s Method of Disks

EDV = 188 ml  ESV = 158 ml  SV = 30 ml  EF = 16%

Panel B

LV Internal Diameter Measurement with M-mode

LVIDd = 6.8 cm  LVIDs = 6.4 cm  FS = 5.9%

EDV = 239 ml  ESV = 209 ml  SV = 30 ml  EF = 13%

Panel A: LV end-diastolic (EDV) and end-systolic volumes (ESV) were measured in 4-chamber and 2-chamber views by tracing the endocardial border. The LV was divided to disks and the volume was calculated by the summation of the volumes of each disk.

Panel B: The LV internal diameters in diastole (LVIDd) and systole (LVIDs) was measured in the same patient. The EDV and ESV was computed by the Teicholz method. This patient has a dilated heart with severe systolic dysfunction.
Figure 2.

Typical views for LVOT cross sectional area (CSA) measurement

Panel A

Panel B

**LV LAX view**

**Deep TG view**

\[ D = 2.37 \text{ cm} \quad \text{CSA}_{LVOT} = 2.37^2 \times 0.785 = 4.4 \text{ cm}^2 \]

Panel A: The LVOT diameter (bold line) is measured on the LV LAX view and the CSA is calculated using the equation for area of circle.

Panel B: The Deep TG view is seen for Doppler measurements. The arrow shows the direction of the Doppler beam and the tip of the arrow localizes the cursor where the diameter was measured.
Figure 3.

Evaluation of SV and the severity of AS by using PWD and CWD

Panel A

**PWD Deep TG view**

\[ V_{LVOT} = 92 \, \text{cm/s} \quad \text{VTI}_{LVOT} = 26 \, \text{cm} \]

Panel B

**CWD Deep TG view**

\[ V_{AS} = 402 \, \text{cm/s} \quad \text{VTI}_{AS} = 104 \, \text{cm} \]

\[ \text{PG}_{\text{peak}} = 67 \, \text{mmHg} \quad \text{PG}_{\text{mean}} = 32 \, \text{mmHg} \]

Panel A: PWD is used to study the flow and SV in LVOT. The CSA_{LVOT} = 4.4 \, \text{cm}^2 \text{ from Figure 2.}

\[ \text{SV} = \text{CSA}_{LVOT} \times \text{VTI}_{LVOT} = 4.4 \times 26 = 114 \, \text{ml.} \]

Panel B: CWD is used to study the flow at the AS.

The severity of AS can be evaluated by the peak and mean PG measured by CWD.

\[ \text{PG}_{\text{mean}} = 32 \, \text{mmHg} \text{ represents moderate AS.} \]
Fractional area change (FAC) can be calculated from the end-diastolic (EDA) and end-systolic area (ESA).

\[
\text{FAC} = \frac{(16.3 - 7.8)}{16.3} \times 100 = 52\% 
\]
Figure 5.

Evaluation of diastolic function with PWD at the MV and pulmonary vein

**Panel A**

Mitral Inflow

\[ E/A = 0.7/0.45 = 1.55 \quad DT = 193 \text{ ms} \]

**Panel B**

Pulmonary Vein Flow

\[ S/D = 0.6/0.6 = 1 \quad Ar = 0.2 \text{ m/s} \]

Panel A: Mitral valve inflow was obtained with PWD. The early diastolic wave (E) and the atrial kick (A) can be differentiated. The white line represents the deceleration time (DT) measurement.

Panel B: Pulmonary vein flow was obtained with PWD. The S wave represents the flow during systole, the D wave is the early diastolic flow and the Ar is a backflow into the pulmonary veins during the atrial contraction.
Figure 6.

Evaluation of diastolic function with tissue Doppler

Tissue Doppler modality was used and the PWD cursor was placed on the lateral part of the mitral valve annulus. The annulus is moving towards the apex during systole (first negative wave) and away from the apex during early diastole (E') and late diastole or atrial kick (A'). The E/E’ ratio is depending on the LA pressure.
**Figure 7.**

**Measurement of LV contractility using CWD image of the MR jet**

CWD measures the velocity change through the MR orifice. The pressure gradient at 1 m/s and 3 m/s was calculated by using the simplified Bernoulli equation (4 x V^2). The pressure difference and the time difference were determined between the two points and the contractility was computed by using the dP/dt formula.

Contractility (dP/dt) = 32 mmHg / 0.13 s = 2461 mmHg/s

CWD measures the velocity change through the MR orifice. The pressure gradient at 1 m/s and 3 m/s was calculated by using the simplified Bernoulli equation (4 x V^2). The pressure difference and the time difference were determined between the two points and the contractility was computed by using the dP/dt formula.
References:


9. Koren MJ, Devereux RB, Casale PN, Savage DD, Laragh JH. Relation of left ventricular mass and geometry to morbidity and mortality in uncomplicated essential hypertension. Ann Intern Med 1991;114:345-52.


Evaluation of RV function

Ferenc Puskas, MD, PhD
University of Colorado Denver
Division of Cardiothoracic Anesthesiology
ferenc.puskas@ucdenver.edu

Objectives
- Anatomy of RV in relation to function
- RV physiology
- TEE assessment of RV function
- RV enlargement
- RV hypertrophy
- Segmental wall motion
- Cases

RV failure after cardiac surgery
✓ 0.1% after all cardiac surgery
✓ 2 to 3% after heart transplantation
✓ 20 to 30% after LV assist device insertion (1500 per year in the US)

Survival Rate with Severe RV Failure
25% to 30%
or2/3 dies

This highlights the importance of early diagnosis to improve management strategies

Echocardiography is the mainstay in RV assessment
Causes of RV failure during Cardiac Surgery

- Pre-existing RV dysfunction
- RV myocardial infarction
  - air embolism
- Post-CPB RV dysfunction
  - suboptimal myocardial protection
  - long bypass time
- Postoperative Pulmonary HTN
  - preexisting pulmonary HTN
  - ischemia-reperfusion injury
  - PE
  - LV failure
  - massive transfusion

Causes of RV failure during Cardiac Surgery

- Dynamic RVOT obstruction
  - Volume depletion
  - High dose inotropes
- Excessive RV volume loading
  - Transfusion
  - Severe TR
- Acute LV unloading
  - Following LVAD support
- Heart Transplantation

RV Anatomy

- RV is divided into 3:
  1. Inflow (sinus)
     1. Postero-inferior, trabeculated
     2. Tricuspid Valve
  2. Encircling Muscular band
     1. Moderator band, Parietal band, Septal band
  3. Outflow (conus, infundibulum)
     1. Antero-superior, smooth
     2. Pulmonic Valve

RV Anatomy

- Triangular (4-ch view)
- RV_area < 0.6 LV_area
- RV_length = 0.6 LV_length
- Apex = LV, not RV
- RV_wall thickness < 5 mm

RV Anatomy

- RV volume is larger than LV volume
  (RVEDV = 49 to 101 ml/m2, LVEDV = 44 to 89 ml/m2)
- thus RVEF (40 to 68%) is lower than LVEF (57 to 74%)
- RV mass is 1/6 of LV mass
- RV can better adapt to volume overload
**Right Coronary Artery**
- **RCA Acute Marginals** to RV free wall
- **Posterior Descending** supplies posterior 1/3 - 2/3 of ventricular septum, not apex
  - Dominance: 67% RCA, 15% LCA, 18% BALANCED
- Branch to **Posterior LV**
- Branch to **AV node**
- Branch to **SA node** (60% RCA, 40% LCA)

**RV Coronary Perfusion**
- In the absence of hypertrophy or pressure overload, proximal RCA flow occurs during both systole and diastole
- However beyond RV marginal branches diastolic coronary flow dominates
- RV has lower oxygen consumption than LV
- RV’s ability to increase oxygen extraction
  - (During STEMI around 1/3 of the RV myocardium is at risk, however the resulting RV infarct size is usually small)
- Extensive collateral system, from moderator band artery from the LAD first septal perforator

**RV Physiology**
- RV coupled to a low pressure highly distensible arterial system
- Stroke volume
  - $LV = RV$ (if no shunt)
- RV ejection (3 components)
  - Bellows like inward movement of the free wall
  - Longitudinal fiber contraction (tricuspid annulus apical movement)
  - Traction of LV contraction
- RV contraction is sequential, starting from inflow to outflow (25 to 50 ms delay)

**Lung volume, PVR and RV function**
- PVR lowest at FRC
- As total lung capacity increases (hyperinflation) PVR increases
- PEEP increases RV afterload and decreases preload
- PEEP increase 5 to 15 cmH$_2$O
  - RV volume increases
  - RV EF, stroke volume decreases
- PEEP increase above 15 cmH$_2$O
  - RV contractility declines

**Ventricular Interdependence**
- Concept: Size, shape and compliance of 1 ventricle effects the size, shape and compliance of the other ventricle
- Plays an essential part in the pathophysiology of RV dysfunction
- Systolic interdependence mediated through the interventricular septum
- 20 to 40% of RV systolic pressure and volume outflow results from LV contraction

**Ventricular Septum**
- Normally moves with center of mass in LV
- Convex toward RV throughout cardiac cycle
- Abnormal motion with RV pressure and volume overload
Basic RV TEE Views

Mid-Esophageal 4-Ch View

Trans-Gastric Short Axis

Trans-Gastric RV Inflow

Mid-Esophageal 4-Ch View

RV Inflow-Outflow View

Tricuspid Valve TG SA

Echocardiographic Indices of RV Systolic Function

- Geometric Indices
  - RVEF (RV FAC)
  - TAPSE (tricuspid annular plane systolic excursion)
- Myocardial velocity
  - Tricuspid Annular Plane Maximal Velocity
  - Isovolumic Acceleration
- Hemodynamic
  - RV dP/dt
- Time interval
  - Tei index (RV MPI)
Accurate assessment of RVEF is difficult using echocardiography because of complex shape and heavy trabeculation.

**RVFAC**
- Ratio of RV systolic area to end diastolic area
- Measured in four-chamber view
- Correlates well with RVEF in non-segmental disease
- Normal RVFAC: 32% to 60%
  - Mildly abnormal: 25 to 31%
  - Moderate: 18 to 24%
  - Severe: < 17%

**TAPSE**
- Measures the longitudinal systolic motion of the free edge of the tricuspid annulus
- Mid Esophageal 4-chamber view (M-mode)
- 20 to 25 mm (> 15 mm)

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Puskas, Ferenc, MD, PhD
Evaluation of RV Function

CRASH 2012
TAPSE

TAPSE (14.4 mm)

RV and Cardiology

TR Jet for Estimating Pulmonary Artery Pressure
- Simplified Bernoulli Equation
  \[ \Delta P = 4V^2 \]
  Systolic RVP (PAP) = \( \Delta P + RAP \)
- Mid Eso 4-Ch, RV inflow – outflow view

Estimates of RA pressure (spontaneous ventilation)
- IVC < 1.7 cm: CI > 50%: 0 to 5 mm Hg
- IVC > 1.7: CI > 50%: 6 to 10 mm Hg
- IVC > 1.7: CI < 50%: 10 to 15 mm Hg
- IVC > 1.7: fixed: > 15 mm Hg

RV Dysfunction

• CI: Collapse index
**RV Enlargement**

- Volume Overload

**RV Volume Overload**

- Paradoxical septal motion toward RV during systole
- Distinct from septal ischemia (absent septal thickening)
- Distinct from ventricular pacing (early septal translation (LV pre-ejection-septum moves into LV than towards RV))

**Paradoxical Septal Motion**
Paradoxical Septal Motion

Right Atrial Enlargement

RV Hypertrophy
- Pressure Overload
- \( RV_{\text{Wall Thickness}} > 5 \text{mm} \)
  \[ = \frac{LV_{\text{Wall Thickness}}}{LV_{\text{Wall Thickness}}} \]
- Prominent Apical Trabeculations
- Systolic D-shape

RVH

Severe RVH
RVH

RVH from PS

RVH from PS

RV segmental wall motion abnormality

RV Wall Motion

- Qualitative not Quantitative
- Akinesia, Hypokinesia, Dyskinesia
- Multiple Views

RV and Coronary Occlusion

- Proximal RCA (proximal to marginal branches, in a right dominant system) effects: Lateral and inferior RV wall
- PDA occlusion: RV inferior segments
- LAD anterior MI: RV anterior wall
RV wall segments

RV Anterior Wall

Thank you!
THE MITRAL VALVE

Fadi Victor Nasrallah, MD, MBA
Associate Professor
UCD
Denver, Colorado

OUTLINE

- Mitral Valve Anatomy and Function
- Imaging of the Mitral Valve: 2D and 3D
- Review of Normal Parameters
- Mitral Regurgitation
- Mitral Stenosis
- Mitral Valve: Replace or Repair?
- Systolic Anterior Motion

Anatomy

- Think Mitral Valve Complex:
  - Leaflets
  - Chordae
  - Papillary Muscles
  - Left Ventricle
  - Annulus

Anatomy : Leaflets

- Bicuspid valve with large anterior leaflet and a smaller posterior leaflet
- Posterior leaflet is $1/3^{rd}$ the surface area of the valve but accounts for $2/3^{rd}$ of the circumference of the valve
- Anterior leaflet is attached to the same fibrous structure as the left and noncoronary cusps of the aortic valve
MV ANATOMY

Anatomy : Chordae Tendinae
- Approximately 12 chordae are attached to each papillary muscle
- Approximately 120 chordae are attached to each leaflet
- Primary chordae attach to free edge of the leaflets
- Secondary chordae attach to the mid section of the leaflet
- Tertiary chordae attach to the annulus

Anatomy : Papillary Muscles
- Anterolateral and Posteromedial (AL and PM)
- During systole, the PMs contract to keep the chordae tight, the LV moves inward, and the annulus area decreases by 25%
- The result is significant leaflet overlap and prevention of prolapse

Anatomy : Annulus
- Dimensions measured during systole:
  - Intracommissural Diameter : 37 +/- 4 mm
  - Anteroposterior Diameter : 30 +/- 3 mm
  - IC/AP ratio : 1.25 +/- .14
A Complete Exam

- 2D Echo / 3D Echo
- Annulus Measurements
- Color Doppler
- Pulmonary Vein Flow Profile
- Valve Gradient
- Valve Area

IMAGING OF THE MITRAL VALVE

- MV Axis
- ME 4-Chamber
- ME Mitral Commissural
- ME 2-Chamber
- ME LAX
- TG 2-Chamber
- TG Basal SAX
MITRAL REGURGITATION

EVALUATION OF THE MECHANISM OF MR LESION

■ ANATOMIC FUNCTIONAL MECHANISMS:
  - Normal Leaflet Motion
    Annular dilatation causing poor coaptation
    Destruction of leaflet tissue
    Vegetation
    Tumor
    Cleft in valve

■ ANATOMIC FUNCTIONAL MECHANISMS:
  - Excessive Leaflet Motion
    Prolapse due to elongated leaflet or chordae
    Flail leaflet due to ruptured chordae or papillary muscle.
  - Reduced Leaflet Motion
    Shortened thickened leaflets
    Shortened thickened chordae

EVALUATION OF THE MECHANISM OF MR LESION

■ PATHOLOGIC CAUSES:
  - Rheumatic
  - Myxomatous Degeneration
  - Connective Tissue Disease
  - Endocarditis
  - Trauma
  - Congenital
OTHER ECHO FINDINGS

- Enlarged LA
- Enlarged LV, volume overload
- Expansion of LA during ventricular systole
- Rightward bowing of the interatrial septum during ventricular systole
- Enlarged pulmonary artery

PHYSIOLOGIC ASSESSMENT OF THE SEVERITY OF MR LESION

- PULSED WAVE DOPPLER:
  - Evaluate flow across mitral valve to determine presence of concomitant mitral stenosis
  - Evaluate pulmonary vein flow for flow reversal

- COLOR FLOW DOPPLER:
  - Evaluate jet direction
  - Color map of the jet area
  - Measure jet area versus left atrium area
  - Vena contracta width
  - Calculate the regurgitant volume and fraction
ESTIMATION OF THE SEVERITY OF MR LESION
Grading Mitral Regurgitation (ASE Guidelines):

- Jet area (cm²): Mild: <4 Severe: >8
- Percentage of LA area (%): Mild: <20 Severe: >40
- Vena Contracta (cm): Mild: <0.3 Severe: ≥ 0.5
- Regurgitant Fraction (%): Mild: <20 Severe: ≥ 60
- Regurgitant orifice area (cm²): Mild: <0.1 Severe: ≥ 0.35

PW of MV: concomitant MS
PW of LUPV: S wave blunting
TRANSLATION OF FINDINGS ON TEE

Color Jet Area Map
Regurgitant Jet Versus Left Atrium Area
Vena Contracta Width

Example:

- Jet area (cm²): 4.92 cm²
- Percentage of LA area (%): 35%
- Vena Contracta (cm): 0.83 cm

MODERATE TO SEVERE MR!

Calculation of Regurgitant Volume

- \( RV = \text{Volume that crosses MV in diastole} - \text{SV across the LVOT in systole} \)

VTI Across Mitral Valve
Diameter of Mitral Valve
VTI Across LVOT
Diameter of LVOT
Regurgitant Volume and Fraction
Example:

- \( RV = (\text{Area}_{MV} \times \text{VTI}) - (\text{Area}_{LVOT} \times \text{VTI}) \)
- \( RV = (0.785 \times 3 \times 3.6 \times 17.3) - (3.14 \times 1.17 \times 1.17 \times 13.8) \)
- \( RV = 146 - 60 = 86 \)
- \( RF = \frac{86}{146} = 59\% \)

**MODERATE to Severe MR!!**

**PISA**

- Proximal: As blood converges to pass through a regurgitant orifice
- Isovelocity: It must accelerate so that the same volume of blood moving backward towards that narrow orifice can pass through it
- Surface Area: The accelerating blood cells will reach the aliasing velocity that is set by the Echo machine. The color change represents the surface of the hemisphere with the RBCs are moving with the same velocity

**Aliasing Velocity Determination**

**PISA**

<table>
<thead>
<tr>
<th>Surface area of hemisphere (cm²)</th>
<th>Aliasing velocity (cm/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regurgitant Orifice Area (cm²)</td>
<td>Peak velocity through the orifice (cm/sec)</td>
</tr>
</tbody>
</table>

must equal
ROA by PISA

- ROA(cm2) = 2 \pi r^2/Vo x Va (cm/sec)
  - r: radius of first color reversal semicircle on the ventricular side of the mitral valve during systole
  - Vo: Peak velocity of regurgitant jet by CW Doppler.
  - Va: Nyquist limit read off the color bar

Example:

\[ V_a = 61.6 \text{ cm/s} \quad r = 0.75 \text{ cm} \]
\[ V_o = 344 \text{ cm/sec} \]

Plug into Equation

- ROA(cm2) = 2 \pi r^2/Vo x Va (cm/sec)
- ROA(cm2) = 2 \times 3.14 \times 0.75 \times 0.75 \times 61.6/344
- ROA = 0.63 \text{ cm}^2

SEVERE MR !!!!!!!
INTRAOPERATIVE TEE ASSESSMENT OF MITRAL REGURGITATION: REPLACE OR REPAIR?

MITRAL REGURGITATION

- The Mitral valve leaflets:
  - The degree of MR
  - The specific location of the prolapsing or flail leaflet segments
  - Areas of tethering and restriction
  - Areas of normal leaflet function
  - Perforation, calcification, excessive length, mobility

MITRAL REGURGITATION

- Subvalvular Apparatus:
  - Chordal thickening
  - Papillary muscle and ventricular wall function, presence of LA enlargement
  - Robust secondary chordae that may be suitable for transposition to prolapsed leaflets
  - Simulate awake state with inotropes

CARPENTIER CLASSIFICATION

A pathophysiological classification of valvular dysfunction and specific reparative techniques for each:
- Type I - normal leaflet, normal chordal motion
- Type II - leaflet prolapse, excessive chordal motion
- Type III - restricted leaflet or restricted chordal motion
COMMONLY REPAIRED LESIONS

- Isolated P2 prolapse: Resection and ring annuloplasty
- If excessive leaflet length: Sliding leaflet plasty
- Isolated anterior leaflet prolapse: Chordal transfer, artificial chordal replacement, chordal shortening (poor long term outcome)

COMMONLY REPAIRED LESIONS

- Bileaflet Prolapse: Combined quadrangular resection and chordal procedure
- Papillary Muscle Rupture: Usually the posteromedial papillary muscle. Reimplantation or MVR
- Ischemic MR: CABG, repair vs MVR?
- Cardiomyopathy: Annuloplasty
MITRAL STENOSIS

FADI VICTOR NASRALLAH
UCHSC
DENVER, COLORADO

ETIOLOGY OF MITRAL STENOSIS
- Rheumatic Heart Disease
- Annular Calcification
- Congenital
- Left Atrial Myxoma
- Prosthetic Valve Stenosis
- Endocarditis
- Left Atrial Thrombi

ETIOLOGY OF MITRAL STENOSIS
- Cor Triatriatum
- Malfunction of mitral valve prosthesis
- Inadequate size of mitral valve prosthesis

TEE FINDINGS IN MITRAL STENOSIS
- Diastolic doming of the anterior mitral leaflet (“hockey stick appearance”)
- Thickened, calcified leaflets, especially the leaflet tips
- Thickening, fusion, and shortening of the chordae tendinae, especially in rheumatic heart disease
OTHER FINDINGS ON TEE

- Left atrial enlargement, with spontaneous contrast (smoke) in the left atrium
- Left atrial thrombi
- Left atrial appendage thrombi
- Small, underfilled LV with nl contractility
- Right ventricular, right atrial, and pulmonary artery enlargement
- Increased peak and mean gradient across the valve.
  - Include both the E and A wave in the calculation
  - There is no A wave in atrial fibrillation
  - Modified Bernouilli equation gradient:
    \[ P2-P1 = 4v^2 \]

CW or PW DOPPLER FINDINGS

- Increased E wave velocity (>1.3m/sec)
- Prolonged Pressure half-time:
  - Rate of decrease in diastolic flow after E wave is decreased (slope is flat, descent is prolonged)

COLOR FLOW DOPPLER FINDINGS

- Turbulence or aliasing across the valve during diastole
- PISA on the left atrial side of the valve

CALCULATION OF VALVE AREA

- Planimetry:
  - Visualize the MV orifice in diastole from a TG basal short-axis view
  - Scan the MV orifice superiorly to inferiorly to acquire the smallest orifice
  - Optimize the gain settings
CALCULATION OF VALVE AREA

- Pressure Half-time:
  - The time required for the atrioventricular pressure difference to decrease from the maximum to one-half that value
  - The more severe the MS, the slower the rate of pressure decline
  - MVA = 220/PHT

CALCULATION OF VALVE AREA

- Deceleration time:
  - The interval between the peak velocity and the time at which the extrapolated inflow velocity reaches baseline
  - MVA = 759/Deceleration time (ms)

CALCULATION OF VALVE AREA

- The Continuity Equation:
  - In the absence of regurgitation or shunts, flow volume at the MV should equal that at another valve
  - Flow = Area 1 x Time-Velocity Integral 1
    = Area 2 x Time-Velocity Integral 2
  - MVA = LVOT Area x LVOT TVI / MV TVI
  - MVA = d2 x .785 x LVOT TVI / MV TVI

CALCULATION OF VALVE AREA PISA

- Proximal: As blood converges to pass through a stenosed orifice
- Isovelocity: It must accelerate so that the same volume of blood moving towards that narrow orifice can pass through it
- Surface Area: The accelerating blood cells will reach the aliasing velocity that is set by the Echo machine. The color change represents the surface of the hemisphere with the RBCs are moving with the same velocity
- Can be used in the presence of regurgitation and shunts
PISA
Surface area of hemisphere \( \times \) Aliasing velocity
(cm²) (cm/sec)

must equal

Mitral Valve Area \( \times \) Peak velocity
(cm²) through the orifice (cm/sec)

PISA
- MVA(MS). \( V_{\text{peak}} = A \times \text{Aliasing velocity} \times \text{V(aliasing)} \)
- MVA(cm²) = \( 2 \pi r^2 \times \frac{\alpha}{180} \times \frac{V_a}{V_p} \) - \( r \): radius of first color reversal semicircle on the atrial side of the mitral valve during systole
- \( \frac{\alpha}{180} \): angle correction factor
- \( V_p \): Peak velocity of jet by CW Doppler.
- \( V_a \): Nyquist limit read off the color bar

PISA CALCULATION Example:

\[
\text{MVA} = 2 \times 3.14 \times 1 \times 1 \times 110/180 \times 0.4/2.2
\]

\[= 0.67 \text{ CM²}\]

\[= \text{SEVERE MS!}\]
CONSIDERATIONS IN ASSESSMENT

- Left atrial size: LAE > 45 mm AP diameter
- PA Pressure: PASP = 4(Vtr)2 + CVP
- Planimetry: Difficult with heavy Ca+ and previous commissurotomy
- Continuity Equation: Inaccurate with AI, MR or LVOT obstruction

CONSIDERATIONS IN ASSESSMENT

- PHT and DHT: Inaccurate with abnormal compliance, significant AI and post-valvuloplasty
- PISA: Accurate in the presence of MR

INTRAOPERATIVE TEE ASSESSMENT OF MITRAL STENOSIS: REPLACE OR REPAIR?

MITRAL STENOSIS

- Represents the most difficult potential for repair
- If patient is in sinus rhythm or Maze procedure being performed
- LAX view needed for evaluation of subvalvular apparatus
- Likelihood of repair depends on the severity score: < 8 - good results

SPECIAL CONSIDERATIONS

- Calcified Annulus: Increased risk of ventricular rupture, damage to LCX, and post-op leaks
- Rheumatic Disease:
  - MS with minimal calcification, good pliability, no MR = balloon valvuloplasty
  - MR = very challenging, usually MVR
ASSESSMENT OF REPAIR OR REPLACEMENT

- Paravalvular leaks: 1+ to 2+ MR increases incidence of reoperation threefold compared to trace or no MR
- New aortic insufficiency: Deep suture placement in mitral annulus injuring left or noncoronary leaflets of aortic valve.

ASSESSMENT OF COMPLICATIONS

- LCX Injury: Wall motion abnormalities in lateral or inferoposterior walls
- Ventricular Rupture:
  - Disruption of AV groove
  - Predisposing Factors: Female sex, advanced age, annular calcification
  - TEE shows continuous entrainment of intracardiac air
  - Repair: Placement of endocardial patch

THE ISSUE OF SAM

- Possible after any repair procedure
- The anterior leaflet is displaced towards the LVOT during systole
- Normal coaptation is lost and mitral regurgitation occurs
- Suspect SAM when the BP is low, CO is low and contractility is adequate on TEE
- Treatment: volume, increase afterload, discontinue inotropes.

RISK FACTORS FOR SAM

- Excessive leaflet tissue
- IVSH bulging into LVOT
- Small annuloplasty ring
- Excessive resection of the posterior leaflet
- Use of rigid annuloplasty ring
ASSESSMENT OF SAM RISK

- Excess mitral leaflet tissue: “Floppy mitral valve” of myxomatous disease
- Distance from coaptation point to septum:
  - If C-sept < 2.5 cm, high risk
- The AL/PL ratio:
  - If AL length/ PL length < 1.0 , high risk

ASSESSMENT OF SAM RISK
EXCESS ML TISSUE

C-sept = 1.90 cm

\[
\text{AL/PL} = \frac{1.64}{1.9} = 0.86
\]
The Anatomy and Function of the Normal Aortic Valve

Ferenc Puskas, MD, PhD
Assistant Professor
Division of Cardiothoracic Anesthesia
Department of Anesthesiology
University of Colorado at Denver and Health Sciences Center

Learning objectives

1. How does normal anatomy translates into echo views?
2. What surgeon needs to know?
3. Doppler interrogation of Aortic Valve (AoV)
4. Significance of Bicuspid AoV
5. Prosthetic alternatives
6. How much leak is too much?

Classification Used

ACC/AHA Practice Guidelines

Goals of Aortic Valve (AoV) TEE exam

- Anatomy of valve, aortic root and left ventricle outflow tract (LVOT)
- Valvular and sub-valvular motion
- Relevant pathology
  - Chamber size
  - Wall thickness
  - LV function

Purpose of Intraoperative AoV TEE exam

- To refine and confirm preoperative diagnosis
- Etiology and severity of AoV disease
- Sizing of Aortic Annulus
- Surgical Success – small annulus, surgeon can be prepared for other alternatives (root enlargement, or stentless valve implantation)

20 cross-sectional views composing the recommended comprehensive TEE examination

Papillary fibroelastomas

- Aortic Valve Cusps (44.5%)
- Either side of AoV (more commonly aortic side)
- Short pedicle, multiple
- Lambl’s excrescences:
  - Degenerative in origin
  - Edge of AoV along the coaptation point
- They may cause angina, infarction or embolism

Epiaortic views

- Midesophageal aortic valve short-axis equivalent view

Epiaortic views

- Aortic Root View

Aortic Valve Doppler Imaging

- Continuous wave Doppler (CWD): Transvalvular velocities with modified Bernoulli equation are converted to peak and mean pressure gradients
- Pulsed wave Doppler (PWD): LVOT gradient
- Deep TG LAX view, 0-120 degrees

Aortic velocity and gradient

<table>
<thead>
<tr>
<th>Severity of AS</th>
<th>Jet velocity m/s</th>
<th>Mean Gradient mmHg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt; 3.0</td>
<td>&lt; 25</td>
</tr>
<tr>
<td>Mild</td>
<td>3.0 – 4.0</td>
<td>25 – 40</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt; 4.0</td>
<td>&gt; 40</td>
</tr>
</tbody>
</table>

Estimation of Aortic Valve Area Using the Continuity Equation

- Assumption: Orifice is circular
  \[ \text{Area}_{\text{LVOT}} = 0.785 \times \text{diameter}^2 \]

- Rearranged Continuity equation
  \[ \text{AVA} = \text{Area}_{\text{LVOT}} \times \text{TVI}_{\text{LVOT}}/\text{TVI}_{\text{Aov}} \]
  \[ \text{All cm/s!} \]
Bernoulli and Continuity Equation Pitfalls

- LVOT diameter measurement error (squared)
- Subaortic obstruction (obscures LVOT VTI)
- Non-sinus rhythm
- Incorrect peak AoV velocity (MR)
- Incorrect angle: Doppler equation, importance of echo beam in relation to blood flow

Doppler equation, % error from angle of incidence

\[ \Delta f = 2F_t \times v \times \cos \theta / c \]

\[ \Delta f = \text{Doppler shift} \]
\[ F_t = \text{Frequency transmitted} \]
\[ v = \text{velocity} \]
\[ \cos \theta = \text{cos of blood flow and beam angle} \]
\[ c = \text{speed of sound (1560 m/sec)} \]

<table>
<thead>
<tr>
<th>Angle</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>45</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Error</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>14</td>
<td>30</td>
<td>50</td>
</tr>
</tbody>
</table>

Bicuspid Aortic Valve

- Bicuspid aortic valve (BAV) occurs in approximately 1% to 2% of the population
- Most BAV have 3 aortic sinuses and the larger one of the two cusps has a raphe instead of a commissure
- The right coronary artery is usually non-dominant and small

Bicuspid Aortic Valve

- Aortic Stenosis
  - 5th and 6th decade
- Aortic regurgitation
  - Isolated
  - Associated with
    - With root dilatation/aneurysm
    - Endocarditis

Bicuspid Aortic Valve and Ascending Aorta Dilatation

- 44% in normally functioning BAV
- 50-64% with various degrees of valve diseases
- Aortic Dissection - 5%
- Aortic wall medial abnormalities
  - Genetic weakness resembling cystic medial necrosis (it co-exist (co-inherited) with BAV)

Choosing Type of Valve Operation

- Surgeon’s experience and preference
- Repairable? – Repair
- Contraindication to Coumadin?
- Patient factors
  - Age
  - Likely life span
  - Heart rhythm
  - Other valves?
  - Future Pregnancy?
  - Patient preference
  - Size of annulus
Prosthetic Valves

- Mechanical Valves
  - Single Tilting disk
    - Medtronic-Hall – Medtronic® (central regurgitant jet)
    - Bjork-Shiley (no longer available)
  - Double Tilting Disk
    - St. Jude – St. Jude Medical® (most widely used)
    - Carbomedics – Sulzer Carbomedics®

Bjork-Shiley

St. Jude

St. Jude
Prosthetic Valves

- Tissue Valves
  - Stented Bioprostheses
    - Hancock – Medtronic
    - Carpentier-Edwards – Baxter Healthcare

Images of a porcine bioprosthetic valve xenograft (A), bovine pericardial valve (B), and a human aortic valve allograft (C), also called a homograft.


Tissue Valve

Stentless Aortic Bioprostheses

- St. Jude Medical Toronto SPV (porcine aortic root) – only subcoronary implant
- Medtronic Freestyle (porcine aortic root)
- Edwards Lifesciences Prima Plus
- CryoLife O’Brien, AorTech Freesewn Porcine Elan, Shelhigh No-React, Biocor PSB/SJM, Sorin Pericarbon

Medtronic Aortic Root ‘Freestyle’ bioprosthesis

- Absence of a stent a sewing ring leaves more room for blood flow
- In many cases a Freestyle valve that is one or two size larger can be implanted

Full root technique

- Sinus of Valsalva and diseased aorta excised

Puskas, Ferenc, MD, PhD The Anatomy and Function of the Normal Aortic Valve

CRASH 2012
Root inclusion technique

- After performing an aortotomy and removing diseased aortic leaflets, the bioprosthesis is placed inside the native aorta.

Freestyle with Root Inclusion

Complete subcoronary technique

- After performing aortotomy and removing the aortic valve leaflets, the scalloped valve is placed inside the native aorta. Clearance for the coronary ostia is allowed by scalloping all three sinuses of the bioprosthesis.

Freestyle AV LAX

Aortic Paraprosthetic Leak

- 85 patients after AVR followed for 5 years
- Paraprosthetic Leaks were detected in 47% of the patients, 90% were small and remained unchanged
- New sudden severe paraavalvular regurgitation (3 patients) was associated with endocarditis (2) and prosthetic valvular failure (1)

### Intraoperative Aortic Regurgitation with Stentless Valves

- 96 patients with Freestyle bioprosthesis
- Post-pump minimal to mild regurgitation was present in 52% of the patients
- One year no patient had more than mild regurgitation
- Aortic regurgitation completely resolved in 62% with post-pump regurgitation
- **Conclusion:** Minimal to mild regurgitation is common and does not predict clinically significant progression


### The Anatomy and Function of the Normal Aortic Valve

Thank you!
Evaluation of Aortic Regurgitation

Ferenc Puskas, MD, PhD
Assistant Professor
Division of Cardiothoracic Anesthesia
Department of Anesthesiology
University of Colorado at Denver and Health Sciences Center

Learning objectives

- What causes AR?
- When to replace?
- Assessment of severity with pitfalls
- What is the most accurate measurement?

Causes of AR in Patients Having Isolated AVR at Baylor University Medical Center (1993–2005)

<table>
<thead>
<tr>
<th>Cause of AR</th>
<th>Total</th>
<th>Ages at Operation, Range (Mean)</th>
<th>Acute</th>
<th>Chronic</th>
<th>HTN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve (122 (46%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicuspid</td>
<td>59 (22%)</td>
<td>22–75 (55)</td>
<td>0</td>
<td>59</td>
<td>39 (66%)</td>
</tr>
<tr>
<td>Quadricuspid</td>
<td>2 (1%)</td>
<td>55–70 (66)</td>
<td>0</td>
<td>2</td>
<td>2 (100%)</td>
</tr>
<tr>
<td>Tricuspid</td>
<td>7 (7%)</td>
<td>35–66 (48)</td>
<td>0</td>
<td>7</td>
<td>2 (29%)</td>
</tr>
<tr>
<td>Infective endocarditis</td>
<td>45 (17%)</td>
<td>21–82 (49)</td>
<td>27</td>
<td>19</td>
<td>29 (53%)</td>
</tr>
<tr>
<td>Rheumatic (1)</td>
<td>9 (3%)</td>
<td>26–62 (47)</td>
<td>0</td>
<td>4</td>
<td>3 (40%)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>2 (1%)</td>
<td>24–42 (33)</td>
<td>0</td>
<td>2</td>
<td>2 (100%)</td>
</tr>
<tr>
<td>Non-valvular (48 (18%))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>28 (10%)</td>
<td>25–70 (56)</td>
<td>21</td>
<td>7</td>
<td>22 (79%)</td>
</tr>
<tr>
<td>Marfan</td>
<td>15 (5%)</td>
<td>21–71 (47)</td>
<td>0</td>
<td>15</td>
<td>10 (67%)</td>
</tr>
<tr>
<td>Aortitis</td>
<td>12 (4%)</td>
<td>35–82 (66)</td>
<td>0</td>
<td>12</td>
<td>10 (83%)</td>
</tr>
<tr>
<td>Cause unclear</td>
<td>91 (34%)</td>
<td>50–84 (66)</td>
<td>0</td>
<td>91</td>
<td>83 (91%)</td>
</tr>
<tr>
<td>Total</td>
<td>268 (100%)</td>
<td>21–84 (57)</td>
<td>48 (18%)</td>
<td>220 (82%)</td>
<td>203 (76%)</td>
</tr>
</tbody>
</table>

Survival of patients with chronic severe AR by symptoms (NYHA class) and LV diameter

- [Graph showing survival rates]

Indications with pure, chronic AR for AVR

- Severe AR \(\rightarrow\) AVR (irrespective of LV function)
- Mild AR – not candidates, if LV dysfunction, other causes have to be considered (CAD)
- Moderate AR – during CABG or surgery on Ascending Aorta \(\rightarrow\) AVR

Additional Consideration for Surgery

- Symptomatic patient with LV dysfunction (EF 0.25 to 0.5) \(\rightarrow\) AVR
- Asymptomatic patient with LV dysfunction (EF 0.25 to 0.5) \(\rightarrow\) AVR
- Asymptomatic patient with normal LV function, but end diastolic dimension > 75 mm, or end-systolic dimension > 50 mm is an indication for AVR

TEE assessment of AR severity

- Color jet area
- Vena contracta
- AR pressure half-time (PHT)
- Aortic flow reversal
- Quantitative Doppler Flow measurements

Severity of Aortic Regurgitation (Qualitative)

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiographic grade</td>
<td>1+</td>
<td>2+</td>
<td>3–4+</td>
</tr>
<tr>
<td>Color Doppler width</td>
<td>Central jet, width &lt; 25% of LVOT</td>
<td>Greater than mild but no sign of severe</td>
<td>Central jet, width &gt; 65% of LVOT</td>
</tr>
<tr>
<td>Doppler vena contracta width (cm)</td>
<td>&lt; 0.3</td>
<td>0.3 – 0.6</td>
<td>&gt; 0.6</td>
</tr>
</tbody>
</table>
### Severity of Aortic Regurgitation (Quantitative)

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regurgitant volume (ml/beat)</td>
<td>&lt; 30</td>
<td>30 – 59</td>
<td>≥ 60</td>
</tr>
<tr>
<td>Regurgitant fraction (%)</td>
<td>&lt; 30</td>
<td>30 – 49</td>
<td>≥ 50</td>
</tr>
<tr>
<td>Regurgitant orifice area (cm²)</td>
<td>&lt; 1.0</td>
<td>0.1 – 0.29</td>
<td>≥ 0.30</td>
</tr>
<tr>
<td>Additional criteria: LV size</td>
<td></td>
<td></td>
<td>Increased</td>
</tr>
</tbody>
</table>

### Color jet area

- Jet width/LVOT width
- Fast, easy, helps assessing mechanism
- Impacted by blood pressure (BP) – high-pressure jets appear larger than a low-pressure jet
- Eccentric (wall) jets only 50% the size of central jets (Coanda effect)
- Effect of instrumentation (next slide)

### LVOT width

### Regurgitation

### Color M-mode jet width

### Effect of Color Doppler Instrumentation on Color Doppler Jet Size

- **Increased Jet size:**
  - ↑ Gain and output power
  - ↓ PRF (encoding lower velocities) – lowest velocity visible is 1/16 of the maximal velocity (determined by PRF)
  - ↑ Transducer frequency – Frequency effect (encoding lower velocities) – dominates TEE
  - ↓ Transducer frequency – Attenuation effect (higher frequency is attenuated more) – dominates TEE
  - ↓ Wall filter
Color Jet width

AR by Vena contracta

- Vena contracta is the narrowest portion of the jet located at or just distal to its orifice
- It is slightly smaller than the anatomic orifice due to contraction of the flow stream by viscous friction and boundary layer effects
- Afterload independent
- EROA = \( \pi \times \left( \frac{VC\,\text{width}}{2} \right)^2 \)

Linear regression plots showing a comparison of vena contracta width in the long-axis view to regurgitant fraction (left) and regurgitant volume (right) assessed by intraoperative aortic flow probe

VC Limitations

- Jet width depends on valve morphology
VC limitations

• Color Doppler instrumentation changes may affect jet size
  – Increased Jet size:
    ✓ Gain and power
    ✓ Transducer frequency
    ✓ PRF
    ✓ Transducer frequency
    ✓ Wall filter

Pressure half time (PHT)

• Quantitative parameter of the pressure equilibration between aorta and left ventricle
• With increasing severity of AR the aortic regurgitant velocity slope gets steeper, and PHT shortens

Pressure half time (PHT)

• Mild AR: Slow > 500 ms, incomplete/faint spectral density
• Moderate AR: Medium 500 – 200 ms, dense
• Severe AR: Steep < 200ms, dense

Color Jet Area

Pressure Half Time
Limitation of PHT

- Pressure equilibration is not only influenced by regurgitant orifice area \textit{BUT}.
- By the systemic vascular resistance: \textit{Increasing SVR} increases regurgitation and \textit{increases PHT} (contradiction!)
- By left ventricle compliance:
  - Decreased compliance increases PHT

Limitation of PHT

- In the presence of impaired left ventricular relaxation the pressure or velocity decay of aortic regurgitation is not related to its severity
- PHT assessment of aortic regurgitation should only be used in patients with pure AR, normal EF and normal LV mass

Marchi et al. Heart. 1999;82:607

Aortic Flow Reversal

- PWD sample obtained in the descending aorta just beyond the aortic arch at a multiplane angle around 90°

Aortic Flow Reversal

- Diastolic flow reversal in descending aorta with Pulsed Wave Doppler (PWD)
  - Mild: brief, early
  - Moderate: Intermediate
  - Severe: Holodiastolic reversal
  - \( \triangleright \) Most Reliable!

Regurgitant Volume (RV) in AR

1. ERO (effective orifice area) x AR flow (VTI)
2. Difference between total SV and forward SV (no intracardiac shunt)

- RV = Total SV – Forward SV
  - Total SV = \( \text{CSA}_{\text{aor}} \times \text{VTI}_{\text{aor}} \)
  - Forward SV = \( \text{CSA}_{\text{aor}} \times \text{VTI}_{\text{aor}} \)

Regurgitant Volume (RV) in AR

- Mild: \(< 30 \text{ ml/beat}\)
- Mild to Moderate: \(30 – 44 \text{ ml/beat}\)
- Moderate to Severe: \(45 – 59 \text{ ml/beat}\)
- Severe: \(\geq 60 \text{ ml/beat}\)
How Do We Measure AR?

Evaluation of Aortic Regurgitation

Thank you!
Evaluation of Aortic Stenosis

Ferenc Puskas, MD, PhD
Assistant Professor
Division of Cardiothoracic Anesthesia
Department of Anesthesiology
University of Colorado at Denver and Health Sciences Center

Learning Objectives

• Pathophysiology of Aortic Stenosis, with Aortic Sclerosis as an early lesion
• Surrogate finding with AS, effecting surgical decision making
• Bicuspid Aortic Valve
• Doppler interrogation of the Aortic Valve
• What about the MR?

Aortic Stenosis

• Prevalence of 2% to 4% of adults over 65 years
• In the US over 50,000 AVR per year
• Standard evaluation is echocardiography
• Symptom onset does not correspond to a single value in all patients
• Symptoms warrant AVR or
• Patient with moderate AS needs a cardiac surgery

AS Etiology and Pathophysiology

Aortic Stenosis (Etiology)

• Acquired
  – Rheumatic
  – Degenerative (calcium)
  – Prosthetic
  – Infective endocarditis
• Congenital
  – Bicuspid

Aortic Stenosis – Most Common Cause

• Calcification of normal trileaflet
• Calcification of congenital bicuspid valve
  – From the base of the cusp to the leaflet
  – Reduction of leaflet motion and effective valve area
  – Without commissural fusion
Stenotic Tri-leaflet AoV

Stenotic BAV

Rheumatic AS – less common

- Fusion of commissures
- Scarring
- Eventual calcification
- Usually accompanied by Mitral valve disease

Aortic Sclerosis

Effect of AoV Calcification

A. Patients with severe AS (jet velocity >4.0 m/s)
B. Patients with mild to moderate AS (jet velocity 2.5 to 4.0 m/s)
✓ Extent of valvular calcification significantly affected event free survival, with events defined as either death of valve replacement necessitated by symptom onset

Freeman, R. V. et al. Circulation 2005;111:3316-3326
**Aortic Sclerosis**

- Irregular valve thickening without LV outflow obstruction
- 25% of adults over 65 yrs, 48% over 84 years
- Associated with a 50% increased risk for MI or cardiac death (without CAD)
- Antegrade Velocity < 2.5 m/s
- Maybe a surrogate marker for systemic inflammatory condition

**AS Associated Pathology**

- Left Ventricular hypertrophy (LVH)
- Diastolic Dysfunction
- Mitral Regurgitation
- Aortic Root/Ascending Aortic Dilatation
- Aortic Atherosclerosis
- Other Valvular Calcification
- Coronary Artery Disease

**Goals of the Echo Study**

- Etiology of AS
- Level of obstruction
- Valve calcification
- Leaflet motion
- Aortic root anatomy
- LV response to pressure overload

**TEE assessment of severity**

1. Aortic valve area (AoV)
   - Planimetry
   - Continuity equation
   - Index
2. AoV gradient
   - Mean
   - Peak
3. Dimensionless index
4. LV function (LV Hypertrophy)
Severity of Aortic Stenosis

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jet velocity (m/sec)</td>
<td>&lt; 3</td>
<td>3.0 – 4.0</td>
<td>&gt; 4.0</td>
</tr>
<tr>
<td>Mean gradient (mmHg)</td>
<td>&lt; 25</td>
<td>25 – 40</td>
<td>&gt; 40</td>
</tr>
<tr>
<td>Valve area (cm²)</td>
<td>&gt; 1.5</td>
<td>1.0 – 1.5</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Valve area index (cm²/m²)</td>
<td></td>
<td></td>
<td>&lt; 0.6</td>
</tr>
</tbody>
</table>

Planimetry

- Maximal Aortic Cusp Separation (MACS)
- Position leaflet tips at the center of two dimensional sector in the AV long axis view
- Rotate to AV short axis view, to ensure smallest orifice of aortic valve at leaflet tips

MACS

Planimetry Pitfalls

- Elusive measurement in AS
- Valve calcification causes
  - Reverberations
  - Shadowing
- Difficult to locate leaflet tips
Shadowing and Reverberations

Continuity Equation

\[ Q_1 V_1 = Q_2 V_2 \]

Therefore \( \frac{A_1}{A_2} = \frac{V_2}{V_1} \)

Velocity of a moving column of fluid increases through areas of narrowing

Continuity Equation

- Measure LVOT diameter just proximal to aortic leaflet attachment
- Measure LVOT flow (TVI) where diameter was measured

\[ \text{AVA} = \text{CSA}_{LVOT} \times \frac{\text{pkv}_{LVOT}}{\text{pkv}_{AOV}} \]

- CSA = 0.785 x diameter$^2$
- pkv = peak velocity
- All cm/s!

AoV Gradient

- Change in cross sectional flow leads to convective acceleration
- This velocity can be converted into pressure gradient using the modified Bernoulli equation:
  
  \[ \text{Gradient} = 4v^2 \]

  - Gradient: mmHg
  - v: velocity, m/s

- Locate maximal velocity
- Most clearly defined spectral velocity envelope

PWD LVOT

Scatter-plot with linear regression fit and 95% confidence intervals for AVA$_{CT}$ (16 detector row CT) and AVA$_{TEE}$ planimetry in 40 patients

Zoghby et al. Circulation. 73,3:452:1986

Pressure recovery

- Increase of pressure downstream from a stenosis due to re-conversion of kinetic into potential energy
- Most important variable is the size of the aorta (clinically relevant in small size aorta < 3 cm)
- Marked overestimation of catheter gradients by Doppler
  - Bileaflet prosthetic valves
  - Coarctation of Aorta
  - HOCM
  - Fixed tunnel obstruction

Remember the Pitfalls

- Doppler equation (beam – blood flow angle < 20°)
- High quality, complete spectral envelope does not guarantees that the angle of incidence is negligible
- Use multiple transducer positions
- Do not confuse with MR jet!

“Index”

- Dimensionless index
  \[ \text{Area}_{LVOT} \times \left( \frac{TVI_{LVOT}}{TVI_{AoV}} \right) = \text{Area}_{AoV} \]
  \[ \frac{TVI_{LVOT}}{TVI_{AoV}} < 0.3 = \text{Severe AS} \]

Circulation. 71;6:1162-1169. 1985

Has been validated in several studies

Continuous-wave Doppler echocardiographic assessment of severity of calcific aortic stenosis: a simultaneous Doppler-catheter correlative study in 100 adult patients

PHILIP J. CRYTE, M.D., F.A.C.P., JAY D. SMITH, M.D., OTIS S. KEATING, M.D., RONALD E. VALENTINO, M.D., RICHARD E. BROMAND, M.D., JOHN F. BRODWIGE, M.D., EDWARD C. SMEIT, M.D., DENNIS J. HANRIT, M.D., AND A. JACK TONG, M.D.

Circulation. 71;6:1162-1169. 1985

Remember the Pitfalls

- Doppler equation (beam – blood flow angle < 20°)
- High quality, complete spectral envelope does not guarantees that the angle of incidence is negligible
- Use multiple transducer positions
- Do not confuse with MR jet!
Grade Diastolic Function!

Perioperative Hemodynamic Management

LV function and AS – usually good and associated with LVH

M-Mode Measurement of EF and Wall Thickness

LV function and AS – can be not so good

Left Ventricular Hypertrophy

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nml</td>
<td>Mild</td>
</tr>
<tr>
<td>Septal thickness</td>
<td>0.6-0.9</td>
<td>1.0 – 1.2</td>
</tr>
<tr>
<td>Posterior wall thickness</td>
<td>0.6-0.9</td>
<td>1.0 – 1.2</td>
</tr>
</tbody>
</table>


LVH – Measure Diastolic Thickness
Evaluation of Left Ventricular Hypertrophy (LVH)

We have moderate MR with AS!

What should I tell the surgeon?

Mitral Regurgitation (MR) and AS

- Frequently associated
- Abnormal loading conditions
- Surgical treatment of MR during AVR is controversial
- MR can potentially regress after AVR

Mitral Regurgitation (MR) and AS

- 30 patients with normal LV function for AVR pre and post TTE and TEE (comparatively and prospectively)
- Moderate MR regresses early after AVR (only the regurgitant jet area, not jet width)
- Predictors for improvement: Left ventricular mass
- Predictive factors of fixed MR: Mitral calcification and/or left atrial dilation

Effects of Functional Mitral Regurgitation (FMR) at the Time of Aortic Valve Replacement on Postoperative MR (mean of 18 months postoperatively)

Additional risk factors are:
- Left atrial diameter <5 cm
- Peak aortic gradient <60 mm Hg
- Mean aortic gradient <40 mm Hg
- Atrial fibrillation


Severity of MR following AVR – impact on survival

- 196 patients with isolated AVR and MR were followed for an average of 2 years
- MR improved 1-2 grades in 48% of patients
- 2+ MR: 43% improved, 36% unchanged and 21% worsened
  - Survival: 98%
- 3+ MR: 38% unchanged
  - Survival: 78%
- Conclusion: Repair moderate to severe MR during AVR


So What to Tell the Surgeon?

- Identify 3+ to 4+ MR during AVR
- Look for surrogate findings:
  - Mitral leaflet pathology
  - Calcified Mitral Annulus
  - LV dysfunction/Hypertrophy
  - LA size
  - Assess Aortic gradients (low gradient predictor of LV dysfunction)

Evaluation of Aortic Stenosis

Thank you!
Know Your Knob!

A practicum of Ultrasonography

Alan Bielsky MD

Objectives

• To learn basic ultrasound physics
• To learn the important knobs on the machine
• To improve real time needle guidance skills
• To have fun

Full Disclosure

• This presentation borrows heavily from Brull et al. in Regional Anesthesia and Pain Medicine, Vol 35, No 2, Supplement 1, March-April 2010.

What is ultrasound?

• Cyclic sound pressure beam which penetrates a medium, and then measures the reflection signature, creating an image

The dials you need to know

• Power
• Frequency
• Gain
• Time Gain Compensation
• Depth
• Focus
Power

Key Word: Resolution

- Axial resolution: the ability to distinguish between 2 objects at different depths in line with the axis of a beam
- Lateral resolution: the ability to distinguish between 2 objects beside one another at the same depth, perpendicular to the beam
- Temporal resolution: rate at which the images are produced

Frequency,

(Keneth)

Higher frequency means less depth
Lower Frequency Means More Depth

Gain

- Changes amplification of raw returning signal
- Increases brightness
- Increases background noise and artifact
Time Gain Compensation (TGC)

- Allows you to adjust gain and different field depth
- Should help counter attenuation at deeper depth and different tissue densities

Depth

- Maximizes temporal resolution
- Selects appropriate aspect ratio (ratio of width to height)

Focus

- Sets where the beam converges (Frenzel Zone) to its narrowest point (Focal Zone) and then diverges (Fraunhoffer Zone).
- Maximizes lateral resolution

Other Terminology

“In Plane”

“Out of Plane”

Greg Rutkowski, Fellow. Hand Model
“Son, if I say it’s safe to put the damn needle in, you put the damn needle in!”

“Son, if I say it’s safe to change that diaper, you change that diaper!”

Key Words
“Align”

Key Words
“Rotate”

Key Words
“Tilt”

Other Terminology

Finally....

OR...
OK! Let’s Trouble Shoot.

What’s Wrong?

Low Gain!

What Wrong?

Too high frequency

What’s Wrong?

Someone messed with your TGC!

What’s Wrong?

In too deep!

What’s Wrong?

Gain Too High!
Objectives

- Why use Ultrasound
- When to use Ultrasound
- Ultrasound Physics / Knobology

Why use Ultrasound

- Safe
- Effective
- “Guidelines” for use during Central Vein Cannulation

Central Line Ultrasound

CRASH 2013
Peripheral IV

- Use “a-line” wire kit.
- Trace vein over a distance
- Deep veins difficult, 1 cm or less
- Needle guides

Injury

- Case reports of:
  - LAST (local anesthetic systemic toxicity)
  - HNP (hemidiaphragm paralysis)
  - Pneumothorax
  - Unintended Arterial cannulation
  - Nerve Injury

Be Safe and Elegant

- Monitoring
- Patient comfort
- Ergonomics / Positioning
- Adjacent targets
- Systematic search
- Keep it clean / sterile

Presumed Safety improvements

- Unexpected Anatomy or Pathology visible
- Correct needle, drug, concentration, and dose
- Keep it Air free
- See the Needle tip
- See the Injection
- Nerve stimulation
- Pressure “monitoring”
Nerve Injury Rates

- Temporary neurologic symptom 1 - 2 months post surgery = 3%
- Deficit 12 months after block is estimated at 4/10,000
- To prove 50% reduction would require "more than 70,000 patients per group."

Neal & Wedel, Reg Anesth Pain Med 2010;35: 335-337

When to use US

- Central IV access
- Peripheral IV access
- Arterial lines
- Regional peripheral blocks
- ? Neuraxial & Paravertebral blocks
- ? Gastric volume evaluation
- ?

Physics and Knobology

- Depth adjustment
- Frequency
- Focus
- Gain

http://www.usra.ca/basic_p

Sound

Mechanical pressure wave
A series of compressions and expansions through a medium
Velocity: the speed of sound is 1540 m/s in human soft tissue

CRASH 2013
Orient / Align Your Brain

Depth & Focus Prediction

- 1-3 cm
  - Interscalene, Supraclav, Axillary, Forearm, Ankle, LFC, TAP, IVs
- 3-5 cm
  - Infraclav, Femoral, Paravertebral, Popliteal
Focal Zone, lateral resolution

TGC, time gain compensation

Ultrasound

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic Ultrasound</td>
<td>&gt; 1.0 MHz</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>&gt; 20,000 Hz</td>
</tr>
<tr>
<td>Audible Sound</td>
<td>20Hz-20,000 Hz</td>
</tr>
<tr>
<td>Infrasound</td>
<td>0-20 Hz</td>
</tr>
</tbody>
</table>
Transducer

- Stable hand or "Ultrastand"

Transducer - Needle

- No "trick shots"
- Slow halting moves
- Alternate eyes from hands to screen
- Practice Proprioception
- Needle wiggle
- "puffing"

Transducer Motion

- Alignment or Gliding
- Rotation
- Tilting
Transverse or Short Axis

Longitudinal or Long Axis

Misaligned : Rotation

Evidence for Ultrasound in Regional Anesthesia

- Literature has Limitations
- not enough yet
- many variables
- complications are very rare
- Conclusions from ASRA expert panel review of the literature;

- Joseph M. Neal, MD,* Richard Brull, MD,* Vincent W. S. Chan, MD,† Stuart A. Grant, MBChB,* Jean-Louis Horn, MD,* Spencer S. Liu, MD,* Colin J.L. McCartney, MBChB,§ Samer N. Narouze, MD, MBChB, Anahi Perlas, MD,* Francis V. Salinas, MD,* Brian D. Sites, MD,** and Ban Chi-ho Tsui, MD***

ASRA conclusions

- Most studies show US superior or equal to “comparator technique.” None show inferiority.
- Statistically proven advantages in block characteristics
- Evidence for UGRA impacting patient safety limited to decrease in surrogate events (vascular puncture, HDP, local anes spread, fewer seizures)
- No evidence for decreased LAST(dose!) Nerve Injury, Pneumothorax
**Panel Conclusions**

“In closing, the panel wishes to emphasize its belief that ultrasound guidance is a significant advance in the practice of regional anesthesia and pain medicine. At this early stage, the volume of evidence-based UGRA literature has already matched or arguably exceeded that for transesophageal echocardiography...”
Why Ultrasound?

**SAFETY**
- Anatomic variations visible
- Collateral “targets” visible
- Injection visible
- Lower volumes LA possible
- +/- epinephrine
- Even with US, reports of systemic toxicity and collateral injury!!

**EFFICACY**
- Donut sign
- Redirect possible for poor LA spread
- Reliable Onset, density, duration: LA concentration higher with lower volumes
- Re-block / supplemental block feasible
- Pediatric “asleep” blocks

**Make it Safe**
- 1st; search for collateral damage targets
- Right drug
- Right location
- See the complete injection
- Keep it clean (sterile)
- Monitoring

**Make it Easy**
- Patient comfort
- Knobology
- Estimate depth
- Estimate focus location
- Optimal frequency and probe
- UltraStand (holds probe)
- Trained assistant

**Make it Simple**
- Ergonomics
  - US position “heads up and forward”
  - heel of probe hand on patient
  - visualize the needle
  - sit if you can
  - practice needling with non-dominant hand, or move your position; no backhanding

Jeff Shifrin, MD, John Armstrong, MD, UCDHSC Dept. of Anesthesiology

CRASH 2013
Supraclavicular Approach

Label These

What’s changed here

NERVES

330

Ultrasound Guided Regional Anesthesia

CRASH 2013

330
Interscalene Approach

Label this Photo

Label this Photo
What might this be?

Posterior IS Block

What’s this & what’s wrong

PISB full needle; in ASM

What’s this & what’s wrong

Red box shows only part of needle due to probe rotation from parallel with needle
Ultrasound Guided Regional Anesthesia

PSIB needle w/in ISG

PSIB injection

PSIB needle redirect

See the injection!

Look for collaterals

Anatomic variation; find the nerves
BP w/in ASM

Brachial Plexus split

Choose the safest needle path

Anterior approach

Median Nerve Location

Anatomic variation; find the nerves
What is this?

Flexor digitorum superficialis muscles

Median N.

What’s this at the elbow?

distal 1/3 forearm

Flexor digitorum profundus muscles

What is this?

Radial A.

What’s this at the elbow?

Ulnar Nerve Location

What’s this at the elbow?
What Nerve & Where

Ulnar N.
distal 1/3 forearm

Color Flow, why no color

RTBA doppler
(red toward, blue away)

RTBA ulnar a.
Radial Nerve Locations

Label these just distal to elbow

Label these
Label these

Axillary Block

What nerves and where?

What nerves and where?

proximal 1/3 arm

Label structures
Label structures
Axilla

Label these

LOWER EXTREMITY

Label these

Femoral Nerve: Ultrasound
- To image the femoral nerve under ultrasound, place the probe along the inguinal crease and use the femoral artery as an initial landmark.
- This is the circular, non-compressible echolucent area in the image

Identify these
Femoral n. branches

Same pt. Femoral a. & n. & what else

Same pt with color flow on: Lateral Circumflex Femoral Artery

Extra credit

Saphenous N. at superior pole of the patella, distal femur
Popliteal Nerve Block

Label these

Label these

Common Peroneal and Tibial combined (surrounded by fat)

Popliteal Blk: Needle at 12 and injection “donut”
Air is your enemy

Scan for collateral targets

Ulnar n., a. & collapsible veins

Practice finding nerves and collateral targets on yourself and anyone else who will let you.
Simulation Study of Rested Versus Sleep-deprived Anesthesiologists

Steven K. Howard, M.D.,* David M. Gaba, M.D.,† Brian E. Smith, M.D.,‡ Matthew B. Weinger, M.D.,§
Christopher Herndon, B.A.,* Shanthala Keshavacharya, M.D.,# Mark R. Rosekind, Ph.D.**
Perception of Intimidation in a Perioperative Setting

David L. Dull and Linda Fox

*American Journal of Medical Quality* 2010 25: 87 originally published online 12 January 2010

DOI: 10.1177/1062860609352107

The online version of this article can be found at:
http://ajm.sagepub.com/content/25/2/87

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What is This?