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Regional Anesthesia/ Acute Pain Management
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Update: Analgesia in Cardiothoracic Surgery

Disclosure:

- I have no disclosures to report regarding financial incentives or gains from pharmaceutical companies or manufacturers.

Analgesia for CT Surgery

- Introduction/ Background
- Regional Analgesia
 - TEA, PVB, Other
 - Benefits, Risks, Efficacy
- Multimodal Analgesics
 - Tylenol/ NSAIDs
 - Ketamine
 - Anticonvulsants
 - Other

Pain Following CT Surgery

- Procedures in US per year:
 - 200k Thoracotomies
 - 300k-500k CABG
- Acute Pain:
 - Up to 87% mod-severe pain
 - Up to 97% shoulder pain
 - > Pain assoc w/ LIMA and <60YO
 - Assoc Ischemia, hypoxia, ileus, prolonged stay
- Chronic Pain:
 - 25% CABG
 - 30-60% Post-thor
 - Difficult to treat
 - Unemployment, decr function
- Causes:
 - Incisional, rib fx/disloc, saph vein, sternal retract, tubes/drains, brach plex

Prevalence of Complications after CT Surgery

- Relatively High Rate of Complications After CT Surgery:
 - High Invasiveness
 - Type of incision- thoracotomies
 - Prolonged duration
 - Co-morbidities (CAD, CHF, Tob, Obesity, DM, OSA, CRI, other)
 - Greatest Risk 1st 72hrs
- High Rate of Cardiac Complications:
 - Mortality = 1.2% (30d)
 - MI = 5%
 - High risk for ischemia (30% p card surg)
 - Arrhythmias (up to 22%)
 - CHF, other

Complications following CT Surgery

- High Rate of Pulmonary Complications:
 - High risk for atelectasis, hypoxemia
 - Pneumonia (up to 30%)/ VAP \$40k
 - Ventilator support, other
- High Rate of Other Complications:
 - Delirium (>20%), POCD
 - CVA (up to 4%)
 - Ileus, PONV, Constipation
 - Renal Insufficiency (>5%)
 - Prolonged Hosp Stay

Goals for Analgesia:

- Minimize pain and suffering
- Maximize patient satisfaction
 - HCAHPS, ACA, IPPS
- Maximize mobilization, function
- Minimize side effects
 - Constipation, PONV, urinary retention, delirium, pruritis, hypotension
- Decreased Chronic Pain
- Titratable
- < stress resp, sympathectomy,

- Decrease Morbidity
 - < Cardiac morbidity
 - < Pulmonary morbidity
 - < resp depression
 - early extubation
 - < pneumonia
- Decrease Costs
 - Decrease ICU stay
 - Length of Stay
 - Decrease complications

Royce, 2014 Editorial

Rationale for Multimodal Analgesia:

- Opioids
- α_2 agonists
- Centrally acting analgesics
- Tricyclics
- Antiepileptic drugs
- Anti-inflammatory agents (Cox-2 inhibitors, nonselective NSAIDs)

- Local anesthetics
- Opioids
- α_2 agonists
- Cox-2 selective inhibitors

- Local anesthetics
- Anti-inflammatory agents

- Local anesthetics
- Anti-inflammatory agents (Cox-2 inhibitors, nonselective NSAIDs)
- Opioids
- Antiepileptic drugs

Prospect Group

Overall recommendations for postoperative pain management for thoracotomy

Preoperative patient assessment

- Recommended regional analgesic techniques: Either may be used if possible
 - Thoracic epidural LA+opioid+epinephrine Bolus dose
 - Paravertebral LA Bolus dose
- Alternative regional analgesic techniques: If epidural analgesia and paravertebral block are not possible
 - Single bolus spinal

Operative techniques: Muscle-sparing thoracotomy if surgical requirements allow + Consider closure technique (nerve compression)

Postoperative

- Thoracic epidural LA+opioid+epinephrine Continuous infusion
- Paravertebral LA Continuous infusion
- Intercostal LA Continuous infusion
- Thoracic epidural LA+opioid+epinephrine Continued 2-3 days postop
- Paravertebral LA Continued 2-3 days postop
- Intercostal LA Continued 2-3 days postop

Expected high intensity pain VAS ≥ 30 mm

- IV PCA strong opioid + COX-2/NSAID/Paracetamol

Expected medium intensity pain VAS $> 30 < 38$ mm

- Paracetamol + NSAID/COX-2 + weak opioid

Expected low intensity pain VAS ≤ 30 mm

- Paracetamol + NSAID/COX-2

Note 3 branches of Intercostal Nerves:

- posterior
- lateral
- anterior

Regional Anesthesia Options:

- TEA, PVB
- ICB, Pleural

Potential Cardiac Benefits of TEA:

- < Ischemia
 - > coronary blood flow
 - > O₂ supply
 - < ST changes, < RWMA's
 - < lactate, troponin levels post-CABG
- < Infarction Size
- > LV & RV function
- < Arrhythmias (both atrial and ventricular)
- Avoids >SVR in AVR pts (post-repair)

Blomberg, '89, Rodgers, 2000, Beattie, 2001; Berendes 2003, Liu 2004, Nishimori, 2006, Hutchison, 2006, Rex 2007, Bigeleisen, 2015

Potential Pulmonary Benefits of TEA:

- Earlier extubation p CABG
- > FRC, cough, VC, paO₂, IS
- Less decrement in postop pulm function (compared to parental opioids)
- < episodes of desat, pneumonia, atelectasis
- > Diaphragm function
- < mortality Thoracotomies 7% to 1-2% past 20 years (? Assoc w/ > TEA use)

Ballantyne 1998; Rodgers 2000, Park 2001, Rigg 2002, Liu 2004, Nishimori 2006, Grider 2012, Bigeleisen, 2015

+ Decreased Mortality and Chronic Pain

< Mortality	< Chronic Pain
<ul style="list-style-type: none"> ■ Rodgers, 2000, BMJ; Wu, 2004, RAPM; Wu, 2006 ■ 30% decr mortality w/ epidural analgesia in > 9500 pts (Rodgers) ■ Prob most helpful w/ high invasiveness and co-morbidities 	<ul style="list-style-type: none"> ■ Obata, 1999, CJA <ul style="list-style-type: none"> ■ Intraop and postop infusions ■ Min IV narcotics ■ Toradol 15-30 mg qid x 3d ■ Tiipana, 2003, Acta Anaes Scand <ul style="list-style-type: none"> ■ PTPS < 12% w/ TEA ■ Andrae, 2013, BJA <ul style="list-style-type: none"> ■ Meta-analysis, 250 CT pts ■ TEA < PTPS at 6 mos ■ Other studies: inconsistent

+ Other Possible Benefits of TEA:

(Transferable Evidence)

- < CNS complications:
 - confusion, delirium, insomnia
- < GI complications:
 - < ileus, n/v, constipation, malnutrition
- < DVT's, PE's
 - < relevant w/ today's prophylaxis
- < ICU stay
- < Hosp LOS
- < Cost
- < Stress Response (<epi, NE, cortisol)

Jorgensen 2000, Rodgers, 2000, Hanna 2009

+ TEA in CT Surgery

- SCA Survey: 7% of anesthesiologists use TEA for cardiac
 - 58% of responders in US
 - Not uncommon in U.K., Canada
 - 40% preinduct, 33% after surgery
- High Prevalence of TEA for Thoracotomies
 - "The Gold Standard"
 - TEA vs PVB

+ Epidural Hematoma Risk in Cardiac Surgery:

- 2 case report w/ 1000's of CPB/central neuraxis tech
 - Rosen, '04: tpa given in ICU, cath pulled
 - 2nd case, 2004, UK
- Latest Risk w/ Epid:
 - 1:12,000 (1:2100 – 1:68,000), Bracco, 2011
- Traumatic Tap
 - Consider placing epidural day before surgery
 - Consider arterial vs venous blood

+ Other TEA Risks:

- Failure: 2-15%
- PDPH: < 1% in older pts
- Hypotension:
 - Up to 40%
 - esp elderly, other antihypertensives
 - Compensated by vasoconst in unblocked derms and > vasopressin release
 - Caution in significant AS/ MS
- Urinary Retention:
 - > w/ Intrathecal morphine and Lumbar EA
 - Uncommon with Thoracic Epidural Analgesia
- Infection- 0.1-1% (duration, disconnects, etc)

+ TEA: Other Considerations

- Discuss periop anticoag (eg Valves)
- Location:
 - T3-4 Sternotomy
 - T6 Thoracotomy
- Preinduction placement/ Test Dose
- Arrow Flex-tip?
- Limit advancement, 3cm
- Secure catheters (devices?)
- Half rate during CPB
- Combine with Opioid or clonidine –synergy
 - MSO₄ 40 ug/ml
 - Dilaudid 5-10 ug/ml
 - Clonidine 0.5-1.0 ug/ml
- UE numbness common
- LE deficits concerning
- Duration: 72hrs/ CT's out

+ TEA in CABG: Notable Studies

Positive	Negative
<ul style="list-style-type: none"> ■ Scott, 2001: 420 pts, U.K., RCT, DB ■ TEA – BC vs PCA-M ■ Results: <ul style="list-style-type: none"> ■ < time to extubation ■ < pneumonia (15 vs 29%) ■ < SVT (10 vs 22%) ■ < ARF (2 vs 7%) ■ < Confusion ■ Liu, 2004: Meta-analysis ■ Also, < time to extubation ■ < dysrhythmias 	<ul style="list-style-type: none"> ■ Svircevic, 2011: 654 pts, Netherlands, RCT, not blinded, "healthier pt popn" ■ TEA- BM vs PCA-M x 48hrs ■ No diff in MI, mortality, CVA ■ Improperly powered for 50% reduction in outcome measures ■ 10-20% effect more realistic (eg POISE, ISIS-2 study) ■ Would need >4200 pts

+ TEA for OPCAB (Off-Pump Coronary Bypass)

- TEA more attractive due to less anticoagulation (1/2 ACT)
- Similar postop pain scores (Sandekoppam, 2014)
- Caputo, 2011, 226 pts, RCT
 - TEA-BC vs PCA x 72hrs
 - Results:
 - 40% < arrhythmias
 - < pain, opiates
 - < time to extubation, LOS
 - 15% epid failures, 1 substantial resuscitation

+ Dual Epidural Catheters: Ivor-Lewis Esophagectomies

- Brown, 2013. RAPM. Mayo Clinic, 3 year period, > 160 pts
- Retrospective, observational; cases paired 1:1
- TEA with bupiv and hydromorphone x 1 vs 2 cath
- >Analgesia compared to single TEA cath
- 50% reduction in combined complications:
 - Anastomotic leaks; pulm complications, sepsis, a.fib
- No difference in side effects

+ PVB's in CT Surgery

<ul style="list-style-type: none"> ■ Advantages: <ul style="list-style-type: none"> ■ Less hypotension (4%) ■ < risk of cord compression w/ hematoma (ASRA guidelines) ■ Sympath block <ul style="list-style-type: none"> ■ unlike Intercostal Blocks ■ < stress resp, pain 	<ul style="list-style-type: none"> ■ Disadvantages: <ul style="list-style-type: none"> ■ Risk of Ptx's (1:300) ■ ? Spread of LA ■ Lack of opioid synergy ■ ? efficacy comp to TEA
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+ Paravertebral vs Thoracic Epidural:

- TEA with local anesthetic plus opioid better analgesia than either with LA alone
- Both improved analgesia comp to intercostal or opiates/PCA
- Equivalent Analgesia: PVB and TEA (LA alone)
- < Pulm complications comp to PCA (both PVB and TEA)
 - > SaO2, FRC, FVC, PEF, cough (Both)
 - > Inc Spirometry with TEA (LA + opioid)
- Both < Persistent Postop Pain
 - Andreae, 2013, Meta-analysis
 - Inconsistent finding

Joshi 2008; Scarci, 2010; Joshi, 2011; Pintaric 2011; and Grider, 2012

+ PVB vs TEA: Side Effects/Complications

- Side Effects:
 - < Hypotension w/ TEA (LA+ opioid) and PVB group
 - comp to TEA (LA alone)
 - < urinary retention (PVB comp to TEA-LA/opioid)
 - < pruritis and nausea (PVB comp to TEA-LA/opioid)
- Similar anticoagulation concerns per ASRA
- Pneumothorax 1:300 PVB (< Concern in thoracotomy)
- LATS: 1 case report of death in C-PVB pt (Fagenholz, 2012)
 - Beware of repeated boluses
 - Higher plasma levels with Intercostal/ paravertebral

Joshi 2008; Scarci, 2010; Joshi, 2011; Pintaric 2011; and Grider, 2012

+ C-PVB for Cardiac Surgery

MIDCAB:	Sternotomy, Clam Shell:
<ul style="list-style-type: none"> Lat Thoracotomy => pain Placement: T6 C-PVB preferred over TEA: <ul style="list-style-type: none"> Only need unilateral anesthesia Anticoagulation risk < Hemodynamic changes Ganapathy, 1999 <ul style="list-style-type: none"> C-PVB very effective for analgesia Case Report Min postop opiates Discharged after 58 hrs 	<ul style="list-style-type: none"> Bilateral C-PVBs: <ul style="list-style-type: none"> Placement: T4 Canto 2003: <ul style="list-style-type: none"> 111pts good results 1% ptx

+ Reg Anes for VATS

- Compared to thoracotomy:
 - < acute pain (< incision, < rib trauma, etc)
 - < referred shoulder pain
 - < chronic pain (although still up to 40+%)
- TEA:
 - Not necessary usually
 - Consider if > prob of open or Opiate Tolerant pt
- PVB/C-PVB:
 - Freq choice in U.K., other
 - < opiates, < pain
- ICB/ C-ICB: may be helpful (3 studies)
- Intrapleural Caths: may be helpful (2 studies)

Kaplowitz, 2012, Hill, 2005, Vogt 2005, Fibla 2011

+ Referred Shoulder Pain

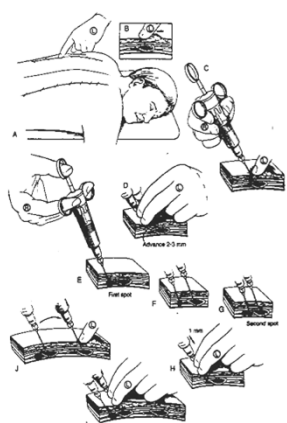
- 60-97% incidence with thoracotomy
- Probably mediated via phrenic nerve
- Helpful:
 - TEA not beneficial
 - Both Acetaminophen + Ketorolac
 - Consider surgical infiltration in periphrenic fat pad (3 studies)
 - Consider Interscalene Block
- Not helpful:
 - Suprascapular Block
 - (Direct) phrenic block not recommended

Kaplowitz 2012, Barak 2007

+ Intrathecal Morphine and/or Clonidine

<ul style="list-style-type: none"> Positive: <ul style="list-style-type: none"> Opiate sparing Significant, prolonged analgesia Min epid hematoma risk Lema, 2003 and 2006, cardiac surgery <ul style="list-style-type: none"> M: 4ug/kg C: 1.0ug/kg < extubation times > analgesia 	<ul style="list-style-type: none"> Negative: <ul style="list-style-type: none"> meta-analysis: no diff in outcome, (Liu, '04) Stress-response: limited if any effect Time to extubation: most RCT's no benefit (even at low dose) Pruritis, N/V common High Clon: < HR, BP
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Vanstrom 88, Chaney 96, 97, 99. Alhashemi 00



Intercostal Blocks

- Most frequent Reg Anesthetic worldwide for thoracotomies
- Meierhenrich, 2011
 - ICB + PCA-M < effectiveness comp to TEA
 - > pain, < resp function
- ICB does not block sympathetics
- Potential role in VATS (Kaplowitz, 2012)
 - Especially C-ICB
- Ptx Risk: 0.1-0.4%

+ Intrapleural Caths

- Advantages:
 - < hypotension, < anticoag concerns
- Technique:
 - Blind vs Intraop
 - LOR, air
 - Cath 6-8 cm post
- Efficacy
 - MIDCAB & VATS: some evidence exists
 - Not recommended for thoracotomy
- Complications:
 - < 1% ptx
 - LA Toxicity
 - phrenic blk

+ Wound Catheters

- **Technique:**
 - Usually 2 soaker caths, 12cm
 - Ropiv or Bupiv 0.25-0.5%
 - 4ml/hr x 2-3 days
- **Efficacy:**
 - < pain, opiates
 - < time to ambulation, LOS
 - Inconsistent
 - (Agarwal 2013 no benefit)
- **Complications:**
 - 9% sternal infection (Agarwal) required cessation of study
 - 75% of infections - deep

White 2003, Liu 2006, Eljezi 2012, Agarwal 2013

+ Cryoablation

- **Goal:** < PTPS
- > Chronic neuralgia due to cryo itself
- -60-70 deg, 14 gu probe under direct vision
- 1min freeze x 2 each level x 3 levels
- Adds 15-30 min to case

Mustola 2011

+ Acetaminophen

- **Mechanism:**
 - ? COX-3 Inhibitor
 - Centrally acting
- **Advantages:**
 - < pain, opiates, PONV
 - No sedation, constipation
 - No bleeding, renal concerns
- **Disadvantages:**
 - Cost: > \$40/d now
 - 100ml vial over 15min
- **IV Formulation:**
 - Europe: 2002, Paracetamol
 - US: 2010, Ofirmev
 - > efficacy > plasma/effect site concentrations
- **Transferable Evidence:**
 - NNT 3.8 for analgesia
 - < PONV, > pt satisfaction
- **Efficacy in CT Surgery:**
 - < ICU, LOS (421 pts)
 - < shoulder pain

Mac 2005, Mauhd 2011, Young 2012, Jahr 2013, Yeh 2012

+ Nonselective NSAIDs

- **Mechanism:**
 - Inhibit cyclooxygenase, < PGs (esp PGE₂), < inflamm
- **Advantages:**
 - < PONV
 - No sedation, delirium
 - No constipation
- **Disadvantages:**
 - Bleeding, renal insuff, gastritis/ ulcers
 - FDA Black Box Warning
 - 2005, ketorolac contraindicated after cardiac surg
- **Transferable Evidence:**
 - < pain (rest, movement)
 - < opiates (20-50%)
 - < PONV; > pt sat
 - > bleeding (2.4 vs 0.4%)

Nussmeier 2005, Maund 2011

+ Nonselective NSAIDs: Efficacy in CT Surgery

- **Cardiac:**
 - No diff in complications (bleeding, ARF, MI, CVA)
 - Can use in select patients
- **Thoracic:**
 - < pain, opiates
 - < stress resp (CRP, IL-6)
 - < shoulder pain
 - Avoid in pleurodesis cases

Hurt 2006, Esme 2005, Oliveri 2014

+ COX-2 Inhibitors:

- **Mechanism:**
 - Inhibits COX-2 (< inflamm, pain) primarily
- **Advantages:**
 - Maintains COX-1 enzyme (gastric mucosa); 50% < risk
 - No bleeding, sedation, constipation risk; < PONV
- **Disadvantages:**
 - > thrombotic risk
 - Same > renal risk as nonselect
 - Celecoxib 100-200mg bid
- **Transferable Evidence:**
 - NNT: 2.1- 3.5 < pain
 - (same as nonselect NSAIDs)
 - < PONV, opiates
- **Efficacy in Thoracic Surgery:**
 - < pain (rest, cough, mobilization)
 - > pat satisfaction
 - No diff in troponin levels
 - (contraindicated in cardiac surgery)

Sun 2008, Senard 2010

+ Ketamine in CT Surgery:

- Mechanism:
 - NMDA antagonist primarily
- Advantages:
 - Abolishes OIH; windup
 - < pain, opiates (25-50%)
 - Min sedation, nausea
 - > pat satisfaction
- Disadvantages:
 - Subanes doses: very few
 - Anes doses: psychomimetic effects, > HR / BP, > saliva possible
- Dosing:
 - Infusion: 1-2 ug/kg/min
 - PCA-M/K: 1:1 ratio ideal

Subramaniam 2004, Bell 2005, Svetlic 2005, Himmelseher 2005, Michelet 2007, Cartensen 2010

+ Ketamine: Efficacy in Thoracotomy

- < pain
- < opiates (using PCA 1:1)
- > resp fxn, O₂ Sat
- No psychomimetic effects

Category	Morphine group (%)	Ketamine group (%)
< pain	~15	~5
< opiates	~22	~8
> resp fxn	~17	~13

Michelet 2007

+ Gabapentin, Pregabalin in CT Surgery

- Mechanism:
 - Activates descending inhibitory pathway via Ca chan (> NE, < EAA)
 - Pregab 6x infinity
- Advantages:
 - Helpful w/ opiate tol pts
 - Anxiolysis
- Disadvantages:
 - Sedation (> doses/elderly)
 - Dizziness (same)
- Dosing:
 - GPN:
 - Preop: 600-1200mg
 - Postop: 300mg tid
 - Pregabalin:
 - Preop: 150-300mg
 - Postop: 75mg bid

Gilron 2007, Tiipana 2007

+ Clinical Results for Gabapentin/ Pregabalin

- Transferable Evidence:
 - < pain
 - < opiates/ side effects
 - < OIH, anxiety
 - > pt satisfaction
 - < chronic pain (esp pregab)
- Efficacy in CT Surgery:
 - Cardiac (OPCAB):
 - Preop only
 - < opiates, pain
 - No diff in sedation, PONV, time to extub
 - Thoracic: preop only with postop TEA
 - No diff in pain, opiates, shoulder discomfort

Buvanendran 2010, Clarke 2012, Kinney 2012, Joshi 2013, Maxwell 2014

+ Alpha₂ Agonists in CT Surgery:

- Mechanism:
 - Activation of Desc inhibitory pathway
 - > NE, GABA, serotonin; < EAA
- Advantages:
 - < stress response (< sympath)
 - < opiate requirement, side effects
 - < OIH, anxiety
- Disadvantages:
 - < HR, BP (high doses, elderly, other antihypertensives, < vol)
 - Expensive; Dex qtt required
- Medications:
 - Clonidine: useful as TEA adjunct
 - Dexmedetomidine:
 - 7 x affinity for receptor
 - 0.25-0.6ug/kg/hr

Wahlander 2005, Prospect Grp, Lena 2008, Ji 2014

+ Dexmedetomidine in CT Surgery

- Cardiac:
 - < mortality (in-house, 30d, and 1 yr) retrospective data
 - < delirium, pain, opiates
 - > bradycardia, hypotension
- Thoracic:
 - In combination with TEA...
 - < supplemental opiates
 - Not recommend due to lack of data

Wahlander 2005, Prospect Grp, Lena 2008, Ji 2014

Lidocaine in CT Surgery:

- Mechanism:
 - Membrane stabilizer
 - Na channel blockade
 - < dorsal horn activity
- Advantages:
 - < pain, opiates (esp lap)
 - < ileus (esp colon surg)
- Disadvantages:
 - Requires infusion
 - Requires ICU monitoring due to potentially hi levels
- Dosing:
 - 1-2mg/min
 - Some as high as 4mg/min
- Efficacy in CT Surgery:
 - Meta-Analysis, 2011
 - 29 RCTs, incl CT surgery
 - < pain, opiates, ileus, N/V
 - Cardiac:
 - Evidence for cerebral and cardiac protection (CPB)
 - (1) neg study for analgesia
 - Thoracic:
 - < pain
 - < opiates

Insler 1995, Wang 2002, Cui 2010, Kim 2010, Tremont-Lukats 2005, Swenson 2010, Vigneault 2011

? Music in CT Analgesia:

- Alternative technique, low cost, no risk
- < anxiety, catecholamines
- < ICU noise
- ? Combine with positive imagery
- Ozer, 2013.
 - 87 Cardiac surgery patients
 - < pain, > O₂ saturation after 30min music

Summary

- Reviewed The Rationale and the Goals for Analgesia in CT patients
- Reviewed the Evidence and Efficacy for Regional Anesthesia
- Multimodal Analgesia is Critical to Comprehensive Recovery
- Effective Acute Pain Control probably more impnt than method

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