Introduction to Anesthesiology

Nathaen Weitzel, M.D.
Assistant Professor of Anesthesiology
Department of Anesthesiology
Overview / Objectives

- Housekeeping details:
  - Grading, Evaluations
  - Case Report
  - Professionalism
- Comments to improve anesthesia / surgical experience
- Overview of Anesthesia
- Historical perspective
- Introduction to current drugs / techniques
What is anesthesia?

an•es•thesi•a (an ‘es-thē’zē-a).

1. Loss of sensation resulting from pharmacologic depression of nerve function or from neurologic dysfunction.
2. Broad term for anesthesiology as a clinical specialty.
Why do we need Anesthesia?

- Fanny Burney: artist from 19th century:
  - Received a wine cordial as her sole anesthetic
  - Also had seven male assistants to hold her down for her mastectomy.
“When the dreadful steel was plunged into the breast, cutting though veins-arteries-flesh-nerves- I needed no injunction not to restrain my cries. I began a scream that lasted uninterruptedly during the whole time of the incision & I almost marvel that it rings not in my ears still! So excruciating was the agony. I then felt the knife racking against the breast bone – scraping it! This performed while I yet remained in utterly speechless torture.”

(The Journals and Letters of Fanny Burney)
The Objectives of Anesthesia

- Loss of awareness / Amnesia
  - If Desired
- Analgesia
  - Reduce movement in response to stimuli
  - Minimize autonomic responses to surgical stimuli
- Muscle relaxation- if required
- Autonomic Regulation
What is balanced anesthesia?

All of these objectives can be achieved with one drug, but at the expense of side effects and toxicity.

**Balanced anesthesia** uses a combination of agents, to limit the dose and toxicity of each drug.
Who are Anesthesiologists?

- Physicians caring for wide variety of patients
- Practice clinical pharmacology and physiology
- Administrators of medications to alter physiology and pathology: **immediate response**
- Analysts and rapid problem solvers
- Team leaders. Our working environment: complex, technical, requires multi-tasking
- Leaders in Clinical and Basic Research
The Anesthesiologist’s Skill Set

- Assessment of patient “readiness” for surgery. Our Expertise includes:
  - Airway management
  - Pharmacology
  - Resuscitation
  - Fluid replacement
  - Postoperative pain control
  - Regional anesthesia
  - Oxygen transport
  - Operative stress reduction
  - Applied Clinical and Basic Research
June 21, 2005

Over 20 years, mortality due to anesthesia decreased from 1 in 5000 cases to 1 in 200,000-300,000 cases!
Patient Safety

- **1950**: Death rate from anesthesia 1:1,500
- **1995**: Death rate from anesthesia 1:250,000
- Anesthesiologists cited in 1999 for leadership in patient safety research
Where do we practice?

• Operating rooms
• Intensive care units
• Labor and delivery suite
• Pain clinic

• Radiology suite
• Gastroenterology suite
• Ambulatory care centers
Drugs in our Armamentarium

- Inhaled anesthetics
- Local anesthetics
- Induction agents
- Muscle relaxants
- Opioids
- NMDA antagonists
How did Anesthesiology Begin?
Background

- Unlike many other medical specialties, **anesthesiology is young**.
- Availability of effective surgical anesthesia: ~150 years.
- Greatest advances: since 1950.
Anesthesia: prehistory

- Surgery has been practiced for thousands of years.
- Ancient Americans trephined the skull.
- Cocaine may well have been used as a topical anesthetic.
Anesthesia: prehistory

Compression Anesthesia

- By applying pressure to major nerve trunks, anesthesia can be produced.
- But the compression itself causes pain!
- Early Version of Bier Block
“As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place.” 1800.
The Beginning of Anesthesia: 1842

Ether known centuries before: 16th century Paracelsus observed ether to put chickens to sleep and awaken unharmed. No jump made to using this in humans.

Crawford W. Long uses diethyl ether for surgical anesthesia to remove neck tumor, but never published results!
Anesthesia in 1844

• Tried to publicly demonstrate nitrous oxide anesthesia at Harvard
• Failed!
• The patient groaned.

Horace Wells
Anesthesia in 1846

1st public anesthesia demo

- WTG Morton brought “Letheon” (diethyl ether) to Harvard.
- Gilbert Abbott had a jaw tumor.
- 1st public demonstration of anesthesia
Anesthesia for Childbirth: Queen Victoria in 1853

Ether by Inhaler

Open Drop Ether

Dr. John Snow
Anesthesia Delivery Systems
Anesthesia and the Operating Room
1941: Robert Miller and Sir Robert MacIntosh simultaneously develop laryngoscope blades designed to maximize visualization of the vocal cords.
Airway

• 1878: First endotracheal tubes were devised for use in drowning victims; not used in anesthesia until 1878 by William Macewan.

• 1885: Joseph O`Dwyer performed multiple blind intubations with flexible metal endotracheal tubes during a diphtheria epidemic. O`Dwyer later developed a rigid tube with a conical end piece that could be attached to a bellows to provide positive pressure ventilation.
Equipment for General Anesthetic Delivery
Inhaled Anesthetics
The Ideal Inhaled Anesthetic

- Non-flammable
- Easily vaporized
- Potent
- Low blood solubility
- Minimal metabolism
- No renal or hepatic toxicity
- Compatible w/ epinephrine
- Muscle relaxant effects
- Reduced sympathetic activity
- Non-irritating to airways
- Bronchodilation
- Non-cerebral vasodilator
Inhalation Anesthetics
Key Pharmacokinetic Principles

• The drug goes in via the lungs

• The drug concentration everywhere rises asymptotically to the inspired partial pressure

• The partial pressure at equilibrium is the same in all tissues, provided the drug enters and leaves via the lungs

• The fastest rate of rise is in the alveolus. This is rate limiting for all other tissues
Uptake Of Oxygen

Fractional Change in $O_2$

Sec from Starting $O_2$ Administration
Uptake of Inhaled Anesthetics
Intravenous Agents
1932: Hexobarbital used clinically
1933: Pentothal introduced at Mayo Clinic
WWII: Pentothal used extensively
1962: Ketamine synthesized
1964: Etomidate synthesized
1977: Propofol released
<table>
<thead>
<tr>
<th>Pharmacodynamic/pharmacokinetic properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causes hypnosis and amnesia</td>
</tr>
<tr>
<td>Rapid onset (time of one arm-brain circulation)</td>
</tr>
<tr>
<td>Rapid metabolism to inactive metabolites</td>
</tr>
<tr>
<td>Minimal cardiovascular and respiratory depression</td>
</tr>
<tr>
<td>No histamine release or hypersensitivity reactions</td>
</tr>
<tr>
<td>Nontoxic, nonmutagenic, noncarcinogenic</td>
</tr>
<tr>
<td>No untoward neurologic effects, such as seizures, myoclonus, antianalgesia, neurotoxicity</td>
</tr>
<tr>
<td>Other beneficial effects: analgesic, antiemetic, neuroprotection, cardioprotection</td>
</tr>
<tr>
<td>Pharmacokinetic-based models to guide accurate dosing</td>
</tr>
<tr>
<td>Ability to continuously monitor delivery</td>
</tr>
<tr>
<td>Physicochemical properties</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Water soluble</td>
</tr>
<tr>
<td>Stable formulation, nonpyrogenic</td>
</tr>
<tr>
<td>Nonirritating; painless on IV injection</td>
</tr>
<tr>
<td>Small volume needed for induction</td>
</tr>
<tr>
<td>Inexpensive to prepare and formulate</td>
</tr>
<tr>
<td>Antimicrobial preparation</td>
</tr>
</tbody>
</table>
Figure. Uptake and redistribution of an IV bolus of thiopental.
# Cardiovascular, Respiratory and CNS Effects of 4 IV Induction Agents

<table>
<thead>
<tr>
<th>Function</th>
<th>Thiopental</th>
<th>Propofol</th>
<th>Etomidate</th>
<th>Ketamine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>↑</td>
<td>-/↓</td>
<td>-</td>
<td>↑↑</td>
</tr>
<tr>
<td>Systemic vascular resistance</td>
<td>-/↓</td>
<td>↓↓</td>
<td>-</td>
<td>-/↑</td>
</tr>
<tr>
<td>Cardiac contractility</td>
<td>-/↓</td>
<td>↓</td>
<td>-</td>
<td>↑</td>
</tr>
<tr>
<td>Histamine release</td>
<td>↑</td>
<td>-/↑</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean arterial pressure</td>
<td>↓</td>
<td>↓↓</td>
<td>-</td>
<td>↑</td>
</tr>
<tr>
<td>Respiration</td>
<td>↓↓</td>
<td>↓↓</td>
<td>-/↓</td>
<td>-/↓</td>
</tr>
<tr>
<td>Cerebral blood flow</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>CMRO₂</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>-/↑</td>
</tr>
<tr>
<td>Intracranial pressure</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>-/↑</td>
</tr>
<tr>
<td>CNS excitation</td>
<td>-/†</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

*CMRO₂* cerebral metabolic rate of oxygen consumption; CNS, central nervous system
The Pharmacology Of Intravenous Anesthetic Induction Agents: A Primer

HC HEMMINGS JR - 2010

www.anesthesiologynews.com/download/Induction_ANSE10_WM.pdf
Muscle Relaxants
Muscle Relaxants

- Introduction in 1940s revolutionized anesthesia practice.
- Muscle relaxants facilitate safe tracheal intubation.
- Led to profound advances in airway management.
- Important to variety of surgical procedures.
- Decreases anesthetic requirements.
- Use to facilitate mechanical ventilation in ICU.
• 1949: Sux synthesized by Nobel winner Bovet
• 1956: Distinction between depolarizing and nondepolarizing muscle relaxants
• 1964: Pancuronium released
• 1970: Vecuronium released
• 1994: Rocuronium released
Ideal Muscle Relaxant

- Non-depolarizing mechanism of action
- Rapid onset
- Short duration
- Rapid recovery
- Non cumulative
- No CNS side effects
- No histamine release
- Reversibility by Choline esterase inhibitor
- High potency
- Pharmacologically inactive metabolites
Muscle Relaxants

- Depolarizing muscle relaxant
  - Succinylcholine

- Nondepolarizing muscle relaxants
  - Short acting
  - Intermediate acting
  - Long acting
Depolarizing Muscle Relaxant

- **Succinylcholine**
  - *What is the mechanism of action?*
  - Physically resemble Ach
  - Act as acetylcholine receptor agonist
  - Not metabolized locally at NMJ
  - Metabolized by pseudocholinesterase in plasma
  - Depolarizing action persists > Ach
  - Continuous end-plate depolarization causes muscle relaxation
Depolarizing Muscle Relaxant

• Succinylcholine

• Does it have side effects?
  • Cardiovascular
  • Fasciculation
  • Muscle pain
  • Increase intraocular pressure
  • Increase intragastric pressure
  • Increase intracranial pressure
  • Hyperkalemia
  • Malignant hyperthermia
Nondepolarizing Muscle Relaxants

- Long acting
  - Pancuronium
- Intermediate acting
  - Atracurium
  - Vecuronium
  - Rocuronium
  - Cisatracurium
- Short acting
  - Mivacurium
Pulse Oximetry: 1990

http://www.asahq.org/publicationsAndServices/sgstoc.htm

Pulse Oximeter
End-tidal CO₂ Monitoring: 1996

http://www.asahq.org/publicationsAndServices/sgstoc.htm
Transesophageal Echocardiography

• TEE use by anesthesiology dates to the late 1980’s with first guidelines published in 1996

• Adult Cardiothoracic Anesthesiology became an ACGME approved fellowship in 2006 and there are 44 ACGME accredited programs for current academic year (2008–2009).
Other Fellowships:

- ACMGE accredited Fellowships:
  - Surgical ICU fellowship: 1 year
  - Pediatric Fellowship: 1 year
  - Chronic Pain Fellowship: 1 year

- Non-accredited fellowships:
  - Obstetrics
  - Acute Pain
  - Liver Transplant / Trauma
Questions?