Sedation in the Pediatric Dental Office

Guidelines and Regulations

Guidelines:
Recommendations for safe practice based on best, currently available scientific data; not standards of care
• AAPD
• ADA
• ASA
• AAP
• AAP/AAPD
• CDA
• CODA

Regulations and Codes: State, provincial, territorial or local laws (statutes) which govern the practice of dentistry, anesthesia and sedation; may require permit or license.

AAPD: There has never been a child with a serious injury or death in an office that follows the guidelines

Yagiela/UCLA: Once you have a sedation incident or death, you have, by definition, fallen out of the guidelines

There have been at least 5 pediatric deaths in U.S. dental offices related to sedation in the last year and a half

Guidelines and Regulations

Guidelines and Regulations
• Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures: An Update
  – AAP/AAPD accepted (adopted by AAPD 2006)
• ADA Guidelines '12 defer to AAPD for ≤12
• CDA Guidelines/Point of Care
  – Most articles defer to AAPD Guidelines
• CODA
  – Regulates training programs, experiences/requirements

Guidelines and Regulations
• Canada: provincial regulations vary
  • Training/education standards are clear but variable
  • Permits necessary in some provinces and territories
  • Inspection required in some provinces and territories
• USA: governed by state laws requiring permit/license
  • usually with inspection
  • expensive before it begins
• Access to GA in Canada is:
  • universal
  • publicly insured
  • Difficult to schedule
• Access to GA in USA
  • Inconsistent between states/ far from universal
  • Reimbursement controlled by insurance companies and state regulations/ tres cher for private pay
  • In office/ in hospital/ in surgicenter
ADA Guidelines 2012

• Defer to AAPD Guidelines 2006 for <12yo
• Terribly confusing
  – Returns to the definition of "Conscious Sedation"
    • conscious sedation: a minimally depressed level of consciousness that maintains the patient’s ability to independently and continuously maintain an airway and respond appropriately to physical stimulation or verbal command and that is produced by a pharmacological or non-pharmacological method or a combination thereof.
  – Adds a definition for enteral and inhalation sedation
    • combination inhalation–enteral conscious sedation (combined conscious sedation) - conscious sedation using inhalation and enteral agents.
  – Maintains the 4 levels of sedation/general anesthesia

AAP/AAPD Guidelines 2006

• Minimal Sedation (old terminology “anxiolysis”)
  – patients respond normally to verbal commands.
  – although cognitive function and coordination may be mildly impaired, ventilatory and cardiovascular functions are unaffected.

AAP/AAPD Guidelines 2006

• Moderate Sedation: (old terminology “conscious sedation” or “sedation/analgesia”)
  – patients respond purposefully to verbal commands, e.g., “open your eyes”, either alone or accompanied by light tactile stimulation.
  – for older patients this level of sedation implies an interactive state if prompted by the provider.
  – for younger patients this is indicated by an age appropriate response. Age appropriate behaviors occur and are expected (e.g., crying).
  – reflex withdrawal, although a normal response to a painful stimulus, is not considered acceptable as the only purposeful response for this level of sedation.
  – no interventions are required to maintain a patent airway
  – cardiovascular function is usually maintained.

AAP/AAPD Guidelines 2006

• Deep sedation: (“deep sedation/analgesia”)
  – patients cannot be easily aroused, but may respond purposefully following repeated verbal or painful stimulation.
  – the ability to independently maintain ventilatory function may be impaired.
  – patients may require assistance in maintaining a patent airway
  – cardiovascular function is usually maintained.
  – reflex withdrawal from a painful stimulus may occur, but is not considered as a higher functioning and purposeful response.

AAP/AAPD Guidelines 2006

• General anesthesia
  – NOT A PART OF THE NEW GUIDELINES
  – Absence of protective reflexes
  – Not arousable
  – May require breathing to be controlled/taken over/airway controlled
  – Cardiovascular function may be compromised
  – Pain control may be required
  • Response to painful stimuli is increased heart rate not withdrawal
**Continuum of Sedation**

<table>
<thead>
<tr>
<th>Intended Level</th>
<th>Responsiveness</th>
<th>Airway</th>
<th>Spontaneous ventilation</th>
<th>Cardiovascular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal Sedation</td>
<td>Normal response to verbal stimulation</td>
<td>Unaffected</td>
<td>Unaffected</td>
<td>Unaffected</td>
</tr>
<tr>
<td>Moderate Sedation</td>
<td>Purposeful response to verbal and tactile stimulation</td>
<td>Adequate</td>
<td>Maintained without intervention</td>
<td></td>
</tr>
<tr>
<td>Deep Sedation</td>
<td>Purposeful response after repeated or painful stimuli</td>
<td>May be impaired</td>
<td>Maintained without intervention</td>
<td></td>
</tr>
<tr>
<td>General Anesthesia</td>
<td>Not arousable even with painful stimuli</td>
<td>Intervention often required</td>
<td>Inadequate</td>
<td>Could be impaired</td>
</tr>
</tbody>
</table>

**Contraindications for Sedation**

- The following are some contraindications to sedation:
  - Sensitivity or allergy to sedation drugs or drug combinations
  - Patients who are ASA III or IV
  - Patients with special needs who may have problems maintaining cardiovascular or respiratory systems
  - Patients who may lack understanding or the ability to respond appropriately
  - Patients with anatomic airway abnormalities, extreme tonsilar hypertrophy, or obesity who may have difficulty maintaining an airway during sedation
  - Patients who pose a risk to the safety or health of staff members
  - Patients who would have difficulty recovering safely and comfortably in the facility
  - Patients for whom resuscitation and transport would be difficult in the event of an emergency

**Drug, Dose or Level of Sedation?**

- Choose level of sedation
- Choose drugs and dosages appropriate to reach that level of sedation
- Provide monitors at the chosen level of sedation
- Be able to rescue at the intended level of sedation
- **Must be able to monitor and rescue at unintended level of sedation**

**Choosing the Child for Sedation**

- (or do they choose you?)
- Personality
  - Doctor
  - Patient
  - Family
- Severity of Case
  - Extent of treatment
  - Complexity of treatment
- Medical Concerns
  - ASA status
  - Age

**Choosing the Child for Sedation**

- Child Behavior and Parent Management

**Choosing the Child for Sedation**

- Doctor
  - Training and education
  - Years of practice
  - Familiarity and experience with drugs
  - Comfort level
  - Assertive/persuasive/flexible may use less sedation
Choosing the Child for Sedation

- Patient
  - Age and cognitive development
    - <36 mo. Precommunicative/unlikely to respond to standard behavior modification techniques
      - Will exhibit sleep deprived behavior including crying, thrashing, inconsolable crying with mild to moderate sedation
    - >36 mo. May respond to combination of anxiolysis and behavior modification techniques
  - Attachment and temperament
    - Temperament appears to correlate with sedation need
      - "Easy, slow to warm up, difficult" affects sedation choice

Choosing the Child for Sedation

- Temperament
  - Interaction with the environment
  - Response to new situations
- Attachment
  - Child’s intensity of interaction with the caregiver
  - High intensity signifies emotional immaturity and insecurity
- "Shyness"
  - Best predicts response at separation
  - Correlates with negative behavior during dental treatment, poor sedation outcomes, decreased amnesia

Choosing the Child for Sedation

- Family
  - The “make it or break it” factor
  - Preconceived notions
    - child “needs” sedation
    - “won’t do well”
    - “is anxious”
    - Don’t want sedation, GA, restraints, etc...
  - Their past experience
    - Transferred or projected feelings
  - Requests
    - “no pain”
    - “don’t want my child to remember…”
  - Their needs
    - One visit
    - Multiple visits

Parenting Today

- It’s not the lives they’ve led

Parenting Today

- It’s the books they’ve read!
Changes in Practitioner’s Management of Patients

- Since beginning of practice
  - Casamassimo, Wilson & Gross, 2002

<table>
<thead>
<tr>
<th>Management technique</th>
<th>Increased</th>
<th>No change</th>
<th>Decreased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents in operatory</td>
<td>64</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>Sedrations</td>
<td>38</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>IVFM</td>
<td>1</td>
<td>17</td>
<td>82</td>
</tr>
<tr>
<td>Medical immobilisation</td>
<td>7</td>
<td>40</td>
<td>33</td>
</tr>
</tbody>
</table>

Pediatric Dentists Believe Parenting Has Changed!

- Limit Setting diminished
- Less likely to use physical discipline
- Parents are unsure of their role as parents
  - CEO v consultant v best friend
- Too busy to spend time with children
- Too self absorbed/materialistic/outward oriented/concerned with status
- Overinvolved/ underinvolved/ controlling

Why?

- Societal changes toward liberalism and breakdown of norms
- Divorce and multiple homes
- Working parents
- Hectic lifestyles
- Loss of extended families
- Increased stress of maintaining lifestyles
- Frequent relocation

Specific Stressors

- Financial pressures
- Decreased time for parenting
- Daily hassles
- Sleep deprivation
- Increased choices

Too Many Choices!

- Simple processes become more complex
  - What’s the BEST choice v what’s good enough?
  - Analysis paralysis leads to increased stress and shutting down
  - High expectations with resultant failure
- As choices increase
  - Decisions require more effort
  - Mistakes are more likely: perceived or real
- Too many parenting choices of techniques
  - Increases inconsistency, anxiety and failure

Choosing the Child for Sedation

- Severity of treatment/disease
  - Extent
  - Complexity
  - Time and number of visits required
  - Cost
    - Multiple sedations v. single GA
    - Time off from work
    - Time out of school
  - Is “monitored neglect” with “preventive intervention” an option?
    - Fluoride varnishes
    - Glass ionomers/ART/IRT/nom du jour
Choosing the Child for Sedation

• Medical status
  – ASA 1 or 2
  – Airway patency
  – Age: what is too young to sedate?
• Age
  – Cognitive v. physical
  – Delay?

Behavioral Evaluation Components

• Parental interview (Parent-Dentist)
  – Developmental milestones
  – Social and Health history
  – Attitudes and Expectations
• Indirect observation of Child-Parent interaction by Dentist
  – Attachment and temperament
  – Child rearing practices / discipline
• Direct child interaction (Child-Dentist)

Behavioral Evaluation

Developmental Milestones

• Obtained by parental interview or questionnaire
• Verified by observation / interaction with the child

Defining the Pediatric Patient

• Developmental Stages
  – Early Childhood (Birth to 8)
    • Physiologic
      – Between birth and 3
        • Quadruples in weight
      – Rate of growth slows between 5 and 8
    • Developmental
      – Peer relationships
        – Birth to 5: parallel play
        – 5 to 8: friendships develop
      – Gender identity
      – Sense of right and wrong
      – “The Plastic Brain”
        • Malleable and reformatory links

Developmental Milestones

• 12-Month Old Developmental Milestones
  – Vocalize/gestures or speaks words to communicate
  – Crawls, cruises, or walks
  – Responsive, affectionate or aggressive towards others
  – Finger feeds, uses cup and spoon independently
  – Has precise pincer grasp
  – Imitates, shakes, bangs and throws objects
  – Waves bye-bye
  – Tests permanence (and your patience)

• 24-Month Old Developmental Milestones
  – Has vocabulary of at least 20 words
  – Uses two-word phrases
  – Can go up and down steps one step at a time
  – Can kick a ball
  – Stacks 5-6 blocks
  – Imitates adults
  – Can follow 2 step commands
Developmental Milestones

- 3-4 Year Old Developmental Milestones
  - Goes up and down stairs without support
  - Kicks ball / jumps in place
  - Rides tricycle
  - Has self-care skills
  - Knows name, age, and gender
  - Shows early imaginative behavior

- 5 Year Old Developmental Milestones
  - Dresses self without help
  - Draws person with head/body/arms/legs
  - Recognizes letters of alphabet
  - Copies triangle/square
  - Plays make believe and dress up
  - Plays interactive games with peers
  - Follows rules of games

Behavioral Evaluation

\[ \text{Observation} + \text{Interaction} = \text{Profiling} \]

Behavior Management in Children

- Non-pharmacologic
  - Exploration/Modeling
  - Tell/Show/Do
  - Desensitization
  - Distraction
  - Voice Modulation
  - Behavior Modification
  - Pedi-wrap/papoose/medical immobilization device

- Pharmacologic
  - Used in conjunction with non-pharmacologic
    - Inhalational
      - \( N_2O/O_2 \)
    - Oral (Enteral) Sedation
      - Benzodiazepine/ Narcotic
    - Sedation (Parenteral)
    - General Anesthesia

Rules of the Continuum of Behavior Management

- It is not linear
- It is not one way
- It is okay to combine techniques
- On different days, the same child will need different techniques
- Be flexible/ give the child the benefit of the doubt
- Define or modify your definition of success
Communication

• Still possible!

Choosing the Child for Sedation

\[(P+P+D) \times (S/C) \times \$/\text{visit} = \text{PS/A}\]

– Sedate or not to sedate
  • That is the question!

– Now choose your weapon!
  • Choosing the sedation for the child
    • Rule of Thumb: Younger children (<3) need to be sedated more deeply but don’t respond as predictably to medicines and have greater respiratory compromise
    • BUT WAIT: There’s more to the selection process! It’s not that easy.

Does General Anesthesia Make My Kid Stupid?!?

• Exposure to virtually all drugs for sedation and anesthesia have been shown in studies to cause:
  – Neurotoxicity and neurodegeneration (neuroapoptosis and prevention of neurogenesis)
  – Cognitive deficits/learning and memory
  – Behavioral disorders

• Effects increase with number of agents used
  – N₂O, Isoflurane, Midazolam
  – Neither N₂O or midazolam alone caused neuroapoptosis

• What to do?
  – Decrease drug doses and combos
  – Increase use of behavior modification and non-pharmacological behavior therapy

References


Pediatric Anatomy and Physiology

• Yes, dear, they are different!
Pediatric Anatomy and Physiology

- The ability to sedate and have a successful outcome is influenced by:
  - Specific respiratory and cardiovascular functioning and physiology
  - Unique anatomic features different from those of an adult
- Children are not little adults and are not proportionally scaled down

Anatomic and Physiologic Differences

- There are fundamental anatomic and physiologic differences between children and adults that directly effect
  - How assessment is performed
  - How children respond to illness and injury
  - How treatment and transportation decisions are made
  - How much drug to give and the bioavailability
    - Rx by weight, age, BMI???

Defining the Pediatric Patient

- Growth Charts
  - Function of height, weight, BMI and age
  - Recent changes because of development and obesity
    - Specific for secular populations

Airway Anatomy and Physiology

- Larger, more anteriorly placed tongue in retrognathic mandible
- Larynx is more cephalad
- Larynx is funnel shaped below thyroid cartilage
- Cartilage is not well developed and allows collapse of airway with negative pressure
- Large quantities of lymphoid tissue (tonsils and adenoids)
- Head is proportionally larger and heavier than in adult
  - Spinal column ends at L3 in infant and L1 in adult

Pediatric Airway Considerations

- Brodsky Classification of Tonsil Size
  - 0,+1,+2: OK to sedate
  - +3,+4: Sedate with caution
  - CO\textsubscript{2} retention
  - Difficult emergency intubation

- Mallampati
  - 1,2,3,4,
  - Can you intubate?
Airway Anatomy and Physiology

• What are tonsils???
  – Important component of immune defense system especially ages 3-6
  – Lymphoid tissue in naso and oropharynx
  – Waldeyer’s ring: adenoids, palatine tonsils, lingual tonsils
  – Fight infection
  – Highly sensitive to irritants like infection, allergies and gastric acid
    – Swell easily and quickly to narrow and obstruct airway
    – Produce T cells outside of the thymus
  – May develop tonsiliths or tonsil stones in the crypts

Sleep Behavior

• Does the child snore?
• Is sleep peaceful or restless?
• Bedwetting?
• Sleep apnea?
• Frequently awakens?
• Nightmares?

Positive answers to two or more questions indicates increased risk for airway obstruction during sleep, treatment and sedation!

Obstructive Sleep Apnea - Resources

• AAP Clinical Practice Guideline
  – Diagnosis and management of childhood obstructive sleep apnea PEDIATRICS 2002;109:704-712
• Chan J, Edman J, Koltai P:
• American Academy of Otolaryngology
  – Pediatric Obstructive Sleep Apnea
  – www.wntnet.org/kidsENT

Sleep Disordered Breathing

– Spectrum Disorder of sleep-related breathing disorders
  – Snoring
  – Upper Airway Resistance Syndrome (UARS)
  – Obstructive Sleep Apnea-Hypopnea Syndrome (OSAHS)
  – No longer considered benign or social nuisance
  – Increase work of breathing with fatigue/inattention/hyperactivity
  – Disordered REM sleep with frequent repositioning to open airway

– Predisposing factors include
  – Obesity
  – Retrognathia
  – Body posture
  – Use of alcohol or sleep sedatives
  – Nasal blockage
Sleep Disordered Breathing

• Snoring
  – Multiple assessments necessary
  – History of noisy or disrupted sleep
  – No drop in oxygen saturation
  – Epworth Sleepiness Scale- situation related
    • 0 = Would never doze
    • 1 = Slight chance of dozing
    • 2 = Moderate chance of dozing
    • 3 = High chance of dozing

• Upper Airway Resistance Syndrome
  – Crescendo snoring
  – Repeated arousals lead to excessive daytime sleepiness and fatigue
  – Arousal leads to airway opening and decrease in upper airway resistance
  – Usually one to three breaths in duration
  – No evidence of oxygen desaturation
  – Final dx may be made by polysomnography

• Obstructive Sleep Apnea-Hypopnea Syndrome
  – Partial or complete episodes of airway obstruction
    • Repetitive collapse of the pharynx
  – Reduction of airflow leads to hypopnea or complete closure apnea
  – Hypopnea- reduction in airflow and baseline ventilation reduced by 50% for 10 seconds
  – Apnea-cessation of airflow with continued respiratory effort for 10 seconds
  – Central apnea has no respiratory effort
  – Patient must demonstrate 5 obstructed breathing events per hour during polysomnography

• Obstructive Sleep Apnea-Hypopnea Syndrome
  – RDI (respiratory disturbance index) = number of sleep apneas + hypopneas/hour of sleep
    • >15/hour indicates possible OSAHS
  – Epworth Scale between 12 and 24
  – Physical Findings
    • Enlarged tonsils
    • Nasal obstruction
    • Retrognathia
    • Macroglossia
    • GERD
    • Anemia
    • (in adults hypertension and cor pulmonale)
  – Social findings
    • Lack of attentiveness and focus
    • Fatigue
    • Eneuresis

Sleep Disordered Breathing

• Treatment Options
  – Tonsillectomy and/or adenoidecctomy
  – RPE to increase size of nasal base
  – Tongue repositioning appliances
  – Mandibular surgery and advancement

• Treatment outcomes
  – Weight gain
  – Height increase
  – Improved focus, concentration and attentiveness
  – Decreased ADHD-type symptoms

• http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/pulmonary/sleep-disordered-breathing/

Airway Anatomy and Physiology

• Chest wall more compliant in the young child
  – inward displacement of rib cage during inspiration
  – ribs are more horizontal, less able to elevate and increase volume during deep inspirations
  – Greater airway closure (especially in preschool children) because of incomplete cartilage rings and soft ribs
  – Diaphragmatic breathing v. chest breathers
    • Gravitational differences associated with ventilation

• Small peripheral airways = 50% of total airway resistance in children from birth through 5 years
  – thus, child is severely affected by diseases that impact small airways (bronchiolitis)

• Elastic recoil of the lung is decreased in the child (their lungs are stiffer!!!)

Sleep Disordered Breathing

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  – thus, child is severely affected by diseases that impact small airways (bronchiolitis)

• Elastic recoil of the lung is decreased in the child (their lungs are stiffer!!!)
A child may have pronounced retractions of the chest wall because the chest wall is less muscular and has more flexible bones.

Breathing Considerations

- Small children are dependent on contraction of the diaphragm to breathe.
- Chest expansion alone cannot create enough negative pressure.
- A child’s primary response to respiratory distress is to increase the rate and effort of breathing, NOT DEPTH.
  - This increases energy use leading to inability to maintain increased rate and large quantities of lactic acid requiring increased O₂ demand and eventual hypoxemia and failure.

A silent chest is an ominous sign of low blood oxygen in the pediatric patient.

<table>
<thead>
<tr>
<th>Pediatric Respiratory Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Infant (birth–1 year)</td>
</tr>
<tr>
<td>Toddler (1–3 years)</td>
</tr>
<tr>
<td>Preschooler (3–6 years)</td>
</tr>
<tr>
<td>School-age (6–12 years)</td>
</tr>
<tr>
<td>Adolescent (12–18 years)</td>
</tr>
</tbody>
</table>

Pediatric Airway Considerations

- “the obligate nose breather”
- Narrow nares, anterior and cephalad glottis (C4 in child vs. C5-6 in adult)
- Large tongue, cricoid cartilage is narrowest part until 5 yrs of age
- Small FRC, closing capacity is > FRC
- Slanting vocal cords with omega shaped epiglottis
- Surfactant production =23-24 wks gestation

Airway Anatomy and Physiology

- Frequent respiratory tract infections result in:
  - aspiration of secretions
  - decreased airway radius
  - increased airway resistance
  - uneven ventilation and perfusion
  - modest hypoxemia
  - Pediatric airway is more reactive than adult
- Pediatric airway smooth muscle is more responsive to stimulation with acetylcholine
  - due to delayed development of degrading enzymes
- Pediatric lungs are like asthmatic lungs

Nasal obstructions can cause respiratory distress.
- Mucus plugs
- Peas
- Paper
Airway Anatomy and Physiology

- Small increases in edema of periphery significantly decrease the size of the airway and increase resistance.

Ventilation v. Oxygenation

- **Ventilation** refers to the movement of air into and out of the lungs via the airway. Important factors to monitor include patency of airway, depth and frequency of ventilation, dead space and obstruction in the upper airway.

- **Oxygenation** refers to the transport of oxygen to metabolically active tissues (e.g., brain). The important factors to monitor are heart rate and oxygen saturation. This is determined by respiration, the exchange of oxygen and carbon dioxide across the alveoli.

### Airway Anatomy and Physiology

- Comparing the functioning of the pediatric to adult respiratory system:

<table>
<thead>
<tr>
<th>Term</th>
<th>Newborn</th>
<th>1 Year</th>
<th>8 Year</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaths/min</td>
<td>40</td>
<td>28</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Tidal volume (ml/kg)</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Alveolar ventilation (ml/kg)</td>
<td>130</td>
<td>120</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Vital capacity (ml/kg)</td>
<td>80</td>
<td>55</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Functional residual capacity (ml/kg)</td>
<td>25 (e.g., 300 ml for 2 yr old)</td>
<td>40 (e.g., 400 ml for adult)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen consumption (ml/kg/min)</td>
<td>6.0 ± 1.0</td>
<td>5.2 ± 0.3</td>
<td>4.9 ± 0.9</td>
<td>3.4 ± 0.6</td>
</tr>
</tbody>
</table>

Respiratory Considerations

- TV (7-10 cc/kg) & Dead space (2-2.5 cc/kg) are consistent with adult volumes.
- O$_2$ consumption 2X the adult = (6 cc/kg/min)
- ETT sizes
  - $16 + \text{age} / 4$ equal size in mm
  - $10 + \text{age} / 2$ equals length in cm

**Appropriate size of ETT has leak at 15-20 cm H$_2$O

Cardiovascular Anatomy and Physiology

- Pediatric heart is stiffer and less compliant.
- Has no collateral circulation.
- Blood pressure is totally dependent on heart rate.
- Cardiac output in children is twice adult output.
  - Compensates for higher metabolic rate.
- To compensate for decreased O$_2$ heart beats much faster because of low residual volume and high metabolic rate leading to failure.
- Small ambient temperature changes shunt blood from periphery to central venous system.

Cardiovascular Diagrams

- Diagrams showing heart structures and circulatory systems.
Circulation Considerations

- Hypovolemia can develop from vomiting or diarrhea in children.
- Compensated vs uncompensated shock
- Capillary refill tests
- Blood pressure is an unreliable indicator of perfusion in the pediatric patient.

Pediatric Pulse Rates

<table>
<thead>
<tr>
<th>Age</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant (birth–1 year)</td>
<td>100</td>
<td>160</td>
</tr>
<tr>
<td>Toddler (1–3 years)</td>
<td>90</td>
<td>150</td>
</tr>
<tr>
<td>Preschooler (3–6 years)</td>
<td>80</td>
<td>140</td>
</tr>
<tr>
<td>School-age (6–12 years)</td>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>Adolescent (12–18 years)</td>
<td>60</td>
<td>100</td>
</tr>
</tbody>
</table>

Bradycardia is a late sign of low blood oxygen in the pediatric patient.

Heart Rates in Children

<table>
<thead>
<tr>
<th>Infant</th>
<th>85–220–300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>Sinus Tachycardia</td>
<td>SVT</td>
</tr>
<tr>
<td>Child</td>
<td>60–180–200</td>
</tr>
<tr>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>Sinus Tachycardia</td>
<td>SVT</td>
</tr>
</tbody>
</table>

Cardiac Anatomy and Physiology

<table>
<thead>
<tr>
<th>Age</th>
<th>Awake Rate</th>
<th>Mean</th>
<th>Sleeping Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 3 mo</td>
<td>85–205</td>
<td>140</td>
<td>80–160</td>
</tr>
<tr>
<td>3 mo–2 y</td>
<td>100–190</td>
<td>130</td>
<td>75–160</td>
</tr>
<tr>
<td>2 y–10 y</td>
<td>60–140</td>
<td>80</td>
<td>60–90</td>
</tr>
<tr>
<td>&gt; 10 y</td>
<td>60–100</td>
<td>75</td>
<td>50–90</td>
</tr>
</tbody>
</table>


Low-Normal Pediatric Systolic Blood Pressure

<table>
<thead>
<tr>
<th>Age</th>
<th>Low Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant (birth–1 year)</td>
<td>greater than 60*</td>
</tr>
<tr>
<td>Toddler (1–3 years)</td>
<td>greater than 70*</td>
</tr>
<tr>
<td>Preschooler (3–6 years)</td>
<td>greater than 75</td>
</tr>
<tr>
<td>School-age (6–12 years)</td>
<td>greater than 80</td>
</tr>
<tr>
<td>Adolescent (12–18 years)</td>
<td>greater than 90</td>
</tr>
</tbody>
</table>

1. In infants and children aged three years or younger, the presence of a strong central pulse should be substituted for a blood pressure reading.
2. CO is dependent on HR since stroke volume is fixed, increased HR, decreased BP, increased RR, decreased compliance of the ventricles.

Differences in Pediatric Patients

<table>
<thead>
<tr>
<th>Preterm</th>
<th>HR 120–180</th>
<th>SBP 45–60</th>
<th>DBP 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term</td>
<td>100–180</td>
<td>55–70</td>
<td>40</td>
</tr>
<tr>
<td>1yr</td>
<td>100–140</td>
<td>70–100</td>
<td>60</td>
</tr>
<tr>
<td>3yr</td>
<td>85–115</td>
<td>75–110</td>
<td>70</td>
</tr>
</tbody>
</table>

Cardiac: CO is dependent on HR since stroke volume is fixed, increased HR, decreased BP, increased RR, decreased compliance of the ventricles.
Oxyhemoglobin Dissociation Curve

- Oxygen carried in the blood
  - Attached to the hemoglobin molecule
  - Dissolved as O$_2$ which creates tension and drives O$_2$ into tissue
  - As saturation of O$_2$ decreases in blood, O$_2$ dissociates at an ever increasing rate
  - Hypoxemia defined as PaO$_2 <80%$
- Steepest part of curve occurs at 60%

Shift to Right (Decreased Affinity)
- Inc. PCO$_2$
- Inc. Temp.
- Inc. 2,3-DPG
- Dec. pH

Shift to Left (Increased Affinity)
- Dec. PCO$_2$
- Dec. Temp.
- Inc. Affinity
- Inc. pH
- Fetal Hb

Physiologic Differences

- Large volume of distribution
  - ECF is large!!
- Renal function 70% until 1 year
  - GFR at birth is 15-30% of adult
- Physiologic anemia occurs in the 9-12th week
  - 10-11 g/DL
- Nonshivering Thermogenesis
  - Major mechanism of heat production by metabolism of brown fat
  - Increased metabolic rate means increased fluid use

Physarmacology of Drugs Used In Sedation

- Pharmacokinetics defined by ADME
  - How a drug is introduced, absorbed, distributed, metabolized and finally excreted affects:
    - Metabolism
    - Speed of onset
    - Total effect time
    - Half life

Pharmacology

- Absorption
  - IV 1 minute
  - Inhalation 1-3
  - Sublingual 3-5
  - Subcutaneous 10-30
  - IM 10-30
  - PO 20-60
  - Affected by food, pH, gastric motility, lipophilic
  - Intestinal absorption by CYP450
    - First pass phenomenon to liver for conversion by CYP3A4
      - New metabolite enters circulation for distribution to target organ (brain) and RAS
      - Attached to plasma proteins and in free state in blood in equilibrium state
      - Only active in free state

Drug Metabolism

- Drugs may be metabolized in
  - Liver
    - CYP450 system including CYP3A4
      - Amines and anesthetics
      - Benzodiazepines
      - Alcohol dehydrogenase
    - Bloodstream
      - Pseudocholinesterase
        - Ester anesthetics
    - Intestines
      - CYP3A4
  - Drugs products can go through
    - Deactivation
    - Bioactivation
  - Pass through the blood stream to target organ
    - Bound to protein
    - Free compound in equilibrium
    - Only active form
    - To kidneys for excretion
      - Decreased kidney function may prolong active drug metabolite

Drug Metabolism

- Cytochrome p450 family of superenzymes
  - Mixed function oxidase system
    - Synthesis of cholesterol and lipids
    - Variable enzyme expression and sensitivity between patients to drugs
  - Most common is CYP3A4
    - 50% of all drugs
    - Others include 2D6, 1A2, 2C19
    - CYP means a family of cytochrome P450
      - First # is family
      - Letter is subfamily
      - Last # is gene
Drug Metabolism

• Drug Interactions
  – Induction
    • Increased activity of enzyme therefore enhanced metabolism
    • Decrease of active sedation drug (ie midazolam) form
      – Dilantin
      – Tegretol
      – Rifampin

• Drug Interactions
  – Inhibition
    • Causes decreased metabolism of CYP3A4
      – Clarithromycin, fluconazole, verapamil, protein pump inhibitors (PPI) leads to increased levels of midazolam
      – Grapefruit juice (furano coumarin) causes irreversible inhibition in the intestines
        – Means increased drug present to be metabolized by liver
        – Increased clinical effect but not half life
        – 2 days after ingestion to reestablish clinical level of CYP3A4

• Drug Interactions
  – Competition
    • Drug compounds with similar characteristics compete at the cytochrome site
      – Decreased metabolism of drug therefore increased drug present which means longer drug effect time but decreased effect
        – Tetracycline, cimetidine, cyclosporine

And Where Do These Drugs Go?

• Have to cross the Blood-Brain Barrier
  – Controls, through physical barriers (astrocytes) and active transport, entry of substances into CNS
  – Reticular Activating System
    • State of consciousness, cardiovascular control, respiratory centers and vomiting centers.
    • Cluster of cerebral cortex, basal ganglia, limbic system, and cerebrum
    • Drugs depress this system but may affect more than one center besides consciousness
      – GABA
        – Brain inhibitory neurotransmitter
        – Opens channels allowing influx of chloride ions which renders the neuron less receptive to excitatory signals
        – Benzodiazepines increase GABA at the neuron by acting on the channels

Documents and Documentation

• Who is getting or giving the info?
  – Parent/parents/stepparents/grandparents/extended family
  – Legal guardian
  – Caregiver

• Informed consent
• Instructions to parent or responsible individual
  – Presedation and postsedation dietary precautions
  – Potential or anticipated postsedation behavior
  – Activities
  – Other info
    • Change of clothes
    • Pain meds
    • Transportation and car seats
  – 24 hour emergency contact number
**Documents and Documentation**

- Preoperative health evaluation and assessment
- Current weight and baseline vital signs
- Intraoperative time based record of:
  - Medications administered including local anesthesia
    - Route and dose
  - Vital signs
    - Determined by anticipated and achieved levels of sedation
- Use of medical immobilization devices
  - When placed and removed
- Patient condition at discharge
  - Time of discharge and final vital signs

**Pre-Sedation Assessment**

- **H&P**
  - Determines baselines
    - Underlying physical, mental or social issues
  - Patients must be able to return to this level after procedure completed
  - Helps to determine type of sedation and drug(s) to be used
  - Physician/medical clinic of record
  - Focused physical assessment not physical exam
    - Heart and lungs

**Pre-Sedation Assessment**

- **History**
  - Allergies, allergic or adverse drug reactions
  - Current medications including herbal and OTC
  - Diseases, disorders or physical abnormalities
  - Pregnancy status
  - Previous hospitalizations and course
  - Previous GA/sedation and complications
  - Family history of diseases or disorders

**Pre-Sedation Assessment**

- **Drug Interactions**
  - Use of drugs, either Rx or OTC
    - May interfere with drug absorption or metabolism
      - Prolong or shorten action
  - Cytochrome (CYP450) system
    - Transport the medications to the active site
    - St John’s wort and echinacea inhibit system
    - Erythromycin, Cimetidine inhibit attachment by competition
      - Documented with midazolam

**Pre-Sedation Assessment**

- **Review of Systems**
  - Respiratory
    - Last URI
      - Lungs do not return to normal for 6 weeks following URI
    - Snoring
    - Wheezing
    - Congestion
  - Cardiovascular
    - Murmurs
    - Arrhythmias
    - Peripheral circulation problems

**Pre-Sedation Assessment**

- **Physical Assessment**
  - Age in years/months
  - Weight in kilograms or pounds
  - Last food and drink intake
  - Physical evaluation
    - Heart rate
    - Respiratory rate
    - Blood pressure
    - Airway patency
      - Tested with mirror
      - Visual exam of nasal and oral airway
Pre-Sedation Evaluation

- Listening to the Chest
  - Ventilation
  - Clarity of lung fields
    - "If it don’t sound clear, it ain’t"
  - Heart rate
    - Not to diagnose but to identify a deviation from normal

Fasting Periods

- Clear liquids pass quickly through stomach
  - Peristalsis may be stopped for 12-24 hours before
- Clear liquids if given up to 2 hours before procedure do not pose an increased risk for regurgitation and aspiration
- No longer an age differentiation

<table>
<thead>
<tr>
<th>Food</th>
<th>AAP/AAPD/ASA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear liquids</td>
<td>2</td>
</tr>
<tr>
<td>Breast milk</td>
<td>4</td>
</tr>
<tr>
<td>Infant formula</td>
<td>6</td>
</tr>
<tr>
<td>Non-human milk</td>
<td>6</td>
</tr>
<tr>
<td>Light meal/solids</td>
<td>6</td>
</tr>
</tbody>
</table>

Informed Consent

- Regulated by state, province, territorial laws
- Guided by standards of care
- Discussion of
  - Problem
  - Treatment and benefits
  - Options
  - No treatment
  - Risks necessary to make decision
  - Probability of success
- Document
  - It didn’t happen if not written down

Diseases of Childhood (5-17)

- Untreated tooth decay
  - Between 20% and 30%
- Learning Difficulties/ADHD
  - Between 8.5 and 13%
- Allergies
  - Hay fever 11.6%
  - Food 4.1%
  - Skin 9.4%
- Asthma
  - 10.5 to 15%
- Obesity
  - 17%
- Activity limitation due to one or more chronic health problems
  - 8%
- Depression
  - 8%

Upper Respiratory Tract Infections

- Allergic rhinitis
  - Clear nasal discharge
  - Symptoms relieved by antihistamine
- URI:
  - Yellow or green nasal discharge
    - Old wives’ tale/ not indicative of bacterial or viral infection
  - Nasal passages not patent
  - Fever
  - Cough
  - Symptoms relieved by antibiotic if bacterial
Upper Respiratory Tract Infections

- Potential infection of the dental team
- Cough: irritation of airway more likely
- If nasal passages not patent
  - Unable to use nitrous oxide/oxygen
  - Will not be able to breathe with a rubber dam in place
  - Irritation of airways from post nasal drip when patient is supine
- 6 week rule for infection if lungs involved and reactive

Upper Respiratory Tract Infections

- If child has active URI, cancel sedation and wait at least 2 weeks to reschedule
  - Lungs and airway hyperreactive
  - Takes at least 6 weeks to repair lung parenchyma
- Allergic rhinitis may never completely clear in some kids
  - Need to decide if you want to sedate them or go to the operating room where airway can be protected with an endotracheal tube

Asthma

- Increased responsiveness of trachea and bronchi to stimuli causing narrowing of the airways
- Effects 7-10% of children in the United States
- Cause of most pediatric hospital admissions
- Characterized by smooth muscle spasm, airway inflammation with edema and mucus hyper-secretion

Asthma and Sedation

- 1 of 7 children
- Higher risk of complications - bronchospasm
- Preoperative optimization of medical care
  - If PRN inhaled β2 agonists or oral meds
  - Daily administration for 3-5 days prior to appointment
  - If chronic oral or inhaled meds
  - Consult with pMD re addition of oral steroids
  - Consider GA rather than oral sedation
- Recent exacerbation requiring hospitalization or emergency treatment within 6 weeks of treatment date precludes elective treatment
- Postpone elective treatment for 6 weeks even if no wheezing if URI present
  - 11 fold increase in respiratory complications

Asthma and Sedation

- Not all asthma meds are alike
  - Bronchodilators open the airway acutely
    - β2 Agonist, long and short acting
    - Metaproteranol, salbutamol (albuterol)
  - Adrenergic and anticholinergics
    - epinephrine
  - Inflammation counteractants
    - Leukotriene antagonists (against inflammation byproducts)
    - singlauré
    - Mast cell stabilizers (prevent release of histamine)
    - chromalin
    - Steroids (stabilize cell membranes)
    - IgE blockers
    - Omalizumab injection

Severity Classification of Asthma: Before Therapy

<table>
<thead>
<tr>
<th>Severity</th>
<th>Symptoms</th>
<th>Night Awakenings</th>
<th>Lung Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Intermittent</td>
<td>≤ 2X/week; ≤ 2X/month</td>
<td></td>
<td>FEV &gt; 80% predicted PEF variability &lt; 20%</td>
</tr>
<tr>
<td>Mild Persistent</td>
<td>≤ 2X/week; ≤ 1X/day</td>
<td>&gt;2X/month</td>
<td>FEV &gt; 80% predicted PEF variability 20-30%</td>
</tr>
<tr>
<td>Moderate Persistent</td>
<td>daily use of rescue β2 agonists; ≤ 1X/week</td>
<td>&gt;1X/week</td>
<td>FEV &gt;60% but &lt;80% predicted PEF variability &gt;30%</td>
</tr>
<tr>
<td>Severe Persistent</td>
<td>continual limited physical activity; ≥ 2X/week</td>
<td>frequent</td>
<td>FEV &lt; 60 predicted PEF variability &gt;30%</td>
</tr>
</tbody>
</table>

From A. Milnes

Severity Classification of Asthma after Institution of Therapy

- **Mild**
  - Spasmodic or seasonal
  - Symptoms 1-2 X/month
- **Moderate**
  - Symptoms >2 X/week
  - Nocturnal symptoms 4-5 X/month
  - Symptoms may persist for several days
- **Severe**
  - Symptoms each day and night
  - ER or medical visits 3 or more times per month
  - Activity limited

From A. Milnes

Obesity as an Underlying Cause of Sleep Disorders

Obesity and Sedation

- **Multi-system problem**
- **Significant health and sedation risk factor**
- **Changes metabolism of lipid soluble drugs**
  - Delayed onset
  - Delayed emergence
- **Difficult positioning to keep airway open**
  - Neck roll
  - Chair tilt

BMI Classification

- Make a weight diagnosis using BMI percentile
  - < 5%ile Underweight
  - 5-84%ile Healthy Weight
  - 85-94%ile Overweight
  - 95-98%ile Obesity
  - >=99%ile Gross Obesity

Pediatric Obesity Over Time: National

**Multi-System Effect of Obesity**

<table>
<thead>
<tr>
<th>Pulmonary</th>
<th>Cardiovascular</th>
<th>Gastrointestinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest wall mass ↑</td>
<td>Cardiac output ↑</td>
<td>Intrabdominal pressure ↑</td>
</tr>
<tr>
<td>CO₂ production ↑</td>
<td>Hypertension</td>
<td>Intragastric pressure ↑</td>
</tr>
<tr>
<td>Functional reserve ↓</td>
<td>Stroke volume ↑</td>
<td>Risk of aspiration ↑</td>
</tr>
<tr>
<td>Pulmonary compliance ↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total O₂ consumption ↑</td>
<td>Work of breathing ↑</td>
<td></td>
</tr>
</tbody>
</table>

From A. Milnes
Obesity + Sleep Apnea + Sedation = Disaster!

- Airway, airway, airway
  - Increased chest mass
  - Decreased chest movement
  - Increased work of breathing
  - Partially reclining not supine
- Full stomach or slow gastric emptying
  - High intragastric pressures
  - Increased chance of regurgitation and aspiration
- Post sedation recovery
  - Obstruction

Anorexia and Bulimia

- Metabolites in disarray
  - Terry Schiavo and cardiac rhythm abnormalities
- Lack of body fat for the storage of the fat soluble drugs
  - Irregular and unpredictable uptake and metabolism
- Underlying psychological issues
- Damage to the esophagus

Type 1 (Juvenile) Diabetes

- Significant increase in numbers
- Inability to produce insulin
  - Autoimmune reaction to pancreas
  - Requires monitored insulin dose
- Type 2 is inability to respond to insulin – increasing exponentially: 16-30%
  - Metabolic syndrome is diagnosed in people who have at least three of these five criteria: high blood pressure, insulin resistance, high triglycerides, a large waist and low levels of HDL (“good”) cholesterol
  - Learning disabilities/ brain development occurs if onset <5 yo possibly b/c glucose deficit
- Diagnosis
  - Extreme thirst
  - Frequent urination
  - Dryness, lightheadedness
  - Sugar in urine
  - Hypoglycemia
  - Sudden vision changes
  - Increased appetite
  - Sudden weight loss
  - Fruity, sweet, or wine-like odor on breath
  - Nauseous
  - Heavy, labored breathing
  - Stupefied, unconsciousness

Type 1 (Juvenile) Diabetes

- Multisystem effect
  - Diabetic triopathy:
    - Retinopathy
    - Neuropathy
    - Nephropathy
  - Oral
    - Increased plaque/ decreased saliva
    - Elevated glucose levels/increased bacteria counts
    - Loss of collagen in gingiva
    - Vascular disorder/reduced circ. in gingiva
    - Poor healing

Type 1 (Juvenile) Diabetes

- Controlled by
  - Diet
  - Exercise
  - Insulin
- May be at risk for hypoglycemia and insulin shock if NPO orders followed
  - Individual case consultation
- Monitor by HbA1C
  - Should be less than<6% (BS 120)
  - >8.5% (BS=210) poor with significant complications
- For sedation
  - NPO rules
  - First appointment
  - Insulin when patient able to resume normal food intake

Developmental Disabilities

- Are birth defects related to specific organ or system manifested before 18 yo
- Refers to disabilities affecting daily functioning in three or more of the following areas:
  - capacity for independent living, economic self-sufficiency, learning, mobility,
  - receptive and expressive language, self-care, and self-direction
Developmental Disabilities

- May be caused by:
  - Brain injury or infection perinatally
  - Problems with growth and development
  - Nutrition or metabolic
    - Prenatal maternal health care
      - Diet, alcohol, drugs, smoking
    - Chromosomal or genetic malformations
    - Prematurity
    - Child abuse
  - Early sensory development/sound
- Are not acquired after birth but may be evident and diagnosed after birth
  - Does not include traumatic injury and neurologic loss

ADD/ADHD and Autistic Spectrum Disorders

- Autism spectrum disorders
  - Affects communication and social skills and intelligence
  - Affects ~1/150 live births, M>F
  - May be identified at 1 month of age
  - May be mild to severe
  - IQ range
  - Repetitive behaviors/ specific routines
  - May have folate metabolism defect via MTHFR gene mutation (methylene tetrahydrofolate reductase) which may lead to myelinization problems by blocking methionine synthase
    - DAN! (Defeat Autism Now!) and vitamin B12/folate pathway defect
  - Glutathione deficiency
    - Possible detoxification problem
  - Behavior modification therapy may be adjunct

ADD/ADHD and Autistic Spectrum Disorders

- Genetic basis
  - 25% have relative with spectrum disorder
- May give idiosyncratic reactions to sedative meds
  - GABA/chlorine uptake blocking mechanism of the benzodiazepines and loss of inhibition
- Should take ADD meds prior to sedation
- Be careful of herbal medications and chelating agents given by holistic MDs
  - Compete for bonding sites on Cytochrome P450

ASA Physical Status Categories

<table>
<thead>
<tr>
<th>ASA Status</th>
<th>Preoperative Health Status</th>
<th>Organ System Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA I</td>
<td>Normal/healthy patient</td>
<td>All organ systems intact and functioning</td>
</tr>
<tr>
<td>ASA II</td>
<td>Patient with mild systemic disease</td>
<td>No functional limitations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Has well controlled disease of one body system upon medical history and crosscheck for drug interactions</td>
</tr>
<tr>
<td>ASA III</td>
<td>Patient with severe systemic disease</td>
<td>Some functional limitation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Has controlled disease of more than one body system or major organ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No immediate danger of death</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physician consult required</td>
</tr>
<tr>
<td>ASA IV</td>
<td>Patient with severe systemic disease that is a constant threat to life</td>
<td>Has at least one severe disease that is poorly controlled or at end stage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physician consult required. laboratory tests</td>
</tr>
<tr>
<td>ASA V</td>
<td>Patient not expected to survive &gt;24 hours without surgical intervention</td>
<td>Multiorgan and system failure</td>
</tr>
<tr>
<td>ASA VI</td>
<td>Patient declared brain dead</td>
<td>Maintenance for organ harvesting</td>
</tr>
<tr>
<td>E</td>
<td>Emergency operation of any variety (used to modify one of the above classifications)</td>
<td></td>
</tr>
</tbody>
</table>

Monitors and Monitoring

- Visual and Clinical
  - Quality and quantity
- Mechanical
- Electronic
- Are interdependent
  - Determined by the intended level sedation
  - Are somewhat redundant for safety
AAPD Guidelines: Recommendations for Monitoring

<table>
<thead>
<tr>
<th># of persons</th>
<th>minimal</th>
<th>moderate</th>
<th>deep</th>
<th>g.s.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monitors</th>
<th>Clinical observation</th>
<th>BPC, PCA, PC or Capno</th>
<th>BPC, PCA, PC/Capno, EKG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin color, resp effort</td>
<td>continual</td>
<td>12R, RR, BP, SaO2, q15m</td>
<td>12R, RR, BP, SaO2, ETCO2, EKG, T, q15m</td>
</tr>
</tbody>
</table>

### Clinical Monitoring

- **Observation**
  - Can be obscured or easily overlooked
  - Bright lights may block subtle changes
  - Skin color
  - Pallor

### Monitors and Monitoring

- **Pulmonary**
  - Ventilation
  - Pre-tracheal/cordial stethoscope
  - Capnograph
  - Mirror fog
  - Visualization of chest movements
  - Oxygenation
    - Pulse oximeter
    - Skin coloring (not reliable!)
- **Cardiovascular**
  - Blood pressure
    - Automated or manual cuff
  - Perfusion
    - Capillary refill time
  - Heart rate
    - Pulse oximeter
- **Neural**
  - Brain activity
    - EEG
  - Muscle activity
    - EMG
  - Other
    - Galvanic skin response (autonomic nervous system)
    - Temperature
    - Communication and responsiveness factors
    - Bispectral (BIS) index monitor for level of sedation/GA

### Monitors

- **Observation**
  - Most important monitor
    - Means you’re paying attention
  - Most difficult
    - Skin color/pallor
    - Lips/mucosa
    - Skin
      - Pale, pink, grey
    - Turgor
      - Clammy, dry, cold, moist, sweaty
    - Patient responsiveness
      - Verbal commands, painful stimuli and appropriate response
    - Airway patency
      - Visual check
      - Mouth mirror
      - Precordial stethoscope

- **Precordial Stethoscope**
  - Heart, lung and airway sounds
  - Placed over presternal notch and tightly adhered
  - Inexpensive, easy use
  - Does not guarantee patency, breathing or ventilation
  - Picks up vibration from handpiece

- **Pre-Cordial Stethoscope**

---

*From Wilson*
Monitors

- **Blood Pressure Cuffs**
  - Manual or automatic by picking up oscillatory signals
  - Records systolic and diastolic pressures
  - Automatic also gives mean pressure and pulse rate
  - Set intervals
  - May record pulse in automatic monitors
  - Does not guarantee airway patency (duh!)
  - Critical width of cuff
    - narrow: high; broad: low
  - May be affected by the restraining device

- **Pulse Oximeter**
  - % of saturated Hgb by red light absorption
  - pulse rate
  - safe/noninvasive and continuous
  - critical placement of probe—easily dislodged, on arm with bp, affected by overhead light, body/room temp
  - does not guarantee airway patency especially in hypersaturated patients
  - DOES NOT RECORD WITH SYSTOLIC <50!

- **Capnography**
  - measures expired CO₂
  - Waveform pattern
  - 0% means either no ventilation or no respiration
  - nasal probe (invasive) must be free of obstruction
  - best demonstrates airway patency through gas exchange
  - May be affected by mucus plug in nares
  - rapid reading and reporting within 15 sec.
  - does not work in crying child or mouth breather when attached to nasal mask
  - May also be attached through hole in side of nasal hood
  - Get waveform but inaccurate readings

---

Risks/Options/Benefits: continuum of care

- Pharmacologic and nonpharmacologic
- Local Anesthesia
- Medical Immobilization Devices (papoose board)
- Minimal Sedation/Anxiolysis
- Moderate Sedation
- General Anesthesia by qualified dental/medical personnel
- (Deep Conscious Sedation does not really exist in children)

---

Medical Immobilization Device

- Officially known as procedural immobilization
- Papoose board, Restraining device, soft wrist restraints, head immobilizers
- Mustn’t be tightened such that it causes injury or restricts ventilatory movements
- Must allow free access to monitors
  - One hand or foot out
- Office protocol for use (prevents accusations of assault or child abuse)
  - i.e.: 15 min in unsedated child except in emergency
- Consent for use
  - May have parent assist in placement of child
- Neck roll to open airway
Time To Choose Your Drugs!

But Before We Begin...

- Preparation and setting up for sedation procedures
  - $: suction; size appropriate catheters and functioning suction
  - $: oxygen; adequate supply for procedure and emergency, functioning flow meter
  - $: airway; age, size and route appropriate; face masks, BVM, laryngoscope blades, ET tubes, LMA, stylets
  - $: pharmacy; all the drugs you'll need for tx and emergencies, dosages and concentrations known
  - $: monitors; functioning and appropriate for sedation level and beyond
  - $: equipment; specific for the case

The Ideal Sedative

- Reduces fear and anxiety in children
- Decreases inhibitory behavior
- Provides amnesia
- Maintains cardiovascular and respiratory tone
- Does not cause drowsiness or sleep

The Ideal Sedative

- Decrease patient treatment time by decreasing behavior management time
- Increase treatment efficiency
- Low cost to office
- Low cost to family
- Easily reversed agent/ for duration of treatment

The Ideal Sedative

- Long shelf life
- No side effects or allergenicity
- Is safe
- Works all the time predictably
- Single agent
The Ideal Sedative

◆ DOES NOT EXIST

Caveats of Sedation

◆ No defined line between minimal and moderate sedation
◆ No defined line between moderate and deep sedation
◆ No defined line between deep sedation and general anesthesia
◆ Dropping between levels gets more dangerous
◆ Your license defines the road traveled and the vehicle used

General (but not always set in stone) Rules

◆ Know your drugs
◆ Know your patients
◆ Know your abilities
◆ Know your equipment
◆ Know your staff
◆ Know how to avoid trouble and get out of trouble

Avoid Polypharmacy and Know Drug Interactions

◆ Lidocaine with epinephrine is a drug!
◆ Chloral hydrate breakdown products are similar to halothane
◆ Diazepam has a 12 hour half life
◆ Naloxone has a shorter half life than most narcotics
◆ Flumazenil slowly reverses
◆ Fat soluble vs non fat soluble meds and their effect on half life and metabolism
◆ Interactions on cytochrome p450

The Use of Local Anesthesia As An Adjunct to Pediatric Sedations

AAPD Reference Manual 2012
Oral Health Policies and Clinical Guidelines

Clinical Guideline on Appropriate Use of Local Anesthesia for Pediatric Dental Patients
Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures: An Update
www.aapd.org
Pain in Children

- The response to the sensation of pain is often confused for disruptive behaviors
- May be socialized but is real
- Must be recognized as an important entity
- Changes in physiologic parameters
- Difficult to assess in children under 6
  - Use observation
- Self reporting in children over 6
  - Pain scales
  - *It is the key to a successful sedation!*

Local Anesthetic Agents

- Characteristics
  - Weak bases in chemical equilibrium
    - Lipid-soluble, neutral form
    - Charged, hydrophilic form
  - Three parts:
    - Substituted benzene ring (aromatic group - lipophilic)
    - Intermediate chain
      - Amide or Ester
    - Amino terminus - hydrophilic

Structure-Activity Relationships

- Benzene ring (aromatic residue)
  - Lipid solubility
- Intermediate chain:
  - Metabolism and Classification
    - Ester: -COO-
    - Amide: -NHCO-
- Hydrophilic (amino) terminus
  - Water solubility
- pH of solutions without epi. - 5.5
- pH of solutions with epi. - 3.3
  - Inhibits oxidation of the vasoconstrictor
  - Pain on injection

Local Anesthetic Agents

- Types
  - Esters
    - Hydrolyzed in plasma by pseudocholinesterase
    - PABA is a major metabolite of esters and responsible for most allergic reactions
    - Mainly used as topical anesthetics
    - May lead to methemoglobinemia
  - Amides
    - Metabolized in the liver by cytochrome P450
    - Pulpal anesthesia from 10-90 minutes
    - Soft tissue anesthesia from 1-5 hours

Chemical Principles

- $pK_a$
  - Dissociation constant
  - The pH at which two forms (charged and uncharged) exist in equivalent amounts
    - In other words: 50% uncharged when $pK_a = \text{pH}$
    - Active form is charged form

Mechanism of Action

- Blockade of sodium channels interrupts spread of action potential
  - Tertiary form (non-ionized) penetrates epineurium and neuronal membrane
  - Quaternary form (ionized) actually blocks the sodium channel; appears to be predominately active form
Peripheral Sensory Nerve Conduction

Anesthetic solution must cover 3 nodes (≥ 3 mm) to block nerve impulse.

Protein bound section active here blocking Na\(^{++}\) channels.

Influence of pH

- Most LAs are weak bases
  - \(pK_a\) 7.5-9.5
- Only the base form can diffuse rapidly into nerve
- A high \(pK_a\) means slower dissociation to free base
- Clinical result in onset of anesthesia?
- Tissue acidity lowers pH locally
  - Limits formation of free base
  - Leads to ionic entrapment in extracellular space

Determinants of Anesthesia Onset

- Proximity of injection to the nerve
- Concentration and volume of drug injected
- Degree of ionization of the drug
- Time in contact with nerve fibers

Anesthetic Characteristics and Clinical Correlates

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Correlate</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid Solubility</td>
<td>Potency</td>
<td>Lipid solubility enhances diffusion through neural covering and cell membrane allowing a lower milligram dosage</td>
</tr>
<tr>
<td>Protein Binding</td>
<td>Duration</td>
<td>Affinity for plasma proteins corresponds with affinity for protein in sodium channels prolonging the presence of anesthetic within the channel</td>
</tr>
<tr>
<td>Dissociation Constant</td>
<td>Onset time</td>
<td>Determines the portion of an administered dose that exists in the lipid soluble tertiary molecular state</td>
</tr>
<tr>
<td>Chemical Linkage</td>
<td>Metabolism</td>
<td>Esteres are principally hydrolyzed in plasma by cholinesterase; amides are biotransformed in the liver</td>
</tr>
</tbody>
</table>

Comparison of Local Anesthetics Commonly used in Pediatric Dentistry

<table>
<thead>
<tr>
<th>Drug</th>
<th>(pK_a)</th>
<th>Onset (min)</th>
<th>Protein Binding</th>
<th>Duration* (hrs)</th>
<th>T 1/2 (min)</th>
<th>Dose (mg/kg)</th>
<th>Relative Potency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidocaine</td>
<td>7.9 (24%)</td>
<td>1-3</td>
<td>65%</td>
<td>1-2</td>
<td>96</td>
<td>4.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Prilocaine</td>
<td>7.9 (24%)</td>
<td>1-3</td>
<td>55%</td>
<td>1-2</td>
<td>93</td>
<td>6</td>
<td>0.8</td>
</tr>
<tr>
<td>Mepivacaine</td>
<td>7.6 (39%)</td>
<td>1-3</td>
<td>75%</td>
<td>1.5-3</td>
<td>114</td>
<td>4.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Articaine</td>
<td>7.8 (35%)</td>
<td>1-3</td>
<td>≥ 85%</td>
<td>2.5-4</td>
<td>30</td>
<td>5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Bupivacaine: 8.1 (37%) 2-10 95% 4-6 162 1.3 3.6

*Duration - infiltration vs. block; volume and concentration of agent injected, vasconstrictor presence and tissue(s) assessed

Calculating Local Anesthetic Dosage

- Simplified posology
  - Percent solutions represent grams/100mL
  - Move decimal one space right
  - This value represents mg/mL (2% = 20 mg/mL)
- Calculate and record milligrams administered to each child
Recommended Maximum Doses of Local Anesthetics - AAPD/Malamed

<table>
<thead>
<tr>
<th>Drug</th>
<th>Maximum Dose (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articaine with epinephrine</td>
<td>5*</td>
</tr>
<tr>
<td>Lidocaine with epinephrine</td>
<td>4.4</td>
</tr>
<tr>
<td>Mepivacaine plain or with vasoconstrictor</td>
<td>4.4</td>
</tr>
<tr>
<td>Prilocaine plain or with epinephrine</td>
<td>6.0</td>
</tr>
</tbody>
</table>


How Many Local Anesthetic Cartridges for Children When Used With Sedation?

<table>
<thead>
<tr>
<th>Drug</th>
<th>3-yr-old (15 kg)</th>
<th>5-yr-old (20 kg)</th>
<th>7-yr-old (25 kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4% articaine with epinephrine</td>
<td>1.1</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>2% lidocaine with epinephrine</td>
<td>2.9</td>
<td>3.9</td>
<td>4.9</td>
</tr>
<tr>
<td>3% mepivacaine plain</td>
<td>1.8</td>
<td>2.4</td>
<td>3.1</td>
</tr>
<tr>
<td>2% mepivacaine with vasoconstrictor</td>
<td>2.8</td>
<td>3.7</td>
<td>4.6</td>
</tr>
<tr>
<td>4% prilocaine plain or with epinephrine</td>
<td>1.7</td>
<td>2.2</td>
<td>2.8</td>
</tr>
</tbody>
</table>


Commonly Used Local Anesthetic Agents - Dose Recommendations from AAP/AAPD

<table>
<thead>
<tr>
<th>Drug</th>
<th>Maximum dose with epinephrine (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medical Use</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>7.0</td>
</tr>
<tr>
<td>Mepivacaine</td>
<td>7.0</td>
</tr>
</tbody>
</table>

*Determined by relative vascularity of injection area


Factors Contributing to Increased Risk of Local Anesthetic Overdose

- Failure to calculate LA dose by weight
- Treating multiple quadrants at one appointment
- Failure to use LA with vasopressor
- LA administered in all quadrants at one time
- Concomitant use of sedation, especially opioids
- LA administered as standard volume per injection
- Selecting a high-concentration solution

Local Anesthetic Volume Administered

“For children under 10 years of age, it is rarely necessary to administer more than one-half cartridge (20 mg), even for mandibular blocks.”

Astra Pharmaceuticals Package Insert, 1997

Moore’s Rule of 25

- One cartridge/25 lbs. body weight
- Any marketed local anesthetic used in dentistry
- Establishes a conservative dose
- Examples:
  - 50 lbs. 2 carpules
  - 75 lbs. 3 carpules
  - 100 lbs. 4 carpules
- May be too conservative in preschool child
- mg/kg calculation provides greater accuracy

Younger Children Receive Higher Dosages

<table>
<thead>
<tr>
<th>Patient Age (yrs)</th>
<th>Weight (kg)</th>
<th>Total Dose (mg)</th>
<th>Mean Dose (mg/kg)</th>
<th>Range (total mg)</th>
<th>Range (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>13</td>
<td>69.9</td>
<td>5.4</td>
<td>12-252</td>
<td>0.9-19.3</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>96.5</td>
<td>4.8</td>
<td>18-252</td>
<td>0.9-12.6</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
<td>135</td>
<td>3.8</td>
<td>36-252</td>
<td>1.0-7.2</td>
</tr>
</tbody>
</table>


Local Anesthetic Drug Interactions

<table>
<thead>
<tr>
<th>Interacting Drug</th>
<th>Effect and Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS depressants</td>
<td>Increased CNS and respiratory depression may occur. Use cautiously and give the smallest possible dose to achieve the desired effect</td>
</tr>
<tr>
<td>Opioids</td>
<td></td>
</tr>
<tr>
<td>Antidepressants</td>
<td></td>
</tr>
<tr>
<td>Antipsychotics</td>
<td></td>
</tr>
<tr>
<td>Antihistamines</td>
<td></td>
</tr>
<tr>
<td>Centrally acting antihypertensives</td>
<td></td>
</tr>
<tr>
<td>Muscle relaxants</td>
<td></td>
</tr>
<tr>
<td>Antiarrhythmics</td>
<td>Increased cardiac depression may occur. Use cautiously and give the smallest possible dose to achieve the desired effect</td>
</tr>
</tbody>
</table>

Local Anesthetic - Contraindications

<table>
<thead>
<tr>
<th>Medical Problem</th>
<th>Drugs to Avoid</th>
<th>Contraindication Level</th>
<th>Alternative Drug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local anesthetic allergy - documented</td>
<td>All local anesthetic in same chemical class</td>
<td>Absolute</td>
<td>Different chemical class of local</td>
</tr>
<tr>
<td>Bisulfite allergy</td>
<td>LA with vasoconstrictors</td>
<td>Absolute</td>
<td>LA without vasoconstrictor</td>
</tr>
<tr>
<td>Atypical plasma cholinesterase</td>
<td>Esters</td>
<td>Relative</td>
<td>Amides</td>
</tr>
<tr>
<td>Methemoglobinemia</td>
<td>Prilocaine</td>
<td>Relative</td>
<td>Other amide or ester</td>
</tr>
<tr>
<td>Liver dysfunction - (ASA III or IV)</td>
<td>Amides</td>
<td>Relative</td>
<td>Amide or ester but judiciously</td>
</tr>
<tr>
<td>Renal dysfunction - (ASA III or IV)</td>
<td>Amides or Esters</td>
<td>Relative</td>
<td>Amide or ester but judiciously</td>
</tr>
<tr>
<td>Cardiovascular Disease or Clinical Hyperthyroidism</td>
<td>High concentration of vasoconstrictors</td>
<td>Relative</td>
<td>1:100,000 or 1:200,000 carefully or LA without</td>
</tr>
</tbody>
</table>

Systemic Effects of Local Anesthetics

- LAs cross blood-brain barrier
  - Paradoxical increase with hypercarbia
- Local anesthetic may interact with Na+ channels in ALL excitable tissues
  - CNS
  - CVS
- Most serious side effects are CNS mediated and follow a continuum based on [serum]
- Potential for toxicity parallels intrinsic anesthetic potency

Interaction of Sedation Drugs and Local Anesthetic

- Factors increasing potential for LA toxicity
  - Opioid/antihistamine produce respiratory depression
  - Hypoxemia leads to ↑PCO₂, ↓PO₂ and ↓pH
  - Hypercarbia - leads to ↑cerebral perfusion and further ↑CNS distribution of LA because…...
  - Acidosis - ↓protein binding - release of more LA for redistribution to CNS
  - Respiratory acidosis further complicates recovery
    - Cardiac arrest more likely as pH, PO₂ ↓ and PCO₂ ↑

Systemic Effects of Local Anesthetics

- Significantly smaller dosages of LA are required to produce CNS toxicity than CVS toxicity
- Potent, lipid-soluble agents (bupivacaine, etidocaine, ropivacaine) have inherently greater cardiotoxicity than LAs commonly used in pediatric dentistry
  - Direct cardiac electrophysiologic toxicity - stronger binding affinity to Na+ channels
    - Dysrhythmias resistant to resuscitation
  - CNS-mediated activity on Autonomic Nervous System
    - ↓activity in nucleus tractus solitarii → hypotension
    - Potent peripheral inhibitory effects on sympathetic reflexes
    - Potent vasodilatory effects
Systemic Effects of Local Anesthetics

- Metabolites of lidocaine produce sedation
  - Monoethylglycinexylidide
  - glycinexylidide
- Active metabolite of prilocaine, orthotoluidine, induces formation of methemoglobin

Buffering Local Anesthetics

Problems

- Pain from the pH incompatibility of local anesthetic and vasopressor with local tissue pH
  - LA: pH 5-9
  - Vasopressor: pH 3.5
- Tissue injury
- Latent uptake until pH “normalizes”
  - At acidic pH LA exists in non lipid soluble ionized form therefore unavailable to cross to nerve
- Infection lowers tissue pH

Benefits

- Increases amount of lipid soluble active non ionized form
  - From pH 3.5 to buffered 7.4 there is a 6000 fold increase in lipid soluble form
- Patient comfort
- More rapid onset
- Decreased injury to tissue
- CO₂ release from HCl interaction with NaHCO₃ may potentiate action of LA and have its own anesthetic effect

Armamentarium

- 8.4% NaHCO₃ available as 4.2g/50mlH₂O
- Tuberculin Syringe
- Alcohol wipes
- LA. carpule: 1.7ml with epi 1:100000 or 1:200000
- Lasts about 1 week

Is “The Wand” Better?

- 41, 9-13 year old children; anxious and non-anxious
  - Assigned randomized cross-over study
  - Children's Fear Survey Schedule- Dental Subscale; Facial Image Scale, Spielberger’s State Anxiety Index for Children and heart rate used to assess responses/behaviour
- No differences in injection pain between The Wand and traditional dental syringe
- Higher levels of pre-injection anxiety related to more pain during injection than the device used

Technique
**Lidocaine**

- **Aromatic residue**
- **Intermediate chain**
- **Amino terminus**

<table>
<thead>
<tr>
<th>Aromatic residue</th>
<th>Intermediate chain</th>
<th>Amino terminus</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂N</td>
<td>NHCO₂⁻</td>
<td>NCH₃</td>
</tr>
<tr>
<td>CH₃</td>
<td></td>
<td>NCH₃</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Lidocaine Toxicity**

**Rate of Injection**

- > 50 µg/kg/min will create toxicity  
  *Saraway et al., 1987*
- Injection rate < 2 mL/min will produce serum levels below seizure threshold  
  *Malamed, 1996*

*Avoid rapid (>2 mL/min) bolus injections!!*

**Lidocaine Allergy**

**Factors**

- Most “allergic” reactions are “psychogenic” reactions to fear and anxiety. These reactions should be differentiated before referral for allergy testing.
- To diminish chance of syncope, anesthetics should be administered to the patient while lying down

**Articaine**

- 4% concentration* with 1:100,000 epi
- 1.7 mL cartridge
- Amide with an ester side chain  
  (metabolized in liver and plasma)
- High tissue diffusion (liposolubility)  
  (thiophene substituted for benzene ring)

*Compared to 2%: Faster onset, Similar safety*
Articaine (Septodont®)

- Gold color band indicator
- Latex-free stopper and diaphragm

Articaine Biotransformation

- 90% hydrolyzed by plasma pseudocholinesterase
- 10% metabolized by P450 liver enzyme
- Half-life = 27 mins. (vs. 60-90 mins. Lido.)
- Inactive metabolite (articainic acid)

Articaine

Comparison to 2% Lidocaine
(Malamed et al, JADA and Pediatr Dent, 2000)

- Potency / Onset: 1.5 X
- Clearance: 3.0 X
- Risk: 0.6 X
- Efficacy: Same
- Duration of action: Same

Articaine – Efficacy by Technique

Comparison to 2% Lidocaine

<table>
<thead>
<tr>
<th>Technique</th>
<th>Study References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandibular Block</td>
<td>Donaldson et al, J Can Dent Assoc, 1987</td>
</tr>
<tr>
<td></td>
<td>Malamed et al, JADA, 2000</td>
</tr>
<tr>
<td></td>
<td>Tofoli et al, Anesth Prog, 2003</td>
</tr>
<tr>
<td></td>
<td>Claffey et al, J Endo, 2004</td>
</tr>
<tr>
<td></td>
<td>Mikessel et al, J Endo, 2005</td>
</tr>
<tr>
<td></td>
<td>Berlin et al, Oral Surg, 2005</td>
</tr>
<tr>
<td>Maxillary Infiltration</td>
<td>Donaldson et al, J Can Dent Assoc, 1987</td>
</tr>
<tr>
<td></td>
<td>Haas et al, Anesth Prog, 1990</td>
</tr>
<tr>
<td></td>
<td>Haas et al, J Can Dent Assoc, 1991</td>
</tr>
<tr>
<td></td>
<td>Vahatalo et al, Anesth Prog, 1993</td>
</tr>
<tr>
<td></td>
<td>Oliveria et al, Brit Dent J, 2004</td>
</tr>
</tbody>
</table>

No Clinical Difference in Success Rates

Articaine – Efficacy by Technique

Comparison to 2% Lidocaine

<table>
<thead>
<tr>
<th>Technique</th>
<th>Study References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraligamentary Injection*</td>
<td>Berlin et al, Oral Surg, 2005</td>
</tr>
<tr>
<td>Mandibular Infiltration**</td>
<td>Kanaa et al, J Endo, 2006</td>
</tr>
<tr>
<td></td>
<td>Robertson et al, JADA, 2007</td>
</tr>
</tbody>
</table>

* No difference in success rate
** Statistical difference in success rates

Articaine Safety and Efficacy in Children

- Not established in US children < 4 yrs. old?
  - Malamed, JADA, 2000 (efficacy); 2001 (injury)

- Canadian data established safety in 1-4 year olds
  - Wright et al, Anesth Progress, 1989

- Sulfur allergy contraindication?
  - Sulfur atom is not an allergen
    - Sulfur ≠ Sulfa (Bactrim®) ≠ Sulfite (antioxidant)

- Palatal diffusion from buccal infiltration?
  - Evidence refuting greater diffusion
    - Oliveira et al, BDJ 2004, 197:45-6
  - Evidence supporting greater diffusion
Articaine
Disadvantages / Precautions

- Potential toxicity due to [4%]?
  - Decrease toxicity with repeated injections over time
- Paresthesia  
  - Greater incidence (5X) reported from mandibular blocks (lips and tongue)
  - Higher than expected for frequency of use
  - Incidence = 0.03%, all cases were transient, resolving in 1-2 mos.
  - Articaine - 1.2% (11/882); Lidocaine - 0.5% (2/443)
  - Is concentration and dose dependent, can also be a result of direct nerve trauma, inflammation or hemorrhage
- Methemoglobinemia can be produced

3% Mepivacaine Plain

- Rapid absorption if no vasoconstrictor
- 50% higher concentration than 2% lido.
- 3 X serum level than 2% lidocaine with epi.  
  Goebel et al. Anesth Prog, 1978
- Disproportionate number of toxicity cases  
  Moore, Pediatr Dent, 2000
- Similar duration of soft tissue anesthesia  
  Hersh et al., JADA, 1995

4% Prilocaine
Citanest (Dentsply)

- Higher concentration
  - Exposes young children to potential toxicity
  - Precaution in patients with anemia, sickle cell disease, hypoxia, acetaminophen
- Methemoglobinemia
  - Sensitivity to metabolite, o-toluidine
  - Potentiated by acetaminophen, phenacetin

Local Anesthesia Technique

- Use topical and make it red
  - Hides the color of blood
  - Numbs mucosa but not much deeper
  - Still requires distraction and clenching
  - Don’t use too much
  - Usually benzocaine 20% or tetracaine
    - Ester of PABA
    - Methemoglobinemia
  - EMLA ineffective intraorally

Topical Anesthesia Warning - FDA

FDA is concerned about the serious public health risks related to compounded topical anesthetic creams.
Two deaths have been connected to compounded topical anesthetic creams made by Triangle Compounding Pharmacy and University Pharmacy, two of the five pharmacies receiving warning letters.
Similar topical anesthetic creams are compounded by the other firms, and today’s action serves as a general warning to firms that produce standardized versions of these creams.
Don’t block children under 8 or use a full carpule

- Porous bone
- Teeth clenched
- Move needle along alveolar bone
- Interdental/papillary
- Never do a “long buccal”
- 1 hour anesthesia time

Infiltration Technique

And the Complications...

Anesthesia Techniques in Children

- Short needle
- Smaller amount
  - Diffuses over a larger relative area
  - Less mylenization

Local Anesthesia Overdose or Allergy: What Should You Do?

Allergic Reactions to Local Anesthetics

- Exceedingly rare now that esters are rarely used
- Sulfites may precipitate reactions
  - Sodium metabisulfite
  - Acetone sodium bisulfite
  - Prevent oxidation of adrenergic vasoconstrictors
- Most patients affected have asthma or RAD
- Latex in dental cartridges
  - Diaphragm made from synthetic halo-butyl isoprene blended with natural rubber and therefore contains latex
  - Plunger made from solid natural rubber latex
  - No reports of allergic reactions from dental cartridges
Risk Factors for Complications

- Polypharmacy sedations without understanding possible drug interactions
- Excessive dosages of narcotics and/or LAs
- Failure to recognize respiratory depression
- Inadequate resuscitation
- Inadequate monitoring
- Inadequate medical evaluation before treatment

Local Anesthetic Considerations During Sedation

- CNS and CVS depressant in excessive dosages
- Potentiation of sedative activity by LA
- Calculate/record maximum recommended LA dose in mg/kg
- DO NOT EXCEED DURING TREATMENT!

Manifestations of Local Anesthetic Overdose

<table>
<thead>
<tr>
<th>Signs and Symptoms of Mild to Moderate Overdose</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confusion</td>
<td>Headache</td>
</tr>
<tr>
<td>Talkativeness</td>
<td>Lightheadedness</td>
</tr>
<tr>
<td>Apprehension</td>
<td>Vertigo</td>
</tr>
<tr>
<td>Excitement</td>
<td>Blurred vision</td>
</tr>
<tr>
<td>Slurred Speech</td>
<td>Ringing in ears</td>
</tr>
<tr>
<td>Generalized stutter</td>
<td>Number of peripheral tissues</td>
</tr>
<tr>
<td>Muscular twitching</td>
<td>Flushed or chilled feeling</td>
</tr>
<tr>
<td>Nystagmus</td>
<td>Drowsiness</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Disorientation</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>Loss of consciousness</td>
</tr>
</tbody>
</table>

Dose-Dependent Systemic Effects of Lidocaine

<table>
<thead>
<tr>
<th>Plasma Concentration (µg/mL)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>Analgesia</td>
</tr>
<tr>
<td>5-10</td>
<td>Lightheadedness</td>
</tr>
<tr>
<td>10-15</td>
<td>Numbness of tongue</td>
</tr>
<tr>
<td>15-25</td>
<td>Muscle twiching</td>
</tr>
<tr>
<td>20-25</td>
<td>Seizures</td>
</tr>
<tr>
<td>25-35</td>
<td>Coma</td>
</tr>
<tr>
<td>&gt;35</td>
<td>Respiratory arrest</td>
</tr>
<tr>
<td>&gt;50</td>
<td>Cardiovascular depression</td>
</tr>
</tbody>
</table>

Managing a Local Anesthetic Overdose

- Terminate dental procedure
- Protect the patient from injury
- Monitor vital signs
- Initiate basic life support (A,B,C) including positive pressure oxygen
- Activate EMS immediately
- Administer diazepam or midazolam for seizures if >5 min
- When seizures end - monitor and manage post-seizure respiratory and cardiovascular depression

Pharmacologic Management

- Phentolamine Mesylate (OraVerse - Novolar)
  - Approved May 9, 2008 by FDA for patients > 6 years old or > 15 kg
  - Up to a 56% acceleration of time to normal soft tissue sensation
  - Non-selective $\alpha$-adrenergic antagonist $\rightarrow$ vasodilation at site of administration
  - Pharmacokinetics reveal a second peak in [lidocaine] immediately after administration of OraVerse
- Not indicated in a local anesthetic overdose due to increased blood concentration of LA
Vasopressor Considerations

- Use is predicated on alpha receptor stimulation leading to vasoconstriction
  - Delays absorption
    - Reduces systemic toxicity
    - Prolongs duration of anesthesia
      - Concentrations > 1:200,000 provide no advantage
  - Reduces hemorrhage following infiltration at surgical site
    - Higher concentrations useful

Vasoconstrictor Drug Interactions

<table>
<thead>
<tr>
<th>Interacting Drug</th>
<th>Effect and Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricyclic antidepressants</td>
<td>Sympathomimetic effects may be enhanced. Use epinephrine cautiously. Avoid levonordefrin.</td>
</tr>
<tr>
<td>Non-selective β-blockers (metoprolol)</td>
<td>Hypertensive and/or cardiac reactions are more likely. Use cautiously.</td>
</tr>
<tr>
<td>COMT inhibitors (entacapone)</td>
<td>Hypertensive and/or cardiac reactions are more likely. Use cautiously.</td>
</tr>
<tr>
<td>Phenothiazines (promethazine)</td>
<td>Hypertensive and/or cardiac reactions are more likely. Use cautiously.</td>
</tr>
<tr>
<td>Butyrophenones (haloperidol)</td>
<td>Hypertensive and/or cardiac reactions are more likely. Use cautiously.</td>
</tr>
<tr>
<td>α-blockers (prazosin)</td>
<td>Hypertensive and/or cardiac reactions are more likely. Use cautiously.</td>
</tr>
</tbody>
</table>

Reasons for Anesthetic Failure

- Accessory Innervation
- Anatomical variation
- Inflamed tissue
- Patient apprehension
- Incorrect technique

Routes of Administration: Balancing Safety and Efficacy

- Inhalation
- Enteral
  - Oral
  - Rectal
- Parenteral
  - Intravenous
  - Intramuscular
  - Intradermal
  - Submucosal
  - Intranasal
- Combination of Techniques

Duration of Anesthesia - Shorter using LA's without vasoconstrictors?

- no reduction in the duration of soft tissue anesthesia when employing 3% mepivacaine or 4% prilocaine instead of 2% lidocaine with epinephrine
- Using more concentrated LA means maximum dose is reached with fewer carpules - increased risk of overdose

What We Are Familiar With...

- What are we taught?
  - Inhalation
  - Nitrous Oxide/Oxygen Analgesia
- Oral Sedation
  - Chloral hydrate
  - Chloral hydrate/Narcotic/Phenothiazine
  - Phenothiazine
  - Phenothiazine/Narcotic
  - Benzodiazepine/Phenothiazine
  - Hallucinogens
  - Low dose anesthetics
  - Combo du jour
Risks and Benefits

**Inhalation**
- + consistent, easy to train, open system, covers smell, covers sight, no mechanical or electrical monitoring
- - Cost of equipment, runs constantly, storage of tanks, nausea and vomiting, hallucinatory

**Oral**
- + Slow uptake, first pass breakdown, cost, ease of administration
- - lack of titration, gastric upset, lack of oral reversal, half life, office time, monitoring

Risks and Benefits

**IV**
- + reliable, consistent, emergency port, titratable
- - cost, poking and searching, post op complications, needle phobia

**IM**
- + quick, easy reliable, some titration
- - muscle pain, nerve damage, difficult to titrate, needle phobia

**Transdermal**
- + non threatening, quick application, few complications, long acting
- - slow uptake, inconsistent

Risks and Benefits

**Submucosal**
- + injectable, consistent with dental practice, uptake mirrors that of IV, sublingual route not invasive (could this be oral?)
- - not allowed without license, area may become inflamed, local anesthetics may interfere with uptake

**Intranasal**
- + quick onset, inexpensive, may allow use of other modalities (IV), oral and mucosal uptake
- - invasive, nosebleeds, bad taste

What About Combining Techniques?

• Combination of Techniques
  - + helps tailor sedation and allow depth titration and pain control, decrease individual drug doses
  - - may cause deep sedation, unpredictable outcomes, polypharmacy

• DOCS program?
  - + multiple stacked doses of oral meds- Triazolam (halcyon)- not to exceed max. daily dose
    - Science?
    - Beneficial?
    - Training?
  - - Not approved for children (questionable for adults)

Absorption Times

<table>
<thead>
<tr>
<th>Route of Administration</th>
<th>Absorption Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intravenous</td>
<td>1</td>
</tr>
<tr>
<td>Inhalation</td>
<td>1 to 3</td>
</tr>
<tr>
<td>Sublingual</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Nasal</td>
<td>5 to 10</td>
</tr>
<tr>
<td>Subcutaneous</td>
<td>10 to 30</td>
</tr>
<tr>
<td>Intramuscular</td>
<td>10 to 30</td>
</tr>
<tr>
<td>Enteral (oral)</td>
<td>20 to 60</td>
</tr>
</tbody>
</table>

Caveats of Sedation

- No defined line between minimal and moderate sedation
- No defined line between moderate and deep sedation
- No defined line between deep sedation and general anesthesia
- Dropping between levels gets more dangerous
- Your license defines the road traveled and the vehicle used
How Sedative Drugs Work

- **Reticular Activating System (RAS)**
  - Cluster of cells in cerebral cortex, basal ganglia, limbic system and cerebellum
  - Controls:
    - State of consciousness
    - Cardiovascular tone
    - Respiratory center
    - Vomiting center

How Sedative Drugs Work

- **GABA drugs**
  - GABA is an inhibitory neurotransmitter
    - Opens chloride channels preventing neural excitation
    - Muscle relaxation, anxiolysis and anticonvulsant effects
  - GABA Receptors
    - Many receptor sites
    - Benzodiazepines work at GABA$_A$ receptor sites (there are many)
      - Potentiating and enhance the chloride ion channel response when GABA is present
      - Safety of benzodiazepines is because they do not directly act on GABA sites
    - Non-benzodiazepine GABA agonists work at specific sites on the GABA receptor to minimize side effects
    - Nitrous oxide works on the BZ receptor sites

How Sedative Drugs Work

- **NMDA**
  - Controls intracellular transfer of electrical signals through Ca$^{2+}$
  - Modulated by glutamate and glycine
  - Work as competitive antagonists or noncompetitive agonists to NMDA, glycine antagonists or Ca$^{2+}$ channel blockers
    - Prevent transfer of electrical impulses
    - Dissociative anesthesia, catalepsy, amnesia and analgesia

Avoid Polypharmacy and Know Drug Interactions

- Lidocaine with epinephrine is a drug!
- Chloral hydrate breakdown products are similar to halothane
- Diazepam has a 12 hour half life
- Naloxone has a shorter half life than most narcotics
- Flumazenil slowly reverses
- Fat soluble vs non fat soluble meds and their effect on half life and metabolism
- Interactions on cytochrome $P_{450}$
How Sedative Drugs Work

- Opioid Receptors
  - Narcotics and nitrous oxide
    - Act at the receptor or cause release of endogenous endorphins
  - Synthetic, semisynthetic and natural
    - Inhibit release of excitatory neurotransmitters
      - Primary afferents and dorsal horn of the spinal cord
      - Block the release of substance P
      - Cause euphoria by relieving anxiety and sedation
    - Disrupt REM and non REM sleep
    - Dose dependent respiratory depression in the pons and medulla

- Alcohols
  - Work on specific GABA receptors
  - CNS depressants
    - Respiratory and cardiac depressants
- Antihistamines, phenothiazines and pheno-like drugs
  - Sedative hypnotics
  - Antagonists on the H₁ receptor site
    - Antimuscarinic (excitatory pathway)

Inhalation

- Safe
- Effective
- Quickly and easily reversible

Nitrous Oxide/Oxygen Analgesia

- Works on GABA and provides anxiolysis
- Reduces gagging
- Works on opioid receptors and reduces pain
- Works on NMDA and provides amnesia and disassociation
- Provides distraction
  - Mask blocks sight lines
  - Covers smells
- Prolongs treatment times
- Potentiates the effects of other sedatives
- Improves behavior over sequential visits
- Decrease adverse incidents

“...A mixture of 93% nitrous oxide and 7% oxygen is inhaled until the third stage of anesthesia is attained (the pupils of the eyes turn up and become fixed) in about one minute. When too much nitrous oxide is given the patient usually becomes cyanotic and bridging may occur, which may be overcome quickly by the administration of a small portion of oxygen.”

John Brauer, Dentistry for Children, 1947

- Acceptable to parents
- Inhalation analgesia/anxiolytic/CNS depressant
- 40:60-50:50 concentration
- 2-4 min on set / 5 min recovery
- Diffusion hypoxia is theoretical
- Equipment costs
  - Initial setup
  - Maintenance and monitoring
- No electronic or mechanical monitors
- Allows decrease in L.A.
  - 40%/4mg MSO₄ in closed system
- Weak anesthetic
  - MAC>100 (the hypoxia kills them)
Nitrous Oxide/Oxygen Analgesia

- Open vs. closed system changes concentration
- Oropharyngeal \([N_2O]=15\%\) when machine is set at 45\%
- Supplemental oxygen reduces risk of desaturation during sedation
- May also decrease the occurrence of hypercarbia
- May mask hypoventilation because of hypersaturation by \(O_2\)

The Dental/Nasal Hood

- Form fitting
- Scavenging
- Modifications for capnography
- Allows airway access

Nitrous Oxide/Oxygen Analgesia

- Carried in the blood as a dissolved free gas
- Does not bond to hemoglobin
- Does not undergo biotransformation
- Partial pressure equilibrium quickly reached because does not dissolve well

Nitrous Oxide/Oxygen Analgesia

- Contraindications
  - Otitis media or sinusitis
  - Diffuses into cavity at a rate 37 X > \(N_2O\) leaves
  - Severe emotional or drug related dependencies
  - Sickle cell disease
  - May be argued that 50\% \(O_2\) decreases chance of crisis during stressful dental procedures
  - First trimester pregnancy
  - Chronic Obstructive Pulmonary Disease
  - Treatment with Bleomycin Sulfate
  - Autism
  - Blocks Vit B12 and folate metabolism with chronic use
  - Affects nerve development

Nitrous Oxide/Oxygen Analgesia

- And now the bad
  - \(N_2O\) pollution and potential occupational exposure risks
  - Spontaneous abortions
  - Blocks cobalt coenzyme/vitamin B12
  - Nervous system and brain function
  - Muscle fasciculation and nerve damage from chronic exposure
  - Weak agent requires additional behavior management techniques
  - N/V and disorientation at high concentrations
  - 100\% tissue saturation occurs by 30 min
    - Must decrease concentration especially if rubber dam in place
    - Frequent adjustments
  - 100\% tissue saturation occurs by 30 min
  - Must decrease concentration especially if rubber dam in place
  - Frequent adjustments

Nitrous Oxide/Oxygen Analgesia

- Safe and effective use
  - Combined flow at 6L/m
  - Scavenger set to 45L/m
  - Reduce concentration of gas--room air may enter
  - Reservoir bag full but not stretched
  - Use smaller 2L bag
  - 100\% \(O_2\) to start
  - Gradually over 2-3 minutes increase to...
Oral Sedation

- **Techniques for oral administration**
  - **Armamentarium**
    - Dropper
    - Syringe
    - Dosing spoon
    - Dosing cup
  - **Position**
    - Child slightly reclined, never prone
    - Administer small amounts by side of tongue
    - Do not force down throat
  - **Complications**
    - Laryngospasm, aspiration, soft tissue trauma

Oral Sedation

- **Use of NSAID preoperatively**
  - Effective in adults in reducing post op pain
  - Equivocal in children
  - Parents are non compliant in administering drugs post op
    - Delays pain onset
    - Decreases pain intensity
    - Reduces amount of post op analgesia needed
  - Heavily flavored syrup masks taste of other meds
  - Reduces effectiveness of prostaglandins which diminish effect of L.A.

---

**Diphenhydramine (Benadryl)**

- **Antiemetic/antihistaminic**
- Over the counter/ at home
  - Solo medicine
    - Combined in cough and cold formulations
      - May cause additional drowsiness
- 1-2 mg/kg
- 15-30 min onset
- 30-45 min working time/ 2 hour duration
- Anxiolysis, amnesia, may cause drowsiness
- Xerostomia

**Promethazine (Phenergan)**

- **Class:** anti-emetic/anti-histaminic
- Phenothiazine derivative
- CNS depression
- Possible extrapyramidal reaction including ataxia
- Onset 15 min.
- Peak 60 min.
- Duration 2-8 hours
- Effect: Anti-emetic, anti-histiminic, sedative, and anxiolytic
  - **BLACK BOX WARNING for fatal respiratory depression in children < 2**
**Benzodiazepines**

- Wide therapeutic index
- Anxiolytic
- Amnesic
- Anticonvulsant
- Antihistaminic
- Antiemetic
- Muscle relaxant
- Sedative
- Potentiates CNS depressants/Limbic S.
- Short to intermediate onset and duration of action
- Minimal adverse reactions
- Potency: Midaz 2X Diaz
- Lipid solubility: Midaz>Diaz

**Midazolam (Versed)**

- Sedative/hypnotic
- Benzodiazepine, water soluble
- CNS depression, little CV or resp. effect
- .4-.6 mg/kg syrup or injectable form
- Bitter taste
- 10-15 minute onset
- 20-30 min working time
- ½ life 1.7-2.4hr.
- Sedation, amnesia, hands-to-head, ataxia, loss of head control
- Resp. depression can occur at higher doses
- Mix in apple juice or acidic drink to increase uptake in ionized form

**Midazolam (Versed)**

- Adverse reactions
  - Paradoxical response
  - Higher incidence in ADHD
  - Dysphoria (whining, irritable)
  - Agitation (combativeness, hostility)
  - Inconsolable crying
  - “Reversed” by flumazenil
  - Nightmares and hallucinations
  - Hiccups
  - Diplopia

**Diazepam (Valium)**

- Sedative/hypnotic
- Benzodiazepine, fat soluble
- CNS depression, little CV or resp. effect
- .25-.5 mg/kg
- 45-60 min uptake
- 60 min working time
- 20-40 hour half-life (active metabolite)
- Anxiolysis, sedation, amnesia, ataxia
- GABA system - reduced inhibition - idiosyncratic effect
- Liquid and pill form

**Zolpidem (Ambien)**

- An imidazopyridine
- Unrelated to the benzodiazepines, but similar mechanism of action
- Short active, T1/2 = 1.5 – 2.4 hrs
- No active metabolites
- Amnesia
- Reversible with Flumazenil

**Zolpidem (Ambien)**

- Best used in combination with oral Valium
- Used with preadolescent (age 7, 8, 9) 50 lbs: 10mg Valium, 10mg Zolpidem
- Peak concentration at 1.6 hrs
- Side effects: Dizziness, headache, nausea, myalgia, xerostomia, hallucinations
Benzodiazepines

- Reversal Agent
  - Flumazenil
    - Competitive inhibition of the benzodiazepines
    - Also works on zolpidem and zaleplon
    - Shorter half life than midazolam
      - Multiple doses
    - Onset 1-2 minutes
    - Peak 6-10
    - .2 mg q1-2 minutes and max 3 mg/hour
      - No reported adverse affects from overdosage
    - May lower seizure threshold

Opioids/Narcotics

- Narcos = from Narcissus- stared at his image
  - sedation
- Decrease pain
- Decrease anxiety
- Cause respiratory depression, hypotension, unconsciousness
- Potentiates sedation meds
- Common narcotics
  - Fentanyl: short acting
  - Morphine: medium acting
  - Meperidine: medium acting
- Reversible with Narcan (naloxone)
  - Competes at receptor site and is nonactive

Meperidine (Demerol)

- Narcotic-analgesia and sleep
- 1-2 mg/kg
- 30-45 min. onset
- 30-45 min working time
- Sedation, amnesia, analgesia
- Can lower seizure threshold
- Causes release of histamines
- Falling out of favor
  - Shorter agents i.e. fentanyl

Meperidine Adverse Effects

- As dose increases through & beyond therapeutic range:
  - Respiratory rate and depth decreases or ceases
  - Increased likelihood of myocardial depression (hypotension)
  - Increases likelihood of seizures/coma
  - Increased likelihood of vomiting/nausea
  - Increases likelihood of drug-interactive effects (e.g. especially with local anesthetic)

Naloxone

- Naloxone
  - Narcotic antagonist
  - Competitive antagonist a mu-opiod receptor sites
  - Rapid withdrawal
    - May wish to limit withdrawal and just reverse respiratory depression
    - Dosage controversy in pediatric literature
      - Adults: 4mg
      - Pediatric patients:
        - <5: 0.1mg/kg IV/IM q2-3min to max. 5mg
        - >5: 2.0 mg IV/IM q2-3min to max 10mg

Ketamine

- A safe and reliable alternative to traditional conscious sedation and general anesthesia
- Consciousness, cooperative, amnesia, analgesia
- Relative absence of respiratory or cardiac complications
- Partial reversal with naloxone
Ketamine

- Induces a dissociation between the thalamoneocortical and limbic systems, thus preventing the higher centers from perceiving pain
- "Ketamine stare"
- Peak plasma concentrations in about 1 minute after IV and 5 min after IM
- Active metabolite = norketamine

• Clinical effects wane in about 15 min after IV and 30 min after IM injection
• $T_{1/2} = 1 – 2$ hrs in children
• Protective reflexes remain intact
• Stimulates secretions (laryngospasm?)
• Dosage: IV = 0.25 mg/kg
  IM = 2 – 4 mg/kg mixed with 5 mcg/kg glycopyrrolate for salivation control

Chloral Hydrate (Noctec)

- Class: Sedative hypnotic
- CNS depressant
  - Becomes trichlorethanol (legally drunk)
- Minimal CV or respiratory depression at doses <25mg/kg
  - Higher doses selectively inhibit function of the oropharyngeal muscles
- Gastric irritant causes vomiting post-op
- Halothane like metabolite
  - Stimulates myocardium to circulating catecholamines
- Onset 30-60 minutes
- Peak 60 minutes
- Duration 4-6 hours, may resedate after discharge
- Behavioral changes over time
  - disinhibition, angry or happy, hyperactive or somnolent
  - In emergency, cannot administer epinephrine

• No longer available as elixir
• Tablets still available and a compounding pharmacy may still make it
• Much better and safer drugs and options available

Timeline of Chloral Hydrate Effects

- 0-20 min. Personality change
  - friendly or angry with possible hyperactivity
- 20-40 min. Decreasing activity and sleep ensuing
- 40-90 min. Sleep
  - arousal related to severity of stimulation, additive effects of other drugs, patient characteristics

Scheme For Selecting Drugs by Age for Children

- Age
  - 18-36 months  
    Midazolam, Midazolam/Vistaril
  - 37-72 months  
    Midazolam/Demerol
  - > 72 months  
    Diazepam/Zolpedim/Triazolam/Lorazepam
Scheme for Selecting Drugs by Temperament & Behavior

- Temperament/Behavior
  - Easy - midazolam; midazolam/vistaril
  - Difficult - midazolam/demerol; midazolam/demerol/vistaril

Scheme for Selecting Drugs by Procedure for Children

- Procedure Length
  - Ultra short - Midazolam
  - Short - Midazolam/Vistaril
  - Long - Midazolam/Demerol

Drug Combination

<table>
<thead>
<tr>
<th>Combo</th>
<th>Dosage (mg/kg)</th>
<th>Onset</th>
<th>Characteristics</th>
<th>Cautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dem + Vis</td>
<td>Dem (1-3) Vis (0-2)</td>
<td>40-45 min</td>
<td>same as above</td>
<td>Same as above</td>
</tr>
<tr>
<td>Midolzem</td>
<td>0.3-0.6</td>
<td>5-15 min</td>
<td>Floppy, drowsy, to feed, cry</td>
<td>Flumazenil (0.01mg/kg)</td>
</tr>
<tr>
<td>Md + Dem</td>
<td>Md (0.3-0.5) Vis (0-2)</td>
<td>30-60 min</td>
<td>Floppy, drowsy, dysphoria, Respiratory depression, Flumazenil &amp; Narcan</td>
<td></td>
</tr>
<tr>
<td>Md + Vis</td>
<td>Md (0.3-0.6) Vis (0-2)</td>
<td>5-15 min</td>
<td>same as above</td>
<td>Respiratory depression or shallow</td>
</tr>
</tbody>
</table>

Oral Ketamine – Diazepam Regimens

- Comparison between 4mg/kg and 8mg/kg of ketamine in conjunction with 0.1mg/kg diazepam
- Diazepam was given to inhibit postoperative ketamine induced psychic phenomena, not as a sedative
- Patients ranged from 29-65 months; healthy; noncompliant

Oral Ketamine vs. Meperidine/ Promethazine

- 40 male and female patients from 20-60 months old; healthy; noncompliant
- Random assignment to either Ketamine (6 mg/kg) or Meperidine (2mg/kg) & Promethazine (0.5mg/kg)
- Ketamine sedation onset and recovery time were less than half for m/p
- Better over sedation scores for Ketamine

Finally You Can Give the Meds...

- Must be given in a supervised environment even if administered by parent
  - If spits out, do not give additional meds!
- Wait appropriate time until child appears droopy or goopy
  - Tell parent to hold child close/play on floor
  - Visually monitor q3-5m
- Move child to treatment area
  - With or without parents
  - Apply appropriate monitors and other diversions
  - Administer N2O for at least 5 minutes for "settling", max 10
  - Administer local anesthetic to below max recommended dose
  - Treat with rubber dam
- Couldn’t be simpler!
Post Treatment Care

- Not post sedation
  - Have removed stimuli but drug may still be active
  - Child may drop back into deeper level of sedation
  - If reversal used, drug may exceed time for antagonist
- Observed in a suitable facility
  - Oxygen available
  - Monitored on a regular basis (continual)
- Discharged when returns to pre sedation level
  - Awake for 20 minutes in a quiet environment
  - Written instructions with contact number
    - Diet and fluids
    - Fever
    - Nausea/vomiting

Discharge Criteria

- “On the Way” home
- O: orientated to place and people
- N: nausea and vomiting controlled
- T: taking fluids by mouth
- H: hemodynamically stable
- E: escort present
- W: wound intact, bleeding controlled
- A: airway clear
- Y: “yes I want to go home”

The Silver Bullet

- No drug or drug combination gives consistent, 100% results, unless the patient is under G.A.
- Must accept that at this time, with drugs and techniques available, we may only get 70% success, usually less
- We must redefine success or find alternative means and increase accessibility to G.A.
- We must continue to do research, experiment and teach prevention to avoid extensive treatment