Safe Sedation for Kids in the Office

California Society for Pediatric Density
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L. Stephen Long, MD
Pediatric Anesthesiologist
Children’s Dental Anesthesia Group
UCSF Benioff Children’s Hospital Oakland
Part 1: The Risk of Sedation
Mortality was higher for out of OR medical anesthesia Closed Claims

<table>
<thead>
<tr>
<th></th>
<th>Inside of OR</th>
<th>Outside of OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conscious Sedation</td>
<td>6%</td>
<td>58%</td>
</tr>
<tr>
<td>Inadequate Oxygenation</td>
<td>2%</td>
<td>33%</td>
</tr>
<tr>
<td>Death</td>
<td>24%</td>
<td>54%</td>
</tr>
</tbody>
</table>

Outside of OR anesthesia Closed Claims were judged as having substandard care

1. More often judged as having substandard care \((p=0.003)\)
2. More often judged as being preventable by better monitoring \((p=0.007)\)

Pediatric dental sedation/anesthesia deaths occurred most often in the office.

Functional residual capacity (FRC) delays desaturation during apnea.

Closing capacity is highest at birth and then decreases as children age.
Poiseuille's Law explains why children’s airways have higher resistance to airflow. Resistance to flow is inversely proportional to the radius.
Airway edema can easily obstruct a child’s airway

**Infant**
- Normal: 4 mm
- Edema: 1 mm
- Resistance: $R \alpha \frac{1}{\text{radius}^4}$, ↑16x
- Cross-sectional area: ↓75%

**Adult**
- Normal: 8 mm
- Edema: 8 mm (same size as normal)
- Resistance: ↑3x
- Cross-sectional area: ↓44%
Why do children desaturate rapidly?
Children store less oxygen in their lungs but consume more oxygen per minute.

<table>
<thead>
<tr>
<th></th>
<th>Child</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_2$ consumption</td>
<td>6 ml/kg/min</td>
<td>3 ml/kg/min</td>
</tr>
<tr>
<td>FRC</td>
<td>25 ml/kg</td>
<td>40 ml/kg</td>
</tr>
</tbody>
</table>
Children desaturate rapidly when apneic

<table>
<thead>
<tr>
<th></th>
<th>Child (15 kg)</th>
<th>Adult (70 kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRC</td>
<td>25 ml/kg</td>
<td>40 ml/kg</td>
</tr>
<tr>
<td>FRC total volume</td>
<td>375 ml</td>
<td>2800 ml</td>
</tr>
<tr>
<td>$O_2$ volume on RA</td>
<td>79 ml</td>
<td>588 ml</td>
</tr>
<tr>
<td>$O_2$ consumption</td>
<td>6 ml/kg/min</td>
<td>3 ml/kg/min</td>
</tr>
<tr>
<td>$O_2$ consumption total volume</td>
<td>90 ml/min</td>
<td>210 ml/min</td>
</tr>
<tr>
<td>Time until no $O_2$ left during apnea</td>
<td>53 seconds</td>
<td>2 minutes, 48 seconds</td>
</tr>
</tbody>
</table>
What mechanisms prevent children from breathing?
Five categories for respiratory failure in children

1. Apnea
2. Upper airway obstruction
3. Laryngospasm
4. Bronchospasm
5. Lower airway obstruction
Only **two** anatomic mechanisms for upper airway obstruction

1. The tongue obstructs the airway posteriorly
2. The pharynx collapses on itself
The pediatric tongue is large

- Located mostly in oral cavity
- Potential site of airway obstruction
- As a child grows, posterior third of tongue descends into pharynx, forming upper anterior pharyngeal wall
Tonsillar hypertrophy contributes to upper airway obstruction
Nearly 1 out of 10 children has sleep disordered breathing.

What is the best way to support the failing pediatric airway?
Jaw-thrust method.
Oropharyngeal airways treat airway obstruction caused by the tongue
The pediatric occiput is also large

- Occiput is proportionally larger than adult’s
- Thus neck is naturally flexed when supine
Place a towel under the child’s shoulders, not head.
Place a towel under the neck, not the head.

Head-tilt/chin-lift method.
Bag-mask ventilation is the most important skill for airway rescue.
Every dental office should have a self-inflating ventilation bag.
Be proficient at the basics
Part 3: Depths of Sedation
How are these terms defined?

1. Light sedation
2. Moderate sedation
3. Deep sedation
4. General anesthesia
5. Anxiolysis
6. Analgesia
7. Conscious sedation
The sedation continuum is measured by patient response and function

<table>
<thead>
<tr>
<th></th>
<th>Light Sedation</th>
<th>Moderate Sedation</th>
<th>Deep Sedation</th>
<th>General Anesthesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response</td>
<td>Normal response to verbal stimulation</td>
<td>Purposeful response to verbal or tactile stimulation</td>
<td>Purposeful response following repeated or painful stimulation</td>
<td>Unarousable even with painful stimulus</td>
</tr>
<tr>
<td>Airway</td>
<td>Unaffected</td>
<td>No intervention required</td>
<td>Intervention may be required</td>
<td>Intervention often required</td>
</tr>
<tr>
<td>Spontaneous Ventilation</td>
<td>Unaffected</td>
<td>Adequate</td>
<td>May be inadequate</td>
<td>Frequently inadequate</td>
</tr>
<tr>
<td>Cardiovascular Function</td>
<td>Unaffected</td>
<td>Usually maintained</td>
<td>Usually maintained</td>
<td>May be impaired</td>
</tr>
</tbody>
</table>
IMPORTANT GUIDELINE

You should be proficient in rescuing your patient from the next deeper level of sedation than you intended to administer.
Part 4: Monitoring during Sedation
Three things to monitor

1. OXYGENATION
2. VENTILATION
3. CIRCULATION
Measure oxygenation with a pulse oximeter and with your eyes.

Pulse oximeters show you the patient’s blood oxygen saturation and heart rate – but these measurements are 10-20 seconds in the past.
Capnography measures exhaled carbon dioxide.

Capnography is most accurate with a closed airway circuit (e.g., endotracheal tube). When the airway circuit is open (e.g., nasal cannula, face mask) capnography is prone to false alarms.
Stethoscopes measure ventilation continuously and with nuance.
Circulation markers are heart rate and blood pressure

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Heart Rate</th>
<th>Systolic BP</th>
<th>Respirations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toddler (1-3 years)</td>
<td>80-130</td>
<td>70-110</td>
<td>20-30</td>
</tr>
<tr>
<td>Preschool (3-6 years)</td>
<td>80-110</td>
<td>80-110</td>
<td>20-30</td>
</tr>
<tr>
<td>School age (6-12 years)</td>
<td>70-100</td>
<td>80-120</td>
<td>18-24</td>
</tr>
<tr>
<td>Adolescents (12+ years)</td>
<td>60-90</td>
<td>100-120</td>
<td>14-22</td>
</tr>
</tbody>
</table>
Part 5: Opioids and Sedation
A Calgary teen remains paralyzed with extensive permanent brain damage after taking a pill he thought was OxyContin for the first time.

Anthony Hampton, 18, was rushed to the hospital last month after he was found in be not breathing and turning blue, said his father, Reg Hampton. Paramedics were able to get the teen’s heart beating again in the ambulance.

“He has a severe brain injury caused by lack of oxygen,” said Hampton in an interview.
How did opioids hurt Anthony?
Did Anthony breathe a large enough volume of oxygen per minute?

Let’s say he took two breaths per minute:
Percentage of oxygen in air = 21%
2 breaths/min \( \times \) 500 ml/breath = 1000 ml
21\% \times 1000 \text{ ml} = \boxed{210 \text{ ml of oxygen per minute}}

Let’s say he consumed 2 ml/kg/min of oxygen:
2 ml/kg/min oxygen \( \times \) 70 kg = \boxed{140 \text{ ml of oxygen consumed per minute}}
The total pressure of gas in the alveolus is fixed

```
<table>
<thead>
<tr>
<th>Alveolar Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO₂ = 100</td>
</tr>
<tr>
<td>PCO₂ = 40</td>
</tr>
<tr>
<td>O₂</td>
</tr>
<tr>
<td>CO₂</td>
</tr>
</tbody>
</table>

PO₂ = 40
PCO₂ = 46

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Venous Blood

Arterial Blood

PO₂ = 100
PCO₂ = 40
Opioids blunt the respiratory drive

The alveolar gas equation estimates the pressure of oxygen in our lungs

\[ P_{A\text{O}_2} = F_{i\text{O}_2} (P_{\text{ATM}} - P_{\text{H}_2\text{O}}) - P_{a\text{CO}_2} / R \]

NORMAL CONDITIONS

\[ = 0.21 (760 - 47) - 40 / 0.8 \]

\[ = 100 \text{ mmHg} \]
How do opioids affect oxygenation?

\[ P_A O_2 = F_i O_2 (P_{ATM} - P_{H2O}) - P_a CO_2 / R \]

**OPIOID OVERDOSE**

\[ = 0.21 (760 - 47) - 90 / 0.8 \]

\[ = 38 \text{ mmHg} \]
Does a nasal cannula help?

\[ \text{\( P_{A\,O_2} = F_{i\,O_2} (P_{ATM} - P_{H2O}) - P_{a\,CO_2} / R \)} \]

**OPIOID OVERDOSE with NASAL CANNULA**

\[ \begin{align*}
\text{\( P_{A\,O_2} \)} & = 0.30 (760 - 47) - 90 / 0.8 \\
& = 100 \text{ mmHg}
\end{align*} \]
THEREFORE:
You can overcome opioid-induced hypoxemia with a modest increase in oxygen delivery
Sedation without opioids is less likely to blunt respiratory drive

Anxioloytic plus opioid is more dangerous than either alone

<table>
<thead>
<tr>
<th></th>
<th>Midazolam</th>
<th>Fentanyl</th>
<th>Midaz + Fentanyl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxemia (sat &lt;90%)</td>
<td>0%</td>
<td>50%</td>
<td>92%</td>
</tr>
<tr>
<td>Apnea (15 secs)</td>
<td>0%</td>
<td>0%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Part 6: Opioid Trends
Opioid sales vs mortality over time

Pediatric opioid deaths by year

Dental visits generated 15.7% of all outpatient pediatric opioid prescriptions in 2012

There is an association between dental opioid scripts and persistent opioid use.

CONCLUSIONS AND RELEVANCE  The findings suggest that a substantial proportion of adolescents and young adults are exposed to opioids through dental clinicians. Use of these prescriptions may be associated with an increased risk of subsequent opioid use and abuse.

Schroeder A et al. Association of opioid prescriptions from dental clinicians for US adolescents and young adults with subsequent opioid use and abuse. JAMA Internal Medicine 2018.
One third of opioid scripts were written by dental clinicians

• Retrospective review of 754,002 opioid-naïve participants aged 16-25 years in 2015
• 97,462 participants (12.9%) received an opioid script
• 30% of opioid scripts came from dental clinicians

Schroeder A et al. Association of opioid prescriptions from dental clinicians for US adolescents and young adults with subsequent opioid use and abuse. JAMA Internal Medicine 2018.
Opioid use and abuse was higher in the opioid-exposed dental group

<table>
<thead>
<tr>
<th></th>
<th>Controls</th>
<th>Opioid-exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opioid use at 90 days</td>
<td>0.1%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Opioid abuse at 365 days</td>
<td>0.4%</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

Schroeder A et al. Association of opioid prescriptions from dental clinicians for US adolescents and young adults with subsequent opioid use and abuse. JAMA Internal Medicine 2018.
Part 7: Sedatives
Sedatives fall into different classes

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>Mechanism of Action</th>
<th>Drug Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opioids</td>
<td>Mu receptor agonist</td>
<td>Morphine, Meperidine</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>Enhances GABA receptor function</td>
<td>Diazepam, Midazolam, Triazolam</td>
</tr>
<tr>
<td>Antihistamines</td>
<td>H1/2 receptor antagonist</td>
<td>Hydroxizine, Promethazine</td>
</tr>
<tr>
<td>Other</td>
<td>Enhances GABA receptor function</td>
<td>Chloral Hydrate</td>
</tr>
</tbody>
</table>
Opioids are powerful drugs

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Therapeutic Effect</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
<th>Special Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meperidine</td>
<td>Pain relief</td>
<td>Varies</td>
<td>60-120 min</td>
<td>4 hours</td>
<td>Seizures, confusion, dysphoria, constipation</td>
</tr>
<tr>
<td>Morphine</td>
<td>Pain relief</td>
<td>Varies</td>
<td>30-60 min</td>
<td>4 hours</td>
<td>Confusion, sedation, hypotension, constipation</td>
</tr>
</tbody>
</table>
Antihistamines are weaker but safer sedatives

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Therapeutic Effect</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
<th>Special Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroxyzine</td>
<td>Sedation</td>
<td>15-30 min</td>
<td>2-4 hours</td>
<td>4-6 hours</td>
<td>Agitation, dry mouth</td>
</tr>
<tr>
<td></td>
<td>Anti-emetic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promethazine</td>
<td>Sedation</td>
<td>20 min</td>
<td>Varies</td>
<td>4-12 hours</td>
<td>Confusion, disorientation, extrapyramidal reactions</td>
</tr>
<tr>
<td></td>
<td>Anti-emetic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Benzodiazepines are less likely than opioids to blunt the respiratory drive.

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Therapeutic Effect</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
<th>Special Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diazepam</td>
<td>Sedation</td>
<td>30-60 min</td>
<td>1-2 hours</td>
<td>Up to 24 hours</td>
<td>Dizziness, drowsiness, lethargy, headache</td>
</tr>
<tr>
<td>Midazolam</td>
<td>Sedation, amnesia</td>
<td>15 min</td>
<td>30-60 min</td>
<td>2-6 hours</td>
<td>Agitation, headache, hypotension (when given with opioids)</td>
</tr>
<tr>
<td>Triazolam</td>
<td>Sedation</td>
<td>15-30 min</td>
<td>2 hours</td>
<td>Varies</td>
<td>Dizziness, headache</td>
</tr>
</tbody>
</table>
Chloral hydrate’s sedative effects are similar to a barbituate.

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Therapeutic Effect</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
<th>Special Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloral hydrate</td>
<td>Sedation</td>
<td>30 min</td>
<td>Varies</td>
<td>4-8 hours</td>
<td>Nausea, vomiting, diarrhea, confusion, leukopenia</td>
</tr>
</tbody>
</table>
Benzodiazepines and opioids have reversal agents

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Therapeutic Effect</th>
<th>Onset</th>
<th>Duration</th>
<th>Route</th>
<th>Special Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naloxone</td>
<td>Opioid Reversal</td>
<td>1-5 min</td>
<td>45 min</td>
<td>IV, IM, SC</td>
<td>Hypertension, hypotension, nausea, vomiting</td>
</tr>
<tr>
<td>Flumazenil</td>
<td>Benzo Reversal</td>
<td>1-5 min</td>
<td>1-2 hours</td>
<td>IV, IM, SL</td>
<td>Dizziness, seizures, nausea, vomiting</td>
</tr>
</tbody>
</table>
Part 8: Anaphylaxis
Anaphylaxis is a life-threatening event.

1. Trouble breathing or wheezing
2. Facial swelling
3. Hives
4. Nausea or vomiting
Respiratory symptoms may come before cutaneous symptoms

WHEEZING MAY BE THE FIRST SIGN OF AN ANAPHYLACTIC REACTION

STRIDOR OR HOARSENESS ARE ALSO POSSIBLE

Two predisposing risk factors for fatal anaphylaxis in children

1. ASTHMA
2. CORTICOSTEROID USE

Use a cognitive aid when treating anaphylaxis
In an evolving crisis, do not do “more of the same”

IF YOUR TREATMENT DOESN’T WORK, DON’T REPEAT IT.

SWITCH TO A NEW TREATMENT.

SWITCH TO A NEW DIAGNOSIS.
Part 9: Conclusions
Last but not least... A few RULES

RULE #1: It’s not the drug, it’s the dose
RULE #2: Two drugs are more dangerous than one (especially opioids)
RULE #3: Minimize opioids whenever possible
RULE #4: Monitor, monitor, monitor
RULE #5: Chest rise/fall is more important than anything else
Questions?