Rodent Anesthesia and Surgical Monitoring

Prioritizing animal and researcher safety and well-being

Presenter:
Michelle Dotzert, PhD
Applications Specialist at Scintica Instrumentation
Outline

• Requirements for a successful surgery
• Anesthesia overview
• Animal side effects
• Surgical monitoring devices
  • Why incorporate a device into your surgical suite?
• User risks
  • Active scavenging to reduce user risk
• Summary and conclusion
Requirements for a successful surgery
## Requirements for a successful surgery

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-surgical planning</td>
<td>Supplies, personnel, protocols</td>
</tr>
<tr>
<td>Training</td>
<td>Asepsis, gentle tissue handling, hemostasis, suture techniques</td>
</tr>
<tr>
<td>Anesthesia and analgesia</td>
<td>Gas vs injectable, dosing</td>
</tr>
<tr>
<td></td>
<td>Appropriate pain management</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Anesthetic depth and physiologic conditions (body temperature, cardiac and respiratory rates)</td>
</tr>
<tr>
<td>Postoperative care</td>
<td>Thermoregulation, electrolyte and fluid balance</td>
</tr>
<tr>
<td></td>
<td>Behavioural signs of pain, signs of infection</td>
</tr>
<tr>
<td></td>
<td>Removal of skin sutures, clips or staples</td>
</tr>
</tbody>
</table>
Anesthesia
# Volatile Anesthetics

<table>
<thead>
<tr>
<th>Anesthetic</th>
<th>Details</th>
</tr>
</thead>
</table>
| Isoflurane | • Calibrated vaporizer  
• Scavenging required  
• Respiratory depression - may necessitate external ventilation  
• Little hepatic metabolism  
• Fast recovery (1-3 min) |
| Sevoflurane | • Calibrated vaporizer  
• Scavenging required  
• Lower blood-gas solubility (more rapid induction and recovery 1-3 min) |
| Halothane  | • Calibrated vaporizer  
• Significant hepatic metabolism  
• May precipitate cardiac irregularities  
• Fast recovery (1-3 min) |
## Injectable Anesthetics

| Dissociative anesthetic (Ketamine) + alpha-2-agonists (Xylazine or Dexmedetomidine) | - Commonly used cocktail  
- Alpha-2 agonists provide sedation and analgesia  
- Additional dose often required for surgeries >20 min  
- Risk of severe cardiac depression |
|---|---|
| Sodium pentobarbital | - Barbiturate  
- Poor analgesic properties  
- Narrow safety margin  
- Poor analgesia until complete unconsciousness  
- Prolonged recovery  
- Controlled drug status |
| Urethane | - Long periods of anesthesia with little respiratory depression  
- Carcinogenic  
- Not suitable for recovery surgeries |
<table>
<thead>
<tr>
<th>Injectables</th>
<th>Inhalants</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Difficult to choose initial dose</td>
<td>✓ Standard ranges, easy to adjust</td>
</tr>
<tr>
<td>• Risk of overdose during prolonged procedures</td>
<td>✓ Fast and easy removal</td>
</tr>
<tr>
<td>• Prolonged recovery</td>
<td>✓ Shorter recovery time</td>
</tr>
<tr>
<td>• No depth modulation</td>
<td>✓ Simple and rapid depth modulation</td>
</tr>
<tr>
<td>• Risk of misplaced injection into organs</td>
<td>✓ Safe</td>
</tr>
<tr>
<td>Plane</td>
<td>Characteristics</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Plane I</td>
<td>Loss of palpebral and swallowing reflexes</td>
</tr>
<tr>
<td></td>
<td>No amnesia or analgesic effects</td>
</tr>
<tr>
<td>Plane II</td>
<td>Loss of laryngeal and corneal reflexes</td>
</tr>
<tr>
<td></td>
<td>No amnesia or analgesic effects</td>
</tr>
<tr>
<td>Plane III</td>
<td>Intercostal muscle paralysis- diaphragmatic respiration</td>
</tr>
<tr>
<td></td>
<td>Progression to complete amnesia and analgesia</td>
</tr>
<tr>
<td>Plane IV</td>
<td>Overdose</td>
</tr>
<tr>
<td></td>
<td>Intercostal and diaphragm paralysis, respiratory arrest, medullary paralysis and</td>
</tr>
<tr>
<td></td>
<td>vasomotor collapse</td>
</tr>
</tbody>
</table>

*Safe to begin procedures*
Animal Side Effects
Animal Side Effects

Central nervous system depression

- Most common anesthetics induce CNS depression to the point of loss of consciousness. If anesthesia is too deep, respiration may be lost.

- Isoflurane inhibits voltage-gated sodium channels to depress glutamatergic neurotransmission in the hippocampus.

Winegar & Maclver, 2006
Animal Side Effects

Cardiovascular depression

Anesthetic agents, including isoflurane:

- Decrease myocardial contractility
- Decrease stroke volume
- Decrease systemic arterial pressure by reducing total peripheral resistance

Eger EI, 1981
Animal Side Effects

Respiratory depression

- Isoflurane and sevoflurane inhibit respiratory control systems:
  - Feedback control of central respiratory centres
  - Chemoreceptors
  - Pulmonary reflexes
  - Neuronal input

- Altered O$_2$ supply and CO$_2$ elimination contributes to acid-base imbalance

- Most likely emergency situation with volatile anesthetics- monitoring is essential

Cesarovic N et al. 2010
Animal Side Effects

Respiratory depression

- Female C57BL/6J mice
- Arterial blood samples from carotid artery at 10, 30 and 50 min under anesthesia
- Acid-base balance (pH), partial pressure of carbon dioxide ($pCO_2$, mmHg), and standard bicarbonate ($HCO_3^-$, mmol/L) determined with blood gas analyser

Animal Side Effects

Loss of temperature control

• Anesthetic agents inhibit temperature regulation centers in the brain and shivering
• Rodents have a low body mass and high surface area → hypothermia
• Hypothermia is associated with:
  • Arrhythmia
  • Increased recovery time
  • Increased risk of infection (vasoconstriction, impaired immune function)

Taylor DK 2007; Cesarovic N et al. 2001
Animal Side Effects

Loss of temperature control

- Rabbits anesthetized with ketamine/xyline, intramuscularly followed by intubation and maintenance on isoflurane
- Temperature recorded every 5 minutes using esophageal temperature probe

Figure 1. Mean body temperature. Bar, 1 standard deviation.

Surgical Monitoring Devices
Why incorporate a surgical monitoring device into your surgical suite?

- Streamline documentation to meet Institutional Animal Care and Use Committee requirements
- Enable a single researcher to perform procedures and eliminate scheduling conflicts
- Enhance animal well-being
- Enhance surgical outcomes and generate high quality models of disease
Streamline documentation to meet Institutional Animal Care and Use Committee requirements.

Evaluate anesthetic depth, body temperature, cardiac and respiratory rates with appropriate documentation.
Streamline documentation to meet Institutional Animal Care and Use Committee requirements.

Additional benefits:

• Stable preparation
• Identify problems and abnormalities sooner
• Improve surgical consistency
• Improve survival rates
Why incorporate a surgical monitoring device into your surgical suite?

- Streamline documentation to meet Institutional Animal Care and Use Committee requirements
- Enable a single researcher to perform procedures and eliminate scheduling conflicts
- Enhance animal well-being
- Enhance surgical outcomes and generate high quality models of disease
Enable a single researcher to perform procedures and eliminate scheduling conflicts.

- It is necessary to document respiration, body temperature and heart rate, which often necessitates a second person to assist during a surgical procedure.
- Surgical monitoring devices reduce the number of personnel required for surgical procedures, increasing efficiency.
Why incorporate a surgical monitoring device into your surgical suite?

Consider:

- Parameters and controls
- Alarms
- Screenshots
- Data storage and export
Why incorporate a surgical monitoring device into your surgical suite?

- Streamline documentation to meet Institutional Animal Care and Use Committee requirements
- Enable a single researcher to perform procedures and eliminate scheduling conflicts
- Enhance animal well-being
- Enhance surgical outcomes and generate high quality models of disease
Enhance animal well-being

- Depth of anesthesia
  - Respiration

- Hypothermia
  - Hypothalamic depression
  - Hair clipping
  - Cold delivery gas
  - Aseptic preparation solution evaporation

- Identify abnormalities and intervene
  - ECG abnormalities
  - Inadequate anesthesia

- Improved recovery
Why incorporate a surgical monitoring device into your surgical suite?

• Streamline documentation to meet Institutional Animal Care and Use Committee requirements

• Enable a single researcher to perform procedures and eliminate scheduling conflicts

• Enhance animal well-being

• Enhance surgical outcomes and generate high quality models of disease
Enhance surgical outcomes and generate high quality models of disease

- TAC banding
- Coronary artery ligation/ischemia-reperfusion
- Telemetry implants
- Xenografts
Why incorporate a surgical monitoring device into your surgical suite?

Before left anterior descending artery (LAD) ligation

5 minutes post-ligation

Screen captures courtesy of Dr. Merry Lindsey's lab at the University of Mississippi Medical Center
User Risks
Short-term exposure:

- Eye irritation
- Headache
- Skin irritation
- Respiratory tract irritation
- Cough
- Sore throat
- Drowsiness
- Dizziness
- Central nervous system and cardiovascular system effects
- Risk during pregnancy- unknown effects on developing fetus

There are currently no occupational exposure limits.
Recommended not to exceed 2ppm over 1 hour.

Waste gas scavenging is essential!
User Side Effects

Key fill

- Prevent spills
- Appropriate agent is dispensed into the vaporizer
- Less waste
Summary and conclusion
Summary

• Successful surgeries require planning, training, appropriate anesthesia and analgesia, surgical monitoring and post-operative care.

• Volatile anesthetics including isoflurane are safer, and easier to administer than injectables (when appropriate).

• Surgical monitoring ensures animal well-being, increases consistency, and adheres to increasing Institutional Animal Care and Use Committee requirements.

• Occupational exposure to anesthetic gases is often overlooked, and there are few guidelines surrounding user safety. Waste gas scavenging is essential to reduce user exposure.
Conclusion

Surgical monitoring devices enable rapid assessment and documentation of multiple physiological parameters. Live monitoring enables investigators to intervene quickly to ensure animal well-being and accurate surgical outcomes. These devices also streamline documentation and can be used to provide evidence of protocol adherence and good surgical practices. In addition to animal well-being, user safety is an important consideration, and using active anesthetic waste gas scavenging can reduce exposure.
Questions?

Web: www.scintica.com
Phone: +1 519-914-5495
E-mail: sales@scintica.com