Medication Safety in Anesthesia: Risks and Opportunities

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Objectives

- Recognize the risk of medication errors inherent in the anesthesia environment
- Discuss evidence-based opportunities for improved medication safety practices for pharmacists and anesthesiologists
- Evaluate current anesthesia workflow and assess for opportunities for improvement in medication safety
Disclosures

- Will discuss some product brands but I have no affiliation with any brands and do not endorse any specific brands
Audience Question

Does your institution have dedicated pharmacy resources for anesthesia/procedural areas?

1. Yes
2. No
Medication Safety

▪ *To Err is Human: Building a Safer Health System*
  ▪ Highlighted the risks of medical errors, one of which are medication errors
▪ Medication errors cannot be eliminated
▪ Goal is to decrease risk of errors as much as possible
▪ Institute for Safe Medication Practices
▪ Anesthesia Patient Safety Foundation

Dhawan et al. *Rev Bras Anestesiol* 2017
Medication Errors

- NCC MERP definition:
  - “Any preventable event that may cause or lead to inappropriate medication use or patient harm…”
- Medication error that causes harm is an adverse drug event
  - Not all adverse drug events are preventable
Medication errors

Preventable

Potential ADEs

Ameliorable

ADEs

Adverse drug reactions

Morimoto et al BMJ Quality & Safety 2004
Anesthesia Workflow

- Anesthesiologist functions as prescriber, pharmacist and nurse in the medication process
- Limited decision support
- Isolated system, cannot receive feedback from others
  - Restricted environment- Limited exposure for other disciplines
- High risk medications
  - Neuromuscular blocking agents
  - Respiratory depressants
  - Narrow therapeutic index
- When errors occur they can be more severe
Medication Error

The Swiss Cheese Model

Originator: Reason

High Reliability Organizations (HROs) deploy "Independent Redundancies"

Physician: Nurse is "safety net"

Pharmacist: Nurse is "safety net"

Nurse: Has no "safety net"

Patient

Error that reached the patient

"Near Miss" Error that was intercepted

Latent Errors (examples)

- Poor handwriting
- Incomplete information
- Unclear labeling
- High workload

Econceptualdesigns.com accessed January 2019
Audience Question

When you have observed a medication error made by yourself or a colleague, how often have you reported the incident into an incident reporting system?

1. I always report errors made by myself and others
2. I report only serious errors made by myself and others
3. I report most errors, but only those made by others
4. I rarely report errors that I observe
Risks by the Numbers

- Error rate in anesthesia is difficult to quantify
  - Relies on voluntary self-reporting
  - Errors may not be reported and may not be realized
  - Minor errors are underrepresented
- Studies from 2001-2012 report medication error rate ranging from 1:133-1:450 events per anesthetic administered
  - Average of landmark trials is 1 error per 211 anesthetic administrations

Cooper et al *International Anesthesiology Clinics* 2013
## Literature Review: Risks

<table>
<thead>
<tr>
<th>Error type</th>
<th>Webster et al</th>
<th>Khan and Hoda</th>
<th>Yamamoto</th>
<th>Llewellyn</th>
<th>Cooper et al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error rate per anesthetic</td>
<td>1:133</td>
<td>1:265</td>
<td>1:450</td>
<td>1:274</td>
<td>1:203</td>
</tr>
<tr>
<td>Incorrect dose</td>
<td>32%</td>
<td>35%</td>
<td>25%</td>
<td>23%</td>
<td>37%</td>
</tr>
<tr>
<td>Substitution</td>
<td>27%</td>
<td>16%</td>
<td>23%</td>
<td>60%</td>
<td>24%</td>
</tr>
<tr>
<td>Omission</td>
<td>19%</td>
<td>9%</td>
<td>21%</td>
<td>4%</td>
<td>20%</td>
</tr>
<tr>
<td>Repetition/insertion</td>
<td>11%</td>
<td>N/A</td>
<td>7%</td>
<td>6%</td>
<td>18%</td>
</tr>
<tr>
<td>Incorrect route</td>
<td>2%</td>
<td>N/A</td>
<td>8%</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>9%</td>
<td>38%</td>
<td>3%</td>
<td>N/A</td>
<td>2%</td>
</tr>
</tbody>
</table>

Cooper et al *International Anesthesiology Clinics* 2013
Literature Review: Risks

- Nanji et al 2016:
  - Prospective, observational, single-center study
  - Primary outcomes were the incidence of medication errors and adverse events
- Study site:
  - Partners Healthcare System, Boston, MA
  - Electronic anesthesia information system (MetaVision)
  - Bar-code assisted syringe labeling system (Codonics)
## Nanji et al: Methods

### Medication process
From requesting to monitoring

### Medication error
Failure to complete a required action in the medication administration process or the use of an incorrect plan or action to achieve a patient care aim

### Adverse drug event
Patient harm or injury due to a medical intervention related to a drug regardless of whether an error in the medication process occurs

### Observers
Fully trained on above definitions, completed training course
3 anesthesiologists and 1 nurse anesthetist
Trained on a minimum of 10 cases

### Data collection
Excluded pediatric, cardiac, and off-site surgeries
Began when anesthesia provider assumed care, ended when patient arrived in PACU or ICU

### Event classification
Identified events underwent review by two independent members
Nanji et al: Results

- Observed 3,671 medication administrations for 275 patients
  - 193 medication safety events observed
  - 153 medication errors (preventable), 91 adverse drug events (40 not preventable)

The 193 events detected included 153 (79.3%) medication errors (MEs) and 91 (47.2%) adverse drug events (ADEs). A single event can involve both an error and an ADE. Of these events, 40 (20.7%) were ADEs that did not involve a ME, 51 (26.4%) were MEs that led to an observed ADE, 70 (36.3%) were MEs with the potential for an ADE (four intercepted and 66 non-intercepted), and 32 (16.6%) were MEs with little potential for harm.
Nanji et al: Results

- Longer procedures (greater than 6 hours) associated with higher event rates
- More administrations per case (13 or more) associated with higher event rates
- Most common ADEs were incorrect dose (47%) and omitted medications/failure to act (31%)
  - Most common medications leading to a ME were:
    - Propofol (26%), phenylephrine (10%) and fentanyl (9.4%)
- There was no difference in the observed event rate between house staff, CRNA and attending anesthesiologist staff
- Technology and process contributing factors
Nanji et al: Conclusions

- One in twenty peri-operative medication administrations led to a ME or ADE
- No difference in error rates based on level of training/expertise
- Many safety mechanisms already in place at the study site
- Author’s suggest the following:
  - Bar-code assisted syringe labeling systems
  - Specific drug decision support
  - Thoughtful alerts
  - Timing of documentation (prior to administration)
  - Reducing opportunity for work-arounds
  - Thoughtful vendor selection with appropriate training
Summary of Risks

- Varying rate of medication errors in self-reported versus observational studies
  - 1:211 in self-reported
  - 1:20 in directly observed
- Only one prospective observational study has been conducted
- Most common errors:
  - Dosing errors, substitution, omission
  - Often involve high-risk medications
- Severity of errors:
  - Serious > significant > life-threatening
Literature Review: Opportunities

- Wahr et al: literature review of all peer-reviewed articles published from 1994-2014 related to medication safety guidelines for anesthesia and the operating room
- Reviewed 78 articles and created a list of graded safety recommendations
  - Completed by a group of 6 anesthesiologists, one pharmacist and two human process engineers
  - 35 recommendations put forth
    - Graded based on how many articles recommended each and the strength of each publication

Wahr et al *British Journal of Anaesthesia* 2017
Wahr et al: Recommendations

- Patient information
- Drug information
- Cart inventory
- Administration
- Culture
- Pharmacy
<table>
<thead>
<tr>
<th>Topic</th>
<th>Sub-topic</th>
<th>Recommendation</th>
<th>Points</th>
<th>Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture</td>
<td>Culture</td>
<td>Incident or error reporting system</td>
<td>190</td>
<td>30</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Labeling</td>
<td>Every medication labeled with drug name, date, concentration</td>
<td>178</td>
<td>29</td>
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<tr>
<td>Case Medications</td>
<td>Administration</td>
<td>Read and verify every vial, ampule, syringe label before administration</td>
<td>170</td>
<td>28</td>
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<tr>
<td>Case Medications</td>
<td>Labeling</td>
<td>Colour code labels by drug class</td>
<td>152</td>
<td>25</td>
</tr>
<tr>
<td>Cart Inventory</td>
<td>Organize/Standardize drug drawers</td>
<td>Standardize drug trays across all locations</td>
<td>136</td>
<td>21</td>
</tr>
<tr>
<td>Culture</td>
<td>Culture</td>
<td>Adequate teaching and in-service training</td>
<td>134</td>
<td>23</td>
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<tr>
<td>Case Medications</td>
<td>Labeling</td>
<td>Bar code and scanner</td>
<td>114</td>
<td>17</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Preparation</td>
<td>Use prefilled whenever possible</td>
<td>104</td>
<td>17</td>
</tr>
<tr>
<td>Culture</td>
<td>Culture</td>
<td>Written policies for medication safety</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>Patient Information</td>
<td>Single location for recording medications</td>
<td></td>
<td>98</td>
<td>15</td>
</tr>
<tr>
<td>Patient Information</td>
<td></td>
<td>Automated alerts for dose, allergy, interactions</td>
<td>96</td>
<td>15</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>Pharmacy</td>
<td>Pharmacist assigned to support OR</td>
<td>90</td>
<td>15</td>
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<tr>
<td>Case Medications</td>
<td>Preparation</td>
<td>High risk med doses with 2 people</td>
<td>88</td>
<td>13</td>
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<tr>
<td>Cart Inventory</td>
<td>High Risk Meds on Cart</td>
<td>Standardize concentrations across units</td>
<td>84</td>
<td>14</td>
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<tr>
<td>Case Medications</td>
<td>Administration</td>
<td>Bar code scan with audible and visual alert</td>
<td>84</td>
<td>12</td>
</tr>
<tr>
<td>Bulk Inventory</td>
<td>Look-alikes</td>
<td>Avoid buying look-alikes</td>
<td>82</td>
<td>14</td>
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<tr>
<td>Patient Information</td>
<td></td>
<td>Verify allergies</td>
<td>74</td>
<td>14</td>
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<tr>
<td>Cart Inventory</td>
<td>High Risk Meds on Cart</td>
<td>Only one concentration of drug on cart</td>
<td>74</td>
<td>12</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Administration</td>
<td>Smart pump used for all infusions</td>
<td>68</td>
<td>13</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Administration</td>
<td>Retain all vials, ampoules, syringes until end of case</td>
<td>66</td>
<td>10</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Administration</td>
<td>Smart pumps have libraries that are standardized across units</td>
<td>66</td>
<td>11</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Labeling</td>
<td>Preprinted labels with room for concentration, date, time</td>
<td>64</td>
<td>10</td>
</tr>
<tr>
<td>Cart Inventory</td>
<td>High Risk Meds on Cart</td>
<td>Dangerous drugs not stored on cart</td>
<td>62</td>
<td>10</td>
</tr>
<tr>
<td>Cart Inventory</td>
<td>Organize/Standardize drug drawers</td>
<td>Drug trays have modular system</td>
<td>62</td>
<td>9</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Administration</td>
<td>Colour coded infusions sets for epidural vs i.v.</td>
<td>62</td>
<td>12</td>
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<tr>
<td>Culture</td>
<td>Culture</td>
<td>Establish a just culture</td>
<td>62</td>
<td>10</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Preparation</td>
<td>Compounded and diluted drugs are prepared by the pharmacy</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Cart Inventory</td>
<td>High Risk Meds on Cart</td>
<td>No concentrated drugs on cart</td>
<td>58</td>
<td>11</td>
</tr>
<tr>
<td>Culture</td>
<td>Culture</td>
<td>Adequate supervision</td>
<td>56</td>
<td>10</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Administration</td>
<td>2 person verification of all medications administered</td>
<td>52</td>
<td>9</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Communication</td>
<td>At handover, review drugs given and all drugs on cart, field</td>
<td>52</td>
<td>10</td>
</tr>
<tr>
<td>Case Medications</td>
<td>Communication</td>
<td>Verbal orders are verified by speak back using protocol</td>
<td>52</td>
<td>12</td>
</tr>
</tbody>
</table>
Best practice recommendations

**Institute for Safe Medication Practices (ISMP)**
- Epidural tubing without ports, specially labeled
- Smart infusion pumps
- Barcode technology
- Standardize concentrations, diluents and container sizes
- Commercially available products rather than compounding
- Improve readability of labels

**Anesthesia Patient Safety Foundation**
- Medication safety conference in 2010
- Recommendations to focus on four areas
  - Standardization
  - Technology
  - Pharmacy/Prefilled/Premixed
  - Culture

ISMP.org; APSF.org accessed January 2019
Audience Question

What technology does your institution use to enhance medication safety in the operating room?

1. Smart infusion pumps
2. Barcode scanning
3. Labeling hardware/software
4. Automated dispensing machines
Technology: Smart Pumps

- Recommendations:
  - Smart pumps used for all infusions
  - Smart pumps are standardized across all units
  - Pumps have libraries with guardrails and alerts
  - Infusion device has prompts for weight-based limits

Wahr et al British Journal of Anaesthesia 2017
What Makes a Pump Smart?

- Infusion library with guardrails alerts
  - Minimize keystroke errors
- Incorporate standard concentrations and dosing units
  - Avoid dosing errors
Technology: Smart Pumps

Alaris pumps have infusion libraries with anesthesia drugs in anesthesia mode.

Opportunity: ensure all appropriate medications and guardrails are included.

Cannot obtain data for infusions when in anesthesia mode.

Opportunity: ensure all staff are trained to use pumps to maximize safety.

Overall compliance with guardrails is about 90%.
Automated Dispensing Cabinets

- Recommendations:
  - Drug trays in anesthesia carts:
    - Standardized across locations
    - Tray divisions labeled clearly
    - Drugs placed to minimize confusion
    - Modular system
    - Pharmacy manages drug trays
  - Eliminate unusual drugs from usual locations
  - Only preservative free local anesthetics
ADC Standardization Project

- Remove all products that contain preservatives
- Group like medications together, separate high risk drugs
- Avoid stocking unusual drugs in anesthesia stations
- Separate look-alike products
- Standardize contents of all drawers except top drawer
Bar-code Assisted Administration

- Recommendations:
  - Every medication labeled with name, date concentration
  - Unlabeled syringe is immediately discarded
  - Minimize provider prepared syringes
  - Verify high-risk medications and weight-based doses with two people
  - Read and verify every vial/ampule or syringe label before administration

Wahr et al. *British Journal of Anaesthesia* 2017
Technology: Bar-code Assist

- Codonics Safe Label System®:
  - Upon scanning a product provides audible and visual verification
  - Produces a label with all necessary components
- Double check mechanism with only one provider
- Labels can be scanned at a later time, even after hand-off
  - Integrate into electronic health record

Codonics.com access January 2019
EHR/Decision Support

- Recommendations:
  - Medications in standard format in chart
  - Single location for recording medications across surgery
  - Automated alerts in anesthesia system for dose, allergies, drug-drug interactions
  - Establish weight-based dose limits
  - Drug information readily available
    - Malignant hyperthermia, cardiac arrest, rescue protocols

Wahr et al *British Journal of Anaesthesia* 2017
# Pharmacy

<table>
<thead>
<tr>
<th>Procurement</th>
<th>Storage</th>
<th>Preparation</th>
<th>Education/support</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Avoid purchasing look-alike products</td>
<td>• Unique IV solutions stored separately from regular solutions</td>
<td>• Pharmacy responsible for medication flow</td>
<td>• Pharmacist assigned to support OR</td>
</tr>
<tr>
<td>• Changes in drugs supplied require alerts to staff</td>
<td>• Return of unused unusual products</td>
<td>• Pharmacy prepares all compounded or diluted high risk drugs</td>
<td>• OR pharmacists receive specialized education</td>
</tr>
<tr>
<td></td>
<td>• Pharmacy stocks, tracks and delivers drugs to anesthesia cart</td>
<td>• Pharmacy prepares infusions</td>
<td>• Pharmacists available 24/7 for questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Pharmacists participate in departmental education/M&amp;M</td>
</tr>
</tbody>
</table>

Wahr et al *British Journal of Anaesthesia* 2017
Culture

- Recommendations:
  - Non-punitive quality assurance system
  - Written policies and procedures for medication safety, adequate training of new staff on policies
  - Respect and collaboration
  - Workflow changes to enhance safety
    - Read and verify every vial/ampule/syringe before administration
    - Discard unlabeled syringes
    - Sterile field medications: one at a time, labeled, verified

Wahr et al *British Journal of Anaesthesia* 2017
Future Opportunities

- Conduct a gap analysis of anesthesia workflow
- Partner with other departments to improve safety
  - Monthly meetings with anesthesia and pharmacy leadership
- Stay up to date with best practice recommendations
- Engage the EHR
- APSF medication safety video:
Summary and Conclusion

- Medication errors in anesthesia are difficult to quantify.
- Varying rates of medication errors among studies, rates as high as 1:20 anesthetic administrations.
- Best practice recommendations are available from several articles/organizations.
- Changes in culture need to accompany changes in technology and products.
- Anesthesia, pharmacy and other departments are partners in ensuring safe medication use.
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