AANA Journal Course
Update for Nurse Anesthetists

Medication Administration in the Operating Room: New Standards and Recommendations

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Anesthesia is one of the few areas in healthcare with no secondary verification of medication administration, yet it also has the highest number of administered medications, most of which are high-alert medications. Anesthetists often prescribe, dispense, mix, relabel, administer, and document medications without secondary verification. To increase patient safety, vigilance is one of the basic principles of anesthesia delivery in addition to the other fundamentals of medication administration. The Anesthesia Patient Safety Foundation recommends implementing standardizations, barcode medication administration, and the use of prefilled or premixed syringes to assist in the safe delivery of anesthesia. It has been shown that adhering to the principles outlined by the Anesthesia Patient Safety Foundation reduces the number of adverse drug events and results in safer care of patients.

Keywords: Barcode medication administration, medication administration safety, prefilled syringes, premixed syringes.

Objectives
At the completion of this course, the reader should be able to:
1. Identify the role of adverse drug events in anesthesia.
2. Identify the Anesthesia Patient Safety Foundation recommendations in relation to medication administration.
3. Discuss the principles of standardization of medication administration.
4. Discuss the cost of implementing barcode medication administration.
5. Discuss the value of prefilled or premixed syringes compared with anesthetist-prepared medications.

Introduction
Safety of medication administration is continuously at the forefront of anesthesia practice. The combination of polypharmacy, numerous individuals with access to medications in the operating room, the opportunity for anesthesia staff to prepare and administer medications without oversight, and complex working conditions create an environment prone to medication administration errors. In 2000, the Institute of Medicine (IOM) declared a critical need to improve patient safety by learning from errors, raising standards, and creating systems that ensure the use of safe practices at the delivery level of healthcare. The IOM reported that a total of $29 billion is spent each year on preventable adverse events, and $2 billion of this sum is attributed to adverse drug events (ADEs). The IOM also reported that medical errors injure at least 1.5 million Americans each year and cause 7,000 deaths annually. To determine the most effective course of action for decreasing or eliminating the number of adverse events, it is essential that the causes and outcomes of errors are thoroughly investigated.

Anesthesia is one of the few areas in healthcare in which medications are prescribed, mixed, relabeled, and administered without safety checks and secondary verification. The process of mixing and preparing medications by individual anesthesia providers creates numerous opportunities for errors in a busy and stressful environment that can reduce the provider's attentiveness to the tasks being performed. Even though vigilance is a main principle in anesthesia, distractions, fatigue, and other human factors can contribute to error. If errors occur without repercussions, such as modifications and prevention education, these same errors could potentially continuously recur. The knowledge gained from evaluating past errors can be used to assist in designing more effective preventive measures and help decrease the recurrence of adverse events.

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The goals of this course are to present information on the standards established by the Anesthesia Patient Safety Foundation (APSF) to reduce the number of ADEs in anesthesia and review the technology available that can assist anesthesia providers in providing the safest administration of medications. Furthermore, it is also important to examine the use of technology and how implementation of this technology can be cost effective in addition to helping reduce the overall cost of ADEs.

**Medication Administration in the Operating Room**

The medication administration process in a hospital requires several steps that take between seconds to hours to complete. The process for the bedside administration of medications is different from the administration of drugs in the operating room and involves multiple care providers from different areas of the hospital. For example, on nursing floors, a nurse or physician must write and transcribe an order for a medication; a pharmacist prepares and dispenses the medication; a potentially different nurse administers the medication; and then, physicians, nurses, and pharmacists monitor the patient’s reaction to the medication. Depending on the needs of the patient and the staff involved, this process can take minutes to hours to complete (Figure 1). For anesthesia, the process is much quicker, and a single provider typically performs each step of the process. In this process, the patient is first evaluated to determine the most appropriate anesthetic plan and medications to be administered. The anesthetist then prepares, administers, documents, and monitors the effects of each medication administered. This process is completed within seconds to minutes, which may include the administration of multiple medications, some of which are administered simultaneously, and may require as many as 41 steps to complete (Figure 2).

Documentation of the medication and dosage depends on the anesthetist. Furthermore, if an electronic charting system is used, an anesthetist’s documentation records will also affect the billing of medications and accountability of the pharmacy to insurance carriers and the Centers for Medicare and Medicaid Services (CMS). Because only a single provider is typically responsible for documentation, errors can occur depending on the situation in the operating room at any given time during the procedure. It has been found that human error while delivering anesthesia is the leading cause of ADEs. For compliance with the IOM recommendations for decreasing medical errors, a system of checks and balances should be implemented that will help anesthesia care providers deliver and document the safest care possible.

**Guidelines for Medication Administration Safety**

The Joint Commission issues specific guidelines for medication management systems intended to establish an infrastructure for safe and effective medication administration, including guidelines on storage, preparation, labeling, dispensing, and accounting for every medication administered in the hospital. The standardized system for labeling syringes uses universal color-coded labels for each syringe that must include the following information: the drug name, strength, amount, expiration date and time, and date prepared. Although this system has been used in the operating room for many years, it creates an opportunity for human error and is highly dependent on the anesthetist’s compliance and vigilance while preparing medications.

While concurring with the regulations set by the Joint Commission, the APSF has made additional system and technology recommendations that should further improve medication administration safety in the operating room. These recommendations have been found to dramatically reduce the number of errors when they are implemented as intended. Safety measures, such as customized drug trays, standard dilutions of high-alert drugs, barcode medication administration (BCMA), use of prefilled or premixed medications, and electronic documentation of medications in the anesthesia record have been found to reduce the number of ADEs by as much as 21% when users comply with the system’s safety principles. Anesthesia providers have numerous medications available for each anesthetic and depend on the color and labeling of the vials and the position of the medications in the carts to find the medications needed efficiently. These identification techniques create opportunities for human error; medication vials and colors can change, and pharmacy staff could potentially place a medication in an incorrect location in the medication dispensing system. Vigilance is stressed every day in anesthesia, but a system that allows providers to choose, prepare, label, and administer medications without secondary verification is inefficient and prone to mistakes. The incorrect preparation and labeling of medications, injection of wrong medications, undocumented administration of medications, and inaccurate charging of patients for medications can result in errors that should be evaluated based on their potential consequences, not their actual outcomes. If errors are identified soon after occurrence, the potential consequences can be reduced or even prevented.

**Standardizations for Safer Medication Administration**

In 2010, the APSF hosted a medication safety conference to identify the challenges and develop methods for improving the practice of anesthesia. This meeting allowed individuals from different backgrounds, such as pharmacists, anesthesia providers, and technology providers, to develop a plan of action for establishing a safer anesthesia practice. In accordance with the Joint Commission, the
APSF developed a new paradigm based on 3 principles: standardization, technology, and prefilled or premixed medications. These principles emphasize not only areas in which safety has been lacking but also opportunities for growth and development.

- **Standardization of High-Alert Medications.**
  Medications such as phenylephrine or ephedrine should be prepared by a pharmacy to ensure that the syringes and infusions have a standardized concentration and label. When prepared by anesthetists, high-alert drugs can be prepared in different strengths depending on provider preference, and this practice can easily result in administration errors, especially when a second provider administers the drug. The standardization of high-alert medications will eliminate the potential for error when diluting and preparing medications and will increase the safety of the patients and staff.

- **Standardization of Workspace.**
  Standardization also refers to the anesthesia workspace in terms of the arrangement of the medications and equipment. Organizing drug trays to eliminate the proximity of sound-alike or look-alike medications will help decrease the number of ADEs. The removal of rarely used medications from the workspace will help reduce the potential to prepare and administer the wrong medication. A pharmacy located in the surgical area can be beneficial in developing and maintaining medication trays and in dispensing the less common medications. The sterile preparation of medications by the pharmacy is standard in inpatient units and is a standard of the Joint Commission, but this standard is not strictly adhered to in surgical areas. Furthermore, the APSF recommends the elimination of provider-prepared medications whenever possible and the use of pre-prepared kits or drug trays whenever possible. These standardizations will result in universally used dilutions and concentrations of high-alert medications and will help reduce the number of wasted medications that are prepared and never used.

- **Standardization of Technology.**
  Along with the standardization of high-alert medications and workstations, the standardization of the technology used will also help reduce the number of adverse events. Electronic health records are widely used in operating rooms, but the full potential of using these systems in medication administration has not been fully realized. The APSF recommends using BCMA because it provides visual and auditory feedback that can assist anesthesia providers in delivering safer care. Just as intraoperative monitoring has changed the safety of anesthesia, BCMA can help reduce morbidity and mortality caused by ADEs.

  Systems for BCMA provide secondary verification of the 6 rights of medication administration: right medication, route, time, patient, dosage, and documentation. The provider chooses a medication and scans the standardized barcode on the medication. The computer then voices the medication and concentration as a secondary verification for the anesthesia provider before the medication is injected. Along with verifying the medication, the computer documents the administration of the medication in real time on the electronic anesthesia record, which further reduces the number of ADEs resulting from inaccuracies in recording the medications administered.

### Compliance and Cost of Barcode Medication Administration

An increase in patient safety resulting from BCMA use is dependent on the provider’s use of the technology available. Alarms and limits on ventilators, intravenous pumps, and monitors are in place to protect the patients and assist the providers in delivering safe anesthetics. These types of alarms and limits are available in BCMA systems, but providers must acknowledge and use them to provide safer care. The rate of errors using BCMA is inversely proportional to compliance with system alarms.
It has been shown that the number of ADEs decreases when anesthetists adhere to the following principles of BCMA use: scanning each medication before administration, keeping the audible voice prompts enabled, and reacting to system warnings.\(^{11,13}\)

The use of BCMA and premixed or prefilled syringes in the operating room may increase costs during the initial implementation phase, depending on the facility’s technology and use of electronic health records, but will eventually generate savings in time, safety, and the documentation of medications administered.\(^{11}\) According to the IOM, approximately $2 billion is spent annually on ADEs in hospital settings. This amount does not reflect the costs associated with errors in outpatient and office settings or in hospitals that do not use electronic medical records and data collection. If BCMA is not used in operating rooms, a pharmacy located in the surgical area would be beneficial in assisting with the preparation, dispensing, and inventory of medications. This type of setting, however, would require additional pharmacy staff.\(^{14}\) Systems for BCMA can accomplish all of these tasks and provide a means of communication between the pharmacy and anesthesia providers without needing a pharmacy representative in the surgical area.

**Implementation.** The initial cost for implementing BCMA depends on the technology infrastructure available in the facility and operating room (Figure 3).\(^{11}\) If a facility does not have electronic pharmacy management and patient medical record documentation in place, the cost will be greater because of the need to plan, staff, train, initiate, and monitor the implementation of a new system.\(^{11}\) If a hospital is required to implement electronic pharmacy management and BCMA without any previous infrastructure in place that can be upgraded, the estimated cost is between $35,600 and $54,600 per BCMA-enabled bed. This estimate includes system upgrades and hardware replacement.\(^{11}\) The cost potentially could be reduced by half or more if an electronic pharmacy management and electronic health record infrastructure is already in place.

On evaluating the cost of implementation, it is imperative to compare the cost of implementation with the cost of errors prevented because of BCMA use. It has been shown that BCMA prevents an average of 1.1% (range, 0.4% to 1.9%) of errors associated with medication administration.\(^{15}\) This value represents an operating cost of $2,000 per moderate to severe medication error prevented. Compared with the amount proposed by the IOM that is spent on ADEs, $2,000 is a fraction of the total cost to healthcare consumers and facilities.\(^{11}\) A MEDMARX data report (Quantros Inc) found that as many as 81% of medication errors occur in the operating room and postanesthesia care unit.\(^{3}\) This number of errors justifies the implementation of a BCMA system in surgical areas. Clearly, the initial cost of implementing a BCMA system is a large investment for any hospital, but the return on this investment in the form of a reduced number of costly and potentially deadly ADEs is equally great, if not greater.

**Compliance.** The use of prefilled or premixed medications can be beneficial for the entire facility, especially when used in conjunction with BCMA. Not only does the APSF recommend using prefilled or premixed drugs, but Joint Commission standard MM.05.01.07 states that the preparation of medications should be done by a pharmacist or pharmacy staff under the supervision of a pharmacist under sterile conditions except in urgent conditions.\(^{7,8,16}\) The preparation of medications by the pharmacy provides additional verification in addition to BCMA use that will help ensure safer medication administration. Fortier and Kellner\(^{17}\) found that 452 of 896 drug errors in the operating room, which is approximately 50.4%, are the result of drug syringe and preparation errors, including syringe swaps, incorrect vial selection, and syringe labeling error. The preparation of medications by the pharmacy staff ensures the sterility and integrity of medications and the standardized labeling of the syringes, and these steps should increase medication administration safety. In addition to increasing safe medication administration, anesthetists will be able to concentrate on patient management rather than medication preparation, especially in emergency situations.\(^{16}\)

Just as medication preparation by anesthetists is time consuming, the in-house preparation of prefilled syringes is also time consuming for the pharmacy staff. Compounding pharmacies can reduce the responsibility of medication management, but outsourcing can be costly depending on the number of different medications and the amount ordered.\(^{14}\) To help control the costs of outsourcing the preparation of some medications, an evaluation of the commonly used medications and
the medications that are frequently wasted will help determine which drugs would be more cost effective to purchase from compounding pharmacies.\textsuperscript{16} It may be slightly more expensive to outsource the preparation of prefilled syringes, but the savings associated with preventing ADEs justifies the cost.

- Costs. Barcode medication administration not only helps reduce the costs associated with ADEs but also is useful for tracking medication use and waste, both of which must be tracked and documented by the pharmacy, according to Joint Commission regulations.\textsuperscript{5} Regulations by the CMS state that only medications administered to patients can be charged for, and these charges are determined by dosage given to patients and not by the dispensing unit.\textsuperscript{5} Handwritten anesthesia records can be inaccurate when determining which medications are used for an anesthetic and the dosages given. These circumstances create additional work for the pharmacy staff who must confirm that the criteria are met for the billing of drugs. When providers dispense a medication via BCMA, the system requires documentation of the dosage and creates an accurate and appropriate record of the drugs administered. Therefore, these electronic records assist the pharmacy with the tracking and inventory of medications. Furthermore, these type of records used in conjunction with prefilled syringes of commonly used medications can ultimately reduce the amount of money spent on waste and unbillable medication use.\textsuperscript{16}

**Conclusion**

Operating rooms and the perioperative area are the most medication-intensive areas in a hospital. These areas use more medications, especially high-alert medications, than any other unit, but operate with fewer safety measures in place.\textsuperscript{3,14} The APSF’s new paradigm of medication administration includes additional precautions that exceed the standard Joint Commission recommendations of labeling and visual verification of labels.\textsuperscript{6} BCMA; prefilled/premixed syringes; and standardization of medications, workstations, and technology have been shown to reduce the number of ADEs by at least 21\% and, in certain institutions, by much more than 21\%.\textsuperscript{3,9,12,13,15} Most findings on BCMA use and the reduction of medication errors are based on information from areas other than surgery because there is currently a lack of BCMA use in anesthesia departments. The available information, however, is sufficient to promote the implementation of BCMA and prefilled or premixed syringes in anesthesia departments to reduce the number of ADEs and become compliant with the APSF, Joint Commission, and IOM.

**REFERENCES**


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