Photo courtesy of Baxa Corporation

By Joanne Kowiatek, RPh, MPM

Safe Storage and Distribution Practices for **Neuromuscular Blocking Agents**

NEUROMUSCULAR BLOCKING AGENTS (NMBAS), SUCH AS VECURONIUM, succinylcholine, rocuronium, pancuronium, and atracurium, are indicated as adjuncts to anesthesia to induce skeletal muscle relaxation and paralysis (including respiratory muscles) and to facilitate the management of patients undergoing mechanical ventilation.[1] It is due to these actions that NMBAs are considered "high-alert" medications (drugs that bear a heightened risk of causing significant patient harm when they are used in error) according to the Institute for Safe Medication Practices (ISMP) and United States Pharmacopeia (USP). NMBAs are used in the operating room during surgery and in other areas such as the emergency department, cardiac catheterization lab, intensive care units, and interventional radiology, as well as other areas where procedures are performed or where intubation is required, such as during a medical emergency.

Medication errors with NMBAs have been associated with severe patient harm and death. Between January 2000 and December 2005, 651 medication errors involving NMBAs were reported to the USP MEDMARX program.[2] Of these errors, 51% ultimately reached the patient, and 9.4% resulted in some level of patient harm. Among the harmful errors, 65% resulted in temporary harm, and 11 were sentinel events including one fatality.[2] Medication errors involving neuromuscular blocking agents have occurred in multiple areas within a hospital or health system.[3,4] NMBAs should only be administered by staff with training and experience in maintaining an adequate airway and respiratory support and only in facilities where intubation can readily be performed, oxygen can be administered, and respiratory support can be provided.[2] Because of the risk of patient harm associated with the use of NMBAs, their safe storage and distribution is critical to ensure patient safety.

The processes of medication storage may appear to be very straightforward, however, the complex nature of hospital organizations and patient care areas makes the medication storage system prone to breakdowns that may cause medication errors.[5] Many errors can be attributed to common root causes as described in the error case below. As noted in an article from the ISMP, errors that can occur with NMBAs involve look-alike packaging and labeling, look-alike drug names, drug administration after extubation, unlabeled syringes, unsafe storage, inadequate knowledge of drug action, use by untrained staff, and failure to assure ventilator support.[6]

Case Scenario

A recent medication error reported to the ISMP involved a mix-up of cefazolin and vecuronium vials. The patient was in the OR for a same-day surgery with intravenous sedation and was not intubated for the procedure, as it was not necessary. A recent change in the layout of the anesthesia cart medication trays supplied by the pharmacy inadvertently positioned look-alike drug vials next to each other on the trays. The anesthesiologist picked up a vial of vecuronium instead of a vial of cefazolin and administered it to the patient in error. Immediately the error was noted, the patient was ventilated and the patient's airway secured with an endotracheal tube. The patient was sedated and ventilated until the muscle relaxant wore off in the recovery room. Luckily, in this event, there was no permanent harm to the patient.

A key anesthesiologist from the anesthesia quality improvement committee, a certified nurse anesthetist, a pharmacy operations manager, and the pharmacy medication safety manager performed a multidisciplinary safety review of the anesthesiology medication tray, which was subsequently rearranged to separate look-alike drug vials and to divide medications into different sections by drug class. The review also identified medications that should be removed from the tray, due to lack of use and to decrease the chance of error by reducing the medication choices. Education of the anesthesiology and pharmacy staffs was performed to increase awareness of this event and the look-alike drug vials.

Safety Practices to Prevent NMBA Errors

As of October 1, 2005, specific packaging requirements for NMBAs were outlined in the USP's official compendial standards and became mandatory for pharmaceutical manufacturers.[7] These requirements mandate that both the ferrules (metal bands around the tops of vials) and over-seals of neuromuscular blocking agents contain the words "Warning: Paralyzing Agent" or "Paralyzing Agent" (depending on the size of the closure system). Both the container cap ferrule and the cap over-seal must bear the warning in black or white print (whichever provides the greatest color contrast with the ferrule or cap color). Though these warnings are certainly helpful, additional safety practices are essential to prevent errors with NMBAs. The practices outlined in this article draw from numerous recommendations from the ISMP, USP, and other safety experts[2,3,4,6,8,9,10], as well as my own experiences as a medication safety pharmacist/manager.

Safe Storage Recommendations

- Safeguard storage in the pharmacy. Sequester and affix warning labels to vials of neuromuscular blocking agents stocked in the pharmacy. Be sure they do not obscure the vial label in any way.
- Segregate storage and add constraints. Limit the availability of NMBAs to the pharmacy and those selected patient care areas where mechanically ventilated patients are treated, such as the OR, post-anesthesia care unit, emergency department, and intensive care units. When these agents must be available as floor stock (Make this decision in collaboration with critical care medicine physicians and anesthesiologists.), pharmacy should assemble the vials in a sealed box (possibly red) with warnings affixed as noted below. Sequester the boxes in both refrigerated and non-refrigerated locations.
- Personnel should carefully scrutinize (i.e., by conducting a failure mode and effects analysis, or FMEA) any perceived need to store NMBAs in settings where mechanical ventilation is used occasionally or in emergencies, such as emergency departments, procedure and clinic areas, and general nursing units.
- Affix fluorescent red labels that note: "Warning: Paralyzing Agent-Causes Respiratory Arrest" on each NMBA vial, syringe, bag, and storage box. Also use heat-sealed shrink bands (over-wraps) around the neck of the drug vials. Commercially available, these wraps are marked with "Warning: Paralyzing Agent".
- Avoid stocking NMBAs with look-alike medications. If this is not possible, separate NMBAs from their look-alikes in all storage areas.
- Separate neuromuscular blocking agents from all other medications in your storage areas.
- Do not store NMBAs in unit dose medication carts.
- Do not allow NMBAs to be stored in a multi-cassette, automated dispensing device drawer. Store them only in drawers that allow single-item access. Consider handling NMBAs as a controlled substance for safety and storage purposes.

Safe Distribution/Dispensing Recommendations

- Limit access. When possible, dispense neuromuscular blocking agents from the pharmacy as prescribed for patients. Allow floor stock of these agents only in the OR, ED, and critical care units, where patients can be properly ventilated and monitored. The process of limiting storage and access should involve the collaboration of a multidisciplinary group of experts in NMBA use, such as critical care medicine physicians, anesthesiologists, emergency department physicians, critical care nurses, pharmacists, risk management specialists, and medication safety leaders and committees in the hospital.
- Conduct a FMEA on all NMBAs before they are added to the formulary to minimize the addition of products with poor labeling and packaging.
- Pharmacy procurement managers and staff should preferentially select commercial products that have distinctive labeling and packaging.
- Standardize prescribing. Do not accept NMBA orders for "use as needed for agitation." Establish order sets to prevent the misinterpretation of handwritten orders. Include the need for ventilation support during and after administration, and a protocol that stipulates automatic discontinuation of these agents after extubation and removal from a ventilator, or when the patient is transferred from a critical care area. Never accept orders to "resume the same medications" upon patient transfer.
- Build alerts in the pharmacy information management system to verify the patient's location when NMBAs are entered. If the patient is not in a critical care unit, ED, OR, or invasive procedure area, question the order and verify ventilatory assistance before dispensing the drug. If possible, establish computerized crosschecking of the patient's location when entering NMBAs and other drugs limited to administration on a specific unit. Cautionary messages should also appear on automated dispensing cabinet screens when applicable. A pop-up box that asks, "Is the patient being ventilated?" may also be helpful.
- Encourage the prompt removal of discontinued products. Place NMBA vials, bags, and syringes in a sequestered bin for immediate pharmacy pick-up after the patient has been extubated or the drug has been discontinued.
- Use redundancies. Before dispensing and administering NMBAs, require an independent double check of the drug against the actual order.

Additional Safety Recommendations

- Supervise the initial administration. Require bedside attendance of a licensed practitioner who has experience with intubation and airway management during the initial administration of an NMBA.
- Practitioners should ensure that patient selection, dosing, monitoring, and weaning of NMBAs are consistent with the current evidence and national practice guidelines. Practitioners should prescribe adequate sedation along with pain relief — without paralysis whenever feasible — for mechanically ventilated critical care patients.
- NMBAs should not be administered in the critical care setting (for reasons other than placement of an endotracheal tube) without concurrently medicating the patient for pain or anxiety, despite the lack of obvious symptoms or signs.
- Practitioners should monitor the depth of neuromuscular blockade to allow use of the lowest NMBA dose and potentially minimize adverse effects.
- Implement point-of-care bar coding technology to verify drugs, doses, routes of administration, and patients before medication administration.
- Educate staff about the risk of serious errors with these high-alert drugs. Provide the staff with a list of both generic and brand names for all NMBAs available at your location.
- Educate health care professionals who administer neuromuscular blocking agents about the usual dosages and institutional policies and procedures for the safe handling of these medications.
- Use sophisticated, programmable infusion devices ("smart pumps") to deliver selected drug dosages when and where appropriate.
- Establish policies and procedures to ensure that medications in unlabeled syringes are not administered, unless the dose is prepared and immediately administered. Prepare one syringe dose at a time to prevent any confusion from look-alike syringes.
- Health care organizations, in conjunction with the medical staff, should outline credentialing and privileging requirements for providers prescribing and administering NMBAs and consider placing all NMBAs in a formulary category to limit prescribing to those with the experience and qualifications necessary to use these high-risk medications safely.
- Nurses and other professionals who administer medications outside the operating room or critical care setting should be trained to recognize NMBAs and to know their mechanisms of action and associated risks.

Photo courtesy of EPS, Inc.

Use heat-sealed shrink bands (over-wraps) around the neck of drug vials. Commercially available, these wraps are marked with "**Warning: Paralyzing Agent**".

Medication errors involving NMBAs continue to occur and result in patient harm and even death. Increased awareness, vigilance, and action on the part of all parties involved—manufacturers and suppliers, purchasers, and all practitioners involved in the entire medication-use process—are needed to improve the safety of this class of medications.[3] Reviewing and implementing as many of the recommendations above as possible is the best way to reduce the risk of harm from accidental administration of these agents. Also, presenting case examples

Photo courtesy of Hospira

The use of smart pumps during NMBA infusions can reduce the risk of medication errors.

of serious errors or potentially serious errors with NMBAs (see www.ismp.org/Newsletters/acutecare/articles/20050922.asp) to clinicians is a great way to increase hospital staff awareness. ■

Joanne G. Kowiatek, RPh, MPM, is the pharmacy manager for medication patient safety at the University of Pittsburgh Medical Center (UPMC) Presbyterian Hospital in Pittsburgh, a role she has held for six years. With 29 years of hospital pharmacy experience, she has expertise in medication patient safety, regulatory compliance, medication control and security, policy preparation and review, and emergency medication distribution. Kowiatek received her BS in pharmacy from the University of Pittsburgh and earned a master's of public management in health systems from the Carnegie Mellon University's H. John Heinz III School of Public Policy and Management. She is an adjunct instructor in the department of pharmacy and therapeutics at the University of Pittsburgh School of Pharmacy, and is a member of the ASHP Foundation's Award for Excellence in Medication-Use Safety advisory/selection panel. She is a member of ISMP Advisory Board for Nurse Advise-ERR, *a monthly nursing newsletter. In addition, Kowiatek is a 2005 recipient of the ISMP Cheers Award, which honors individuals, organizations, and companies that have set a superlative standard of excellence in the prevention of medication errors and adverse drug events.*

For references and related vendor information, see page 10.

References

1. American Hospital Formulary Service (AHFS) Drug Information; 12:00 Autonomic Drugs; 12:20 Skeletal Muscle Relaxants; Neuromuscular Blocking Agents General Statement (last accessed February 8, 2007).

2. The United States Pharmacopeia (USP) Patient Safety CAPSLink Newsletter, USP Medication Error Analysis, Medication Errors Involving Neuromuscular Blocking Agents. April 2006. http://www.magnetmail.net/actions/email_web_version.cfm? recipient_id=6787258&message_id=178096&user_id=USP (last accessed February 8, 2007).

3. Phillips MS, Williams RL. Improving the safety of neuromuscular blocking agents: A statement from the USP Safe Medication Use Expert Committee. *Am J Health-Syst Pharm*. 2006; 63: 139-142.

4. Smetzer JL, Cohen MR. Preventing Errors with Neuromuscular Blocking Agents. *Joint Commission Journal on Quality and Patient Safety*. 2006; 32(1): 56-59.

5. Kowiatek JG, Crea K. Principles and practices of medication storage. In: Weber RJ, eds. *The Handbook on Storing and Securing Medications*. 1st ed. Chicago: Joint Commission Resources; 2006:19.

6. ISMP Medication Safety Alert Nurse Advise-ERR, December 2006, Volume 4, Issue 12.

7. The United States Pharmacopeia– National Formulary (USP 29-NF 24), General Chapter <1> Injections; Packaging/Containers for Injections/ Neuromuscular Blocking and Paralyzing Agents; 2457; 2006.

8. Society of Critical Care Medicine and American Society of Health-System Pharmacists. Sedation, analgesia, and neuromuscular blockade of the critically ill adult: revised clinical practice guidelines for 2002. *Am J Health-Syst Pharm*. 2002; 59:147-9.

9. Society of Critical Care Medicine and American Society of Health-System Pharmacists. Clinical practice guidelines for sustained neuromuscular blockade in the adult critically ill patient. *Am J Health-Syst Pharm*. 2002; 59:179-95.

10. Cohen MR. *Medication Errors*. 2nd ed. Washington, DC: American Pharmacists Association; 2007.

WHERE TO FIND Anesthesia Trays:

Vendor	Reader Service Number
H&H System	90

WHERE TO FIND Heat-Sealed Shrink Bands:

Vendor	Reader Service Number
Baxa Corporation	22
EPS, Inc.	23
Health Care Logistics	24

WHERE TO FIND Smart Pumps:

Vendor	Reader Service Number
B. Braun Medical, Inc.	25
Baxter International Inc.	26
Cardinal Health	27
Hospira, Inc.	28
Smiths Medical	29

MARKETPLACE

(Advertisements)