

Nurse AdviseERR®

Educating the Healthcare Community About Safe Medication Practices

Safety with nebulized medications requires an interdisciplinary team approach

Nebulization of inhaled medications provides an excellent delivery route for the treatment of both pulmonary and nonpulmonary conditions. The mist is easily inhaled by breathing normally, without requiring coordinated breaths to inhale the medication (as required with metered dose inhalers). This delivery method generally provides a rapid onset of drug action, and minimizes systemic effects. An additional advantage is that the nebulizer is adaptable and can be used with a mouthpiece, adult or pediatric face mask, tracheostomy collar, T piece, or ventilator circuit.

Unfortunately, there can also be errors with nebulized medications that are linked to a wide variety of common system failures and human factors. However, review of errors reported to the *ISMP National Medication Errors Reporting Program (ISMP MERP)* and other sources during 2016 and 2017, revealed patterns among error types and causative factors that were relatively unique to nebulized medications and/or the conditions under which they are prescribed, dispensed, and administered.

Omissions due to unavailability of respiratory therapist or failed communication

By far, the most frequently reported errors related to the use of nebulized medications involved omissions that occurred when respiratory therapy staff were unaware of the prescribed treatment, unavailable to administer the treatment, or incorrectly assumed the patient did not need a treatment. During that 2-year period, more than half of the reports we reviewed were associated with omissions, accounting for hundreds of reported errors.

In many cases, treatments were omitted because the respiratory therapist was busy with a critical patient, often in the emergency department. There were numerous reports of several doses in a row being omitted for individual patients despite repeated calls to respiratory therapy. Also reported were several errors made by nurses who were trying to cover for busy respiratory therapists. In one case, a nurse noticed that the electronic medication administration record (eMAR) had flagged a long overdue nebulizer treatment. But in her haste to make sure the patient received the scheduled treatment, she mistakenly grabbed the wrong plastic vial and administered an as needed (PRN) dose of nebulized albuterol instead of the scheduled dose of the combination product, ipratropium and albuterol.

Another frequently cited reason for omissions was that the prescribed treatments had not been electronically transmitted or transcribed to a respiratory task list, or that the therapist had not otherwise been notified of a new order. For more than half of these omissions, patients missed repeated doses of their prescribed treatment. In one case, a pharmacist selected "inhalation" as the route of administration, instead of "nebulizer," so the new order did not appear on the respiratory task list. The patient missed 4 days of treatments before the error was discovered. In two other omission errors, new orders had been transmitted to a printer in the respiratory therapy department, but the busy therapist had not gone back to the department to check the

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check *it* out

Consider implementing the following recommendations to reduce the risk of errors with nebulized medications.

✓ **Communicate orders.** Establish a reliable system for communicating new and changed orders for nebulized medications to respiratory therapy staff. Test the system before use, monitor its reliability, and investigate all failed communication of orders to determine opportunities for improvement.

✓ **Collaborate on assessments.** Consider collaboration between nursing and respiratory staff to determine if a dose of nebulized medication should be held based on an assessment of the patient. Determine conditions that require prescriber notification of a held nebulizer treatment.

✓ **Document reason for holding treatments and reassess.** Require documentation and communication of the reason for holding or omitting any nebulizer medications, during change of shift report. Obtain clarification for unclear or inappropriate hold orders. If one or more doses were held during a shift for a particular patient, reassessment of that patient should be a high priority on the respiratory therapist's task list/assignment sheet. Ensure all documentation is on the same eMAR.

✓ **Staffing patterns.** Evaluate respiratory therapy staffing patterns to be sure coverage is appropriate to provide all necessary nebulizer treatments. Establish a realistic and reliable back-up plan for emergency coverage that is well coordinated with and communicated to nursing staff. Monitor and evaluate reasons for missed treatments and errors to ensure coverage is adequate.

✓ **Store plastic vials in the carton or foil pouch.** Because the plastic vials are so

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printer. Although nebulizer treatments were often listed on the eMAR, respiratory therapists were relying on a separate task list to determine which patients required treatments.

Another series of omissions involved repeated miscommunication between respiratory therapists. Nebulized amphotericin B was prescribed for a patient post lobar lung transplant due to a high risk of invasive fungal infection. The doses were omitted for more than 3 days. At change of shift report, the only communication the respiratory therapists shared was that the treatments were not being given. No reason for holding the treatments was offered, and no follow-up occurred to determine the reason.

Look-alike plastic medication vials with embossed labels

Most nebulizer medications are colorless solutions packaged in clear, unit-dose plastic vials (sometimes called “bullets” or “pillows”) made of low-density polyethylene resin. These plastic vials are often similar in shape and size. Also, the drug name and strength are often embossed on the small vials given the risk of leaching chemical contaminants into the plastic container if applying adhesives or ink to label the vials.¹ This makes it extremely difficult to read the name of the drug and strength on the embossed container (**Figure 1**). Ongoing mix-ups during dispensing and administration have been reported between different nebulizer medications packaged in these plastic vials, especially albuterol and the combination product, ipratropium and albuterol; dornase alfa and tobramycin; and 3% and 7% hypertonic saline.

Confusion has also occurred with nebulizer medications that are available in various strengths or forms. In one case, a hospitalized child received 2 mL (40 mg) of **GASTROCROM**, an *oral* cromolyn solution, via nebulization instead of 2 mL (20 mg) of the cromolyn *inhalation* solution. The child was receiving both forms of cromolyn. Both products came in small plastic vials with embossed labels (**Figure 2**), and the respiratory therapist mistakenly removed one of the oral cromolyn vials from the patient’s drawer. Although he used a barcode scanner, the therapist overrode an alert indicating the oral dose was not due for several hours. He also failed to notice that oral administration of the drug was documented. The error was identified when the nurse went to administer the oral dose several hours later. The child was monitored but was not harmed.

Some ophthalmic products and pediatric oral solutions are also packaged in similar-looking plastic vials with embossed labeling. For example, artificial tears, packaged in a single dose plastic vial, has been confused with various nebulizer medications in similar-looking vials. In another case, a pharmacist reported that, during a shortage of 24% sucrose solution, the only product available for purchase was **SWEET-EASE**, which is packaged in a plastic vial that looks similar to vials of nebulizer medications (**Figure 3**). The pharmacist was worried that accidental nebulization of this oral solution could cause harm.

Although medications that come in plastic vials are often packaged in a carton that is well labeled, and some are individually packaged in a foil pouch that is also well

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Figure 1. Albuterol inhalation solution has an embossed label that is difficult to read.



Figure 2. Oral Gastrocrom (cromolyn, top) comes in a plastic vial similar to *inhalation* cromolyn solution (bottom).



Figure 3. Sweet-Ease (24% sucrose) oral solution for infants comes in a plastic vial that looks similar to vials of nebulizer medications.

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similar and the embossed labeling is so hard to read, dispense and store the vials in their original foil pouch and/or the original carton if space allows. Avoid auxiliary labels or the use of ink directly on the plastic vials, the volatiles of which can leach through the plastic. Do not mix/store nebulizer medications in the same storage bin.

✓ **Store vials separately.** Stock cartons/foil pouches of each nebulizer medication and solution in separate lidded pockets in an ADC. Use barcode scanning to stock the ADC to verify that the correct product has been placed in each pocket. If a box in the refrigerator is required, be sure the box is closed so stray medications are not inadvertently stored in the box.

✓ **Withdraw from container immediately before use.** Withdraw any nebulizer medication provided in a glass vial or ampul immediately before it is emptied into a nebulizer cup so the syringe never leaves the hand. If the medication must be withdrawn into a syringe in advance, label the syringe with the medication name, strength, time, and date, and a prominent warning that the medication is intended only for nebulization.

✓ **Do not remove via override.** Outside of an emergency, do not allow nebulized medications to be removed from an ADC via override. In an emergency, consider an independent double check by another practitioner if the drug is removed via override. Monitor overrides to ensure compliance.

✓ **Do not store non-diluent solutions near the nebulizer.** Keep acetic acid and other clear solutions, especially irrigation solutions, that are not to be used for dilution of the nebulizer medication away from where the nebulizer and nebulizer medications are kept.

✓ **Barcode nebulizer solutions.** Require nurses and respiratory therapists to use a barcode scanning system prior to administration of nebulized medications. Procure only nebulizer products whose unit doses are individually barcoded by the manufacturer, or create a flag label that incorporates the appropriate barcode and attach it to the tab of the inhalation solution plastic vials.

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labeled, all of the reviewed errors involving product confusion occurred when the clear plastic vials were removed from the carton or foil pouch. In fact, many of these mix-ups occurred after the plastic vials had been intermixed with other nebulizer medications in the same storage bin, or accidentally intermingled with look-alike vials in automated dispensing cabinets (ADCs) due to stocking errors.

Other look-alike containers

Nebulizer medications and diluents not packaged in plastic vials have also been confused with other medications. In one case, a respiratory therapist obtained what he thought was a vial of normal saline to prepare a nebulizer treatment containing albuterol 2.5 mg for a pediatric patient. As he was piercing the stopper, he noticed that he had accidentally grabbed a vial of atracurium (a neuromuscular blocker) that someone had inadvertently returned to a respiratory therapy box in the refrigerator. In another case, a 1 liter plastic container of 5% acetic acid used for cleaning the patient's tracheostomy had been left next to the nebulizer. The bottle of acetic acid was mistaken as a bottle of sterile water and used to dilute a dose of albuterol prior to nebulization. Both bottles were identical in shape and size. The error was identified when the patient's condition worsened with treatment. In a third case, a nurse anesthetist accidentally picked up a syringe containing rocuronium instead of a syringe containing **FLOLAN** (epoprostenol) and administered the neuromuscular blocking agent by nebulization via the ventilator circuit to treat a patient's intraoperative pulmonary hypertension during cardiac surgery. Neither syringe was labeled with the name and strength of the drug.

Obtaining medications from an ADC via override

Trying to obtain a nebulizer medication via override from an ADC was a factor linked to numerous wrong drug/strength/form errors and wrong patient errors. For example, an ipratropium HFA (hydrofluoroalkane) inhaler was removed from an ADC via override and administered to a patient instead of albuterol 2.5 mg/3 mL via nebulization. Although an allergy to ipratropium that caused swelling was documented on the patient's record, the patient did not experience an allergic reaction. Many of the other errors involved mix-ups when selecting albuterol, and the combination product, ipratropium and albuterol. In most of the reported events, a respiratory therapist had removed the medication via override prior to administering the treatment. In a few instances, nurses had obtained the medication via override and either administered it or gave it to a respiratory therapist who was restricted from accessing the ADC.

Failure to use barcode scanning

One of the repeated comments noticed during review of the error reports was that an available point-of-care barcode scanning system had not been utilized prior to administering an incorrect nebulizer treatment. Many nebulizer medications and solutions come in multipacks and do not have barcodes on the individual unit of use vials (although barcodes may be on the outer carton or inner foil pouch). However, the comments in some error reports suggest that, even in the presence of a pharmacy-applied barcode, nurses and respiratory therapists are bypassing the scanning process before administering nebulized medications. Several reports noted that the administration was never documented on the eMAR if the barcode scanning process had been bypassed. In two instances, this work around led to a duplicate dose being administered by either a nurse or respiratory therapist who did not know that the treatment had already been administered.

Confusion regarding the route of administration

Some of the errors involved the growing area of off-label nebulization of medications, many of which are more commonly administered by a different route of administration.² For example, nebulized heparin is sometimes prescribed to attenuate pulmonary

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✓ **Apply auxiliary labeling.** Apply auxiliary warning labels to the foil pouches (or cartons, if necessary) to differentiate the various strengths of nebulizer hypertonic and 0.9% sodium chloride solutions. When dispensing an off-label nebulized medication, affix a warning label to highlight the correct route of administration. Include instructions on the label to use the appropriate sterile bacterial retentive filter when transferring methacholine from a vial to the nebulizer cup.

SAFETY wire

⚡ **Rule of thumb with Simplist syringes.** It is important for nurses to maintain pressure on the syringe plunger rod of any **SIMPLIST** prefilled syringe (Fresenius Kabi) during intravenous (IV) drug administration via an IV port or stopcock attached to a running IV. Due to a drug shortage, a hospital that typically used **CARPUJECT** prefilled syringes of **DILAUDID (HYDROMORPHONE)** 1 mg/mL obtained a supply of the drug in Simplist prefilled syringes. When a nurse needed to administer Dilaudid as a slow IV push via a patient's free-flowing maintenance IV, she attached the syringe to a stopcock on the IV tubing. Rather than give the entire dose at once, the nurse intended to administer small doses in increments. After part of the dose had been administered, the nurse left the syringe attached to the stopcock and turned to chart the dose on a bedside computer. During this time, pressure on the plunger rod was not maintained. When the nurse turned around, she noticed that the syringe plunger rod had been ejected from the syringe barrel (**Figure 1**), and that the IV maintenance solution was free-flowing out of the back of the syringe.



Figure 1. Simplist syringe with the plunger rod removed.

Simplist syringes have a glass barrel that does not have a retaining ring (also referred to as a “backstop” or “positive stop”) to prevent the plunger rod from popping out with back pressure from a running IV solution. But according to syringe experts, even some small syringes, such as 1 mL plastic syringes,

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coagulopathy and inflammation in patients with acute lung injuries, and to reduce ventilator dependence in patients with smoke inhalation injuries.^{3,4} Two error reports in which nebulized heparin had been prescribed noted that nurses had accidentally administered the drug subcutaneously—a more familiar route of administration. There was also one reported error in which the prescriber intended heparin to be administered subcutaneously, but two doses were administered by respiratory therapy via nebulizer. In another case, nebulized **CIPRODEX** (ciprofloxacin and dexamethasone) was prescribed to treat a young patient with tracheitis. The drug, which is an otic suspension, was dispensed in the original dropper bottle. When the nurse scanned the barcode on the medication, the “otic” designation appeared on the screen, and the nurse misread “otic” as “optic” and administered the Ciprodex in both eyes.

Numerous wrong route errors were associated with acetylcysteine, which can be administered by nebulizer, orally, or intravenously (IV). In several cases, the IV formulation was used to prepare the inhalation dose via nebulization. In another case, oral acetylcysteine was ordered prior to cardiac catheterization to reduce the risk of contrast-induced nephropathy (off-label use, unsupported⁵). The correct route of administration was chosen upon order entry, but the database description caused the order to populate a respiratory task list. Because the medication was on his task list, a respiratory therapist called the pharmacy to change the route of administration from oral to inhalation. The pharmacist complied without verifying the route with the prescriber after noticing that the patient also had a respiratory condition. However, the respiratory therapist did not administer the nebulized acetylcysteine because there was no order for a bronchodilator, which is recommended for nebulization 10-15 minutes before acetylcysteine when used as adjuvant therapy for respiratory conditions. The respiratory therapist did not clarify the order, and it was not until the day of the planned catheterization that a nurse realized the patient had not received the prescribed dose.

Equipment-related errors

Numerous errors were reported related to the equipment used to prepare and administer nebulized medications. Some of these events led to omissions, including forgetting to start or plug in the nebulizer. Others led to preparation and administration errors, such as forgetting to use a filter when transferring methacholine (a bronchoconstrictor used for diagnostic purposes) from a vial to a nebulizer. One event led to blood oxygen saturation levels below 60% for a critical patient due to a malfunctioning ventilator circuit during the nebulization of Flolan, with the medication backing up into the nebulizer cup. The set-up had not been changed for more than 24 hours. Once the set-up was changed and the nebulization resumed, the patient's blood oxygen saturation level rose to 100%.

Conclusion

Given the patterns identified during our analysis of errors with nebulized medications, consider forming an interdisciplinary team that includes physicians, pharmacists, nurses, and respiratory therapy staff to evaluate current practices and consider implementing the recommendations listed in the **check it out!** column starting in the right column on **page 1**.

References are located in the column to the right.

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may not have enough “positive stop” to prevent the plunger rod from popping out of the barrel if the pressure from the maintenance IV solution is high enough. Nurses who administer small amounts of a drug from a syringe and then wait between the incremental doses, may not be aware of this. Please be sure nurses know **they should always maintain thumb pressure on the plunger rod and never leave the syringe in place by itself while attached to an IV port or stopcock**. Instructions for proper use of Simplist syringes are available at: www.ismp.org/ext/2. For other safety recommendations go to ISMP's free guidance on the safe use of IV push medications for adults, available at: www.ismp.org/node/97.



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