Automated Dispensing Cabinets Can Help or Hinder Patient Safety Based On the Implementation of Safeguard Strategies

Author: Samantha J. Burton, PharmD, Horsham, PA
Section Editor: Susan F. Paparella, MSN, RN

CE Earn Up to 7.5 Hours. See page 468.

Automated dispensing cabinets (ADCs), also known as automated distribution devices or automated dispensing machines, were first introduced in hospitals in the 1980s and function as an electronic point-of-care storage device for medication distribution.[1-5] Varying levels of decentralized drug distribution can be accomplished using an ADC, including in outpatient areas, such as the emergency department.[6-8] ADC functionality has advanced over the years, providing the potential for safety advantages compared with nonautomated storage options, such as reduced medication selection errors, enhanced efficiency among nursing and pharmacy disciplines, and the ability to monitor inventory and deter drug diversion by way of accurate medication tracking and record keeping.[3,5,7-9] However, such safety gains can be achieved only with careful planning and implementation of automated dispensing systems, along with well-designed and clearly communicated practice expectations for practitioner interaction with the device. Without attention to such details, the risk of medication errors can still be present with ADC use.

A recent highly publicized event illustrates how the lack of system safeguards and over-reliance on technology can contribute to a devastating outcome.[10] A neuromuscular blocker, vecuronium, was administered to a patient instead of the intended sedating/anxiolytic agent, Versed (midazolam). Multiple system failures occurred for this error to reach the patient, with some of those errors involving the use of an ADC. According to public documents released by the Centers for Medicare and Medicaid Services, a resource nurse was asked by the patient's primary nurse to administer Versed to the patient in radiology.[10] The medication was prescribed to ease the patient's anxiety before a positron emission tomography scan. The resource nurse, while simultaneously training an orientee, searched for Versed in the neurology intensive care unit ADC under the patient's profile by entering the first 2 letters of the drug name, "VE." Even though the order for Versed had already been entered by the physician and verified by a pharmacist, the name Versed did not appear in the search field for "VE," because the ADC defaulted to a generic drug name search. The nurse then elected to trigger an override of the cabinet, not realizing she could search by generic name only, and after entering "VE" again, she selected the first medication that populated the search, which was vecuronium, a neuromuscular blocking agent. A warning displayed on the screen stating that the medication should be associated with a STAT order due to drug selection using the override function. The ADC opened, and the nurse removed vecuronium for administration. Many other active and latent failures happened throughout the medication use process, including failure to confirm the correct medication either manually or by using bedside bar code scanning. These failures contributed to the administration of the incorrect medication, which was followed by a lack of patient monitoring after administration of what was believed to be Versed. The patient was resuscitated in radiology,

Samantha J. Burton is 2018-19 Institute for Safe Medication Practices (ISMP*) Safe Medication Management Fellow, ISMP, Horsham, PA.

*ISMP is a nonprofit organization that works closely with health care practitioners, consumers, hospitals, regulatory agencies, and professional organizations to educate caregivers about preventing medication errors. ISMP is the premier international resource on safe medication practices in health care institutions. If you would like to report medication errors to help others, E-mail us at: ismpinfo@ismp.org or call (800)FAIL-SAF(e). This Medication Error Reporting Program keeps information confidential and secure. We will include only the level of detail that the reporter wishes in our publications.

For correspondence, write: Samantha J. Burton, PharmD, Institute for Safe Medication Practices, 200 Lakeside Dr, Suite 200, Horsham, PA 19044; E-mail: sburton@ismp.org.

J Emerg Nurs 2019;45:444-9.
0099-1767

https://doi.org/10.1016/j.jen.2019.05.001

but unfortunately died the next day. The resource nurse was terminated from the institution the following week. Although this medication error event occurred in the radiology department, the lessons learned are applicable to the emergency department. The high-alert medications, technology, and processes involved in this case reflect common risk points for which emergency nurses should be aware.

The emergency department is already a setting with an increased risk for medication-related problems because of the fast-paced, high-stress working environment that often requires quick treatment decisions, sometimes without complete clinical information.[8,11,12] Because of this increased risk, ADC safety must be optimized so the ADC does not further contribute to errors in the emergency department, avoiding system-based failures like those described in the aforementioned event. The Institute for Safe Medication Practices (ISMP) recently updated its *Guidelines for the Safe Use of Automated Dispensing Cabinets*, which offers a comprehensive list of safe practice recommendations that are designed for all practitioners who use this storage and dispensing system, regardless of the device manufactuer.[13] Emergency nurses are encouraged to review the entire set of recommendations; however, the highlighted ISMP Guideline recommendations and safety strategies that follow should serve as priority items to support safe practice in the emergency care setting (Table).

Safe Practice Recommendations

PATIENT AND MEDICATION SELECTION

One of the most significant ADC safety features is the use of patient profiling systems to withdraw medication.[9] A *profiled* ADC permits medication removal by the patient's primary nurse only *after pharmacist order verification* by interfacing with the pharmacy information system.[2,9] Without this functionality, ED staff have access to all medications contained in the cabinet and can withdraw based on an alphabetical look-up list.

Auto-verification through the electronic health record (EHR) is a system often used in the ED setting for designated medications stocked in the ADC or prescribed by designated providers (eg, ED physicians) as an alternative to profiling.[14,15] Auto-verification allows the user to remove the medication prior to pharmacist review and verification, which is then completed retrospectively. With EHR auto-verification, as soon as an order is entered for a designated medication or by a designated provider, it becomes accessible via the ADC. Although this selected functionality may increase efficiency for ED staff, it does not offer the same level of safety protections as when medications are removed in a profiled system. Allowing staff to remove any and all medication from an ED ADC in an auto-verify functionality defeats the safety benefits of a prospective review system. The key to using this functionality safely is to have a defined list of the number and type of medications available on auto-verify and limiting the medications available to those that are most often needed in an emergent/urgent situation. Creating an appropriate list for auto-verification requires collaboration between emergency physicians, nurses, and pharmacists, along with regular review. When ADCs are used in a nonprofiled mode, override mode, or EHR auto-verification mode—regardless of the knowledge, experience, or longevity of the practitioner or his or her care during drug preparation—potential contraindications, unsafe dosing, allergic reactions, duplicate therapy, and any other important drug information may not be realized prior to drug administration.[3]

Patient profiling functionality, as an alternative, allows the ADC user to select medications prescribed and verified for a specific patient by first searching the patient's name within the system. Searchable patients should be limited to only those currently in the emergency department to reduce the risk of selecting the wrong patient. Patients who were in the emergency department previously but are no longer in that location because the patient was admitted, discharged, or left at his or her own will should not remain accessible, because this scenario creates an opportunity for patient selection errors, charging errors, and diversion potential. The use of temporary patient names (eg, John Doe) also should be minimized.[13] If temporary patient names are used at your organization, the ability to enter a temporary patient name into the ADC should be limited to specific practitioners (eg, the charge nurse). All medications accessed via a temporary patient name should be reconciled to a permanent patient name as soon as possible and according to organizational procedures once the patient's identity has been determined.

An *override* to a profiled ADC occurs when a medication is withdrawn from the ADC *before pharmacist order verification* and only when patient harm may result if administration is delayed.[16] This scenario may be more likely in the ED setting because of the emergent nature of many clinical situations.[11] However, overrides should still be limited and should never occur without an order, whether it be electronic, written, telephone, or verbal.[13] If an order is not given prior to an override, the nurse is acting outside of his or her scope of practice. In the past, and as in the earlier case example, overrides have led to selection and removal of the wrong medication, dose, or strength.[10,17] Institutions should have a list of specific medications

TABLE

Selected recommendations for the safe use of automated dispensing cabinets in the emergency department[13]

- Optimize the use of ADCs in a profiled mode that allows medication selection after orders have been reviewed and verified by a pharmacist. Use the profiled mode in both inpatient and outpatient areas, including the emergency department.
- Minimize, as much as possible, the use of temporary patient names. If an organization allows users to enter temporary patient names, restrict the type and number of persons who can perform this function; establish a process to monitor and a timeline to reconcile all transactions performed under this function.
- Require a medication order (eg, electronic, written, telephone, or verbal) prior to removing any medication from an ADC, including those on override.
- Have an interdisciplinary committee provide medication safety oversight of drug availability in the ADC by establishing criteria for including or excluding medications, with special attention to high-alert medications.
- Exclude the following from ADC inventory:
  - Medications that require multiple dilutions
  - Highly concentrated oral liquid and parenteral opioids (except when provided in unit doses to certain patient care units where significant chronic, cancer, or end-of-life pain is treated)
  - FentaNYL patches in areas where only acute pain is treated (eg, in the emergency department, operating room, PACU, and procedural areas)
  - U-500 insulin vials
  - Hazardous medications that have been restricted from ADC storage based on organizational United States Pharmacopeia General Chapter <800> assessment of risk
  - Vials/ampules of concentrated electrolytes (ie, potassium chloride, hypertonic sodium chloride for injection [greater than 0.9% concentration], potassium phosphate, sodium phosphate, and potassium acetate); exception: in surgical areas, vials of concentrated potassium chloride or high-dose potassium cardioplegic solutions are sequestered in sealed kits or locked storage areas and obtained immediately before use; once the procedure has been completed, there is an effective process in place to return unused products to their secure locations or dispose of the partially empty vials or bags
  - Unfractionated heparin vials that contain more than 10,000 units
  - Neuromuscular blockers in areas where they are not routinely needed; in areas where neuromuscular blocking agents are routinely needed and stocked in an ADC, storage bins, pockets, or drawers should include a prominently displayed auxiliary label to clearly warn that, upon administration, respiratory paralysis will occur and ventilation is required (eg, WARNING: CAUSES RESPIRATORY ARREST—PATIENT MUST BE VENTILATED)
- Configure interactive alerts that require users to enter or select clinically relevant information (eg, purpose for drug removal, whether the patient is undergoing ventilation [for neuromuscular blockers]) prior to removal of organization-identified medications. Balance the need for ADC alerts with the understanding of alert fatigue and the ability to have many of these messages directly on the medication administration record.
- Require staff to return all unused nonrefrigerated medications with intact packaging to a common secure one-way return bin in the ADC that is maintained by pharmacy, or to the original secure locked-lidded pocket *only* if it is a noncontrolled substance *and* machine-readable coding verification is used.
- Refrigerated medications selected and not used should be returned to the designated ADC refrigerated return bin.
- Designate emergency medications, rescue agents, and antidotes as permanent stock in the ADC system to avoid accidental elimination from inventory.
- Activate ADC software that prevents clinically inappropriate medications from being loaded into specific cabinets without prior approval. For example, in areas not authorized to stock neuromuscular blockers in their ADC (eg, fast-track locations), enable the ADC block load/restrict access feature, if available, to prevent users from inappropriately stocking the cabinet with these high-alert medications.
- Review and approve all medications designated for override, clinical locations where medications can be removed on override, practitioner types that can remove medications on override, and associated policies through the Pharmacy and Therapeutics Committee, Medication Safety Committee, or their equivalent interdisciplinary group. Update the list of medications, conditions, and practitioner types approved for access via override as appropriate.
- Use an interdisciplinary group to routinely analyze override reports to identify if an order was obtained prior to removing the medication and whether the rationale for each overridden medication was appropriate. Trend override reports by medication, user, and area and address barriers to the pharmacist's review of the medication order prior to drug removal. Discuss results regularly with all disciplines with ADC access.

ADC, automated dispensing cabinet; PACU, post-anesthesia care unit.

Modified with permission from the Institute for Safe Medication Practices, Horsham, PA.

designated as allowable for override, but each override must be dependent on the clinical situation.[13] The fact that a medication is on an approved list for override should not be the only reason an override is justified.

The role of an emergency medicine pharmacist is well recognized in the literature as an essential part of highly functioning ED teams, and this role is quickly expanding.[11,12] One of the primary responsibilities of an ED-designated pharmacist is prospective order review and verification, which decreases the need for emergency staff to access medications on override, a known at-risk behavior. Additional strategies to mitigate override risks with ADCs include not stocking multiple-dose products; limiting the strengths and volumes of medications available on override; requiring documentation of override rationale; and for certain organization-identified medications, requiring a witness upon removal to verify the drug and indication.[10,13]

MEDICATION STORAGE

The ADC inventory should be determined based on the setting, patient population serviced, and safety risks associated with certain medications.[13,18] Some medications, when used in error, have a heightened risk of causing significant patient harm; these products are known as high-alert medications.[19] Additional safeguards are required for high-alert medications throughout the medication use process to reduce the risk of error and minimize harm. Two examples of high-alert medications that should not be stored in emergency care ADCs are fentaNYL transdermal patches (Duragesic) and methotrexate vials. FentaNYL transdermal patches used for chronic pain management are only indicated in opioid-tolerant patients.[20] If a Duragesic patch is applied to an opioid-naïve patient by mistake, the outcome could be devastating because of its potent effect and risk of respiratory depression. Because fentaNYL patches should never be used for treatment of acute pain, and there is adequate time to access this treatment from pharmacy, storage in an ED-designated ADC should not be permitted.[21]

Methotrexate vial storage in an ED-specific ADC also should be avoided. Methotrexate is often prescribed in the emergency care setting for its off-label use in ectopic pregnancy, a life-threatening condition.[22,23] When used for this indication, the dose is determined by the patient's body surface area, and it may be contraindicated in persons who have significant renal disease. Because of the serious and potentially fatal adverse effects associated with this medication, pharmacists should verify prescribed doses and kidney function status before preparing, dispensing, and delivering a patient-specific dose from the pharmacy.[24,25] Methotrexate, an antineoplastic agent, is also considered a hazardous medication that requires special handling during preparation and storage as outlined by the United States Pharmacopeia General Chapter <800> and the National Institute for Occupational Safety and Health.[26,27]

Although neuromuscular blocking agents (eg, succinylcholine and vecuronium) often are necessary in the emergency department, for optimal safety of these high-alert drugs, it is recommended that they be stored within a rapid sequence intubation kit along with other necessary medications and equipment needed for intubation.[10,13,21] If this option is not possible, these agents should be stored in individual locked, lidded, secure compartments as opposed to being openly accessible in a refrigerator or in open matrix drawers, which allow access to all other medications stored in that same drawer. No matter where the agents are stored within the ADC, inside a kit or in a locked and lidded pocket, a clear auxiliary warning that respiratory arrest will occur and ventilation is required must be visible at the storage site. Interactive alerts also can be implemented as an additional safeguard strategy when removing neuromuscular blockers from an ADC—for example, requiring the user to enter a response about whether a patient is undergoing ventilation.[10,13]

MEDICATION RETURN

A current safety challenge associated with ADCs is the placement of medications into the correct ADC pocket. The use of individual locked and lidded pockets and the ability to interface bar code technology with the ADC to automate the stocking and removal process can help prevent and detect misplacement, but the risk for wrong drug errors is not fully eliminated.[3,28] This risk is present not only upon initial stocking of medications but also upon the return of nonadministered medications to the ADC. Therefore, it is recommended that all nonrefrigerated, unused medications be returned to a one-way return bin in the ADC that is maintained by the pharmacy to avoid potential medication mix-ups.[13] Another option is to return the unused medication directly to the assigned compartment in the ADC; however, this option is recommended only if the compartment is a locked and lidded pocket, bar coding is used to verify the medication, and the medication is a noncontrolled substance. When unused refrigerated medications must be returned to the ADC, a designated ADC return bin should be available in the refrigerator, which also should be maintained by the pharmacy.

INTERDISCIPLINARY COLLABORATION

Nursing and pharmacy disciplines assume complementary roles in the safe use and optimization of ADC technology. Teamwork on behalf of both professions, as well as other practitioners who access the ADC, is necessary to apply the previously discussed recommendations. Interdisciplinary collaboration is also essential to ensure appropriate order validation has occurred and to determine suitable medication stock, periodic automatic replenishment (PAR) levels, and restocking frequency for efficient use and to prevent serious medication errors due to an excess stock quantity.[13,29] Once the appropriate medication stock is agreed upon among the disciplines, certain medications must be designated as permanent stock, meaning they cannot be unloaded from the ADC except by designated administrative users.[13] Permanent stock is significant in the emergency department, especially for medications that always must be available for emergent conditions (eg, reversal agents, rescue agents, and antidotes). If a reversal agent, such as naloxone, is accidentally unloaded from an ADC and a patient then presents with respiratory depression due to an opioid overdose, the medication will no longer be readily accessible from the ADC, and this unanticipated delay ultimately could result in patient harm. On the other end of the spectrum, some medications must be restricted from loading into specific cabinets.[10,13] The fentaNYL transdermal patch and methotrexate vials discussed previously are examples of medications that should be blocked from loading into an ED-specific ADC. Finally, a list of medications designated for override should be established by the interdisciplinary team, including the specific approved locations where these medications may be removed on override and the categories of practitioners who may withdraw them.[13] Override reports should be analyzed daily to determine if the rationale was appropriate, if an order was obtained before removal, and if administration was documented.[10,13] Overrides should require further follow-up if any of this information is missing or inappropriate. These reports should be trended over time, and barriers to pharmacist verification before removal should be minimized.

The ADCs located in the emergency department will need to be optimized with their own unique features and drug inventory, which also may vary among multiple ADCs in the emergency department (eg, triage, trauma, and fast track). Drug procurement decisions should be made not only with nursing and pharmacy administration but with input from frontline nurses, pharmacists, and pharmacy technicians. The emergency medicine pharmacist should be a key leader and collaborator in this effort if the role has been established.[11,12]

Conclusion

The high-risk environment and medications used in the emergency department make this setting prone to medication errors.[8,11,12] ADCs, like all information technology systems, are not designed to replace human activity or to prevent all errors but instead to support humans in clinical decision making.[30] An over-reliance on technology and trust in its proper functioning can develop among users, but technology is not infallible, as was demonstrated in the fatal error described. Thus the risks associated with ADCs must be identified and safeguards must be employed to promote safe practice instead of contributing to medication errors. ED leaders should consult The ISMP *Guidelines for the Safe Use of Automated Dispensing Cabinets* for more in-depth information and additional risk-reduction strategies to identify and eliminate safety hazards in the emergency care setting (https://www.ismp.org/resources/guidelines-safe-use-automated-dispensing-cabinets).[13]

REFERENCES

1. Paparella S. Automated medication dispensing systems: not error free. *J Emerg Nurs*. 2006;32(1):71-74.
2. Harolds JA, Harolds LB. Quality and safety in health care, part x. Other technology to reduce medication errors. *Clin Nucl Med*. 2016;41(5):376-378.
3. Grissinger M. Safeguards for using and designing automated dispensing cabinets. *P T*. 2012;37(9):490-530.
4. Brummond PW, Chen DF, Churchill WW, et al. ASHP guidelines on preventing diversion of controlled substances. *Am J Health Syst Pharm*. 2017;74(5):325-348.
5. Roman C, Poole S, Walker C, Smit DV, Dooley MJ. A "time and motion" evaluation of automated dispensing machines in the emergency department. *Australas Emerg Nurs J*. 2016;19(2):112-117.
6. Findlay R, Webb A, Lund J. Implementation of advanced inventory management functionality in automated dispensing cabinets. *Hosp Pharm*. 2015;50(7):603-608.
7. McCarthy Jr BC, Ferker M. Implementation and optimization of automated dispensing cabinet technology. *Am J Health Syst Pharm*. 2016;73(19):1531-1536.
8. Fanning L, Jones N, Manias E. Impact of automated dispensing cabinets on medication selection and preparation error rates in an emergency department: a prospective and direct observational before-and-after study. *J Eval Clin Pract*. 2016;22(2):156-163.
9. Billstein-Leber M, Carillo CJD, Cassano AT, Moline K, Robertson JJ. ASHP guidelines on preventing medication errors in hospitals. *Am J Health Syst Pharm*. 2018;75(19):1493-1517.
10. Institute for Safe Medication Practices. Safety enhancements every hospital must consider in wake of another tragic neuromuscular blocker event. *ISMP Medication Saf Alert*. 2019;24(1):1-6.
11. Eppert HD, Reznek AJ. ASHP guidelines on emergency medicine pharmacist services. *Am J Health Syst Pharm*. 2011;68(23):e81-e95.

12. Roman C, Edwards G, Dooley M, Mitra B. Roles of the emergency medicine pharmacist: a systematic review. *Am J Health Syst Pharm*. 2018;75(11):796-806.
13. Institute for Safe Medication Practices. Guidelines for the safe use of automated dispensing cabinets. Published February 7, 2019. https://www.ismp.org/resources/guidelines-safe-use-automated-dispensing-cabinets. Accessed May 3, 2019.
14. Reisbig K. Improving scanning compliance in the ED. *Pharm Purch Prod*. 2015;12(6):14-17.
15. Traynor K. Pharmacists find ways to make ADCs work in the ED. *Am J Health Syst Pharm*. 2015;72(22):1921-1922.
16. American Society of Health-System Pharmacists. ASHP practice resource for automated dispensing cabinet overrides. https://www.ashp.org/-/media/assets/pharmacy-practice/resource-centers/patient-safety/patient-safety-practice-resource-for-automated-dispensing-cabinet-overrides.ashx. Accessed May 3, 2019.
17. Traynor K. Joint commission eyes overrides of dispensing cabinets. *Am J Health Syst Pharm*. 2018;75(9):e172-e173.
18. American Society of Health-System Pharmacists. ASHP guidelines on the safe use of automated dispensing devices. *Am J Health Syst Pharm*. 2010;67(6):483-490.
19. Institute for Safe Medication Practices. High-alert medication survey results lead to several changes for 2018. *ISMP Medication Saf Alert*. 2018;23(17):1-5.
20. Duragesic [package insert]. *Titusville, NJ: Janssen Pharmaceuticals, Inc; 2009*.
21. Institute for Safe Medication Practices. Targeted medication safety best practices for hospitals. Published December 4, 2017. https://www.ismp.org/guidelines/best-practices-hospitals. Accessed May 3, 2019.
22. Weant KA, Bailey AM, Baum RA, Justice SB, Calhoun CD. Chemotherapy in the emergency department? There is a role for that: methotrexate for ectopic pregnancy. *Adv Emerg Nurs J*. 2017;39(1):18-25.
23. Methotrexate. Lexi-Drugs. Lexicomp. Riverwoods, IL: Wolters Kluwer Health, Inc. http://online.lexi.com. Accessed December 26, 2018.
24. Institute for Safe Medication Practices. Prevent-ERR: methotrexate errors when treating ectopic pregnancy. *ISMP Medication Saf Alert*. 2007;12(24):3.
25. Institute for Safe Medication Practices. Multiply, not divide. *ISMP Medication Saf Alert*. 2005;10(5):3.
26. United States Pharmacopeia. General Chapter <800>: hazardous drugs—handling in healthcare settings. Published December 1, 2017. http://www.usp.org/sites/default/files/usp/document/our-work/healthcare-quality-safety/general-chapter-800.pdf; 2017. Accessed May 3, 2019.
27. National Institute for Occupational Safety and Health. List of antineoplastic and other hazardous drugs in healthcare settings. Published September 2016. https://www.cdc.gov/niosh/docs/2016-161/pdfs/2016-161.pdf?id=10.26616/NIOSHPUB2016161. Accessed May 3, 2019.
28. Institute for Safe Medication Practices. Mix-ups between AuroMedics levofloxacin and levetiracetam. *ISMP Medication Saf Alert*. 2018;23(1):1-3.
29. O'Neil DP, Miller A, Cronin D, Hatfield CJ. A comparison of automated dispensing cabinet optimization methods. *Am J Health Syst Pharm*. 2016;73(13):975-980.
30. Institute for Safe Medication Practices. Understanding human over-reliance on technology. *ISMP Medication Saf Alert*. 2016;21(18):1-4.

Submissions to this column are encouraged and may be sent to

Susan F. Paparella, MSN, RN
spaparella@ismp.org