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Current status of administration of medicines

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Literature review

The literature review was based on searches of knowledge-based resources, journals, and websites. Published studies, reports, conference proceedings, consensus statements, and abstracts published in English were evaluated. Approximately 3000 citations were reviewed.

On an international basis, the domain of administration of medications is primarily the responsibility of nurses, although nurse technicians are used in countries such as Brazil.¹ Medication administration is often referred to as the “sharp edge” in the medication-use process because errors introduced at the prescribing, dispensing, or transcribing step, if not intercepted, will result in the patient receiving the medication in error.

The administration of medications consists of a series of complex, problem-prone processes. In a study

of the origin of errors, 38% of preventable medication errors occurred at the administration step.² It has been claimed that nurses spend up to 40% of their time administering medications.³ The frequency of administration errors ranges from 2.4% to 47.5%, depending on the drug distribution system in place.⁴ In the United Kingdom, a recent report by the National Patient Safety Agency (NPSA) indicated that 56.5% of reported errors associated with severe harm or death occurred at the administration step.⁵

Medication orders require the drug, dose, rate, route, frequency, and, when appropriate, duration to be explicit and specific to the needs of the patient in order to achieve the desired outcome. In effect, medication orders are sentences where an error or lack of precision in any of the elements of the order can result in unintended consequences. Ad-

ministration of the wrong medication, dose, dosage form, route, rate, or frequency are examples of consequences due to misinterpretation, ambiguity, or lack of knowledge or understanding of elements of the medication order sentence.

Principles of safe medication administration

A number of principles for safe medication administration can be gleaned from a review of the literature. The 5 rights (5 R's) of medication administration (right patient, right drug, right dose, right route, and right time) are principles that nurses are taught as part of their nursing education; however, nurses may not always adhere to the 5 R's and may also lack knowledge about the medication, including the indication, usual dose, route, actions, adverse effects, contraindications, and drug–drug or food–drug in-

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teractions. In Denmark, a study using an observational technique at Aarhus University found that 41% of errors occurred at the administration step.⁶ Patient identity was not verified before medication administration in 150 of 166 errors. The Global Hospital Pharmacy Population Survey indicated that verification of the patient's identity is required in only 42% of countries.⁷ In Hong Kong, a medication safety self-assessment guide was developed, which addresses the importance of confirming patient identity before drug administration, charting on the medication administration record, and documentation of drug allergies.⁸ In the United States, patient identification before medication administration is required by the Joint Commission. Pape⁹ and Pape et al.¹⁰ described the use of a checklist, analogous to that used by the airline industry, to ensure that patient identification, as well as other essential steps in medication administration, are followed.

How medications are dispensed to wards also affects medication administration safety. An evaluation of the literature and reports from the Australian Bureau of Statistics revealed that errors occurred in 15–20% of drug administrations when floor stock (using bulk-stock medications) was used versus 5–8% when patient-specific doses were dispensed by the pharmacy.¹¹ Studies conducted during the 1960s and 1970s in the United States led to the establishment of unit-dose dispensing on a patient-specific basis as the standard of practice in hospitals.⁴ Unit-dose dispensing is not an international standard at the current time. The Global Hospital Pharmacy Survey indicated that only 18% of countries require unit dose dispensing for the majority of medications.⁷

Verifying the absence of drug allergies before medication administration is essential in order to prevent patient harm. In the Australian

evaluation, it was noted that previous allergies were not recorded over 75% of the time.¹¹ NPSA reported that 5.4% of errors leading to harm or death were associated with an allergy.⁵ The importance of allergy documentation and verification are supported by a number of professional organizations.^{4, 12–14}

The presence of pharmacists in patient care areas is a key strategy for improving medication safety.^{4, 15} Observation studies have demonstrated fewer administration errors when pharmacists are present on hospital wards. Administration error rates of 5.1–47.5% were observed in traditional floor-stock or ward-stock systems, compared with rates of 2.4–8.6% in a U.K. ward-stock system with original prescriptions and daily ward visits by pharmacists.⁴ The high rate of medication administration errors in the U.K. in the 1960s led to the development of ward-based pharmacy practice.¹⁶ In the United States, safe practices endorsed by the National Quality Forum specify the role of pharmacists collaborating with other health professionals and supporting all aspects of the medication-use process.¹⁷ Polish law specifies that hospital pharmacists should work on the ward and check that medications are being administered correctly.¹⁸

Several studies and reports demonstrate the need to make mathematical calculations a priority focus area.^{19,20} More than 1 in 6 medication errors involve a calculation error.^{21–23} A simulated study in a pediatric stabilization unit in England found that 14.2% of 150 orders were converted from milligrams to milliliters incorrectly, with a maximum dose deviation of 400%. Furthermore, 32.7% of drug doses drawn up in a syringe were incorrect.²⁴ One study demonstrated that 81% of nurses were unable to correctly calculate medications 90% of the time and that 43.5% of test scores requiring calcu-

lations were below 70% accuracy.²⁵ In the United States, a nationwide study conducted to assess practices to validate mathematical skills indicated a required passing rate of 80%; no respondent institutions required 100% accuracy.²⁶ The authors recommended a call for 100% accuracy on mathematical tests for medication administration in order to reduce medication errors.

Best-practice recommendations

A number of professional organizations have established recommendations for safe medication administration. In April 2007, the World Health Organization (WHO) identified nine patient safety solutions developed to prevent harm.²⁷ Six of the solutions are relevant to medication administration and include avoiding or using special precautions with look-alike and sound-alike medication names, verification of patient identity, control of concentrated electrolyte solutions, avoiding catheter and tubing misconnections, and utilization of single-use injection devices. In 2007, six countries signed an agreement entitled the “Action on Patient Safety: High 5s,” an initiative of the World Alliance for Patient Safety and WHO, which also includes management of concentrated injectable medications.²⁸

Since its establishment in 2001, NPSA has published a number of alerts and guidances to reduce medication errors related to misadministration of spinal injections, potassium chloride injections, infusion devices, misplacement of nasogastric tubes, anticoagulation, and injectable and oral liquid medications.^{12,29} More recently, NPSA released a report on medication errors which recommends seven key actions to improve medication safety.⁵

The International Pharmaceutical Federation's “Statement of Professional Standards on Medication Errors Associated with Prescribed Medication” provides recommenda-

tions for the administration of medications, including reading the label three times and using double checks when calculations are necessary.³⁰

The availability of drug resources for nurses on patient care units has been recognized as a best practice by a number of organizations.^{12-14,21,31} In the United States, online drug information resources are available in many hospitals. In the absence of online resources, drug therapy references, organizational policies, and infusion rate charts should be available on patient care units.

A number of professional organizations have developed best-practice recommendations, including the American Society of Health-System Pharmacists,³² National Coordinating Council for Medication Error Reporting and Prevention,¹⁴ Massachusetts Coalition for the Prevention of Medical Errors,^{33,34} Institute for Healthcare Improvement,¹³ and Pathways for Medication Safety, developed by the American Hospital Association, Health Research and Education Trust and the Institute for Safe Medication Practices (ISMP).³¹ The Council of Europe Expert Group on Safe Medication Practices report provides a comprehensive review of medication safety literature and a list of standards and best practices.⁴

I.V. medications

In most European countries, nurses are responsible for not only i.v. medication administration but their preparation as well.³⁵ In other parts of the world, such as Brazil, i.v. medications are prepared by nurse technicians or nurses.¹ In the Global Hospital Pharmacy Population Survey, only 11.9% of responding countries indicated that i.v. preparation was required and only 6% indicated that i.v. medications were prepared by the pharmacy for all patients in nearly all hospitals in their country.⁷

Injectable medications are of particular concern due to the high likeli-

hood for harm.³⁶ Fifty-four percent of potential adverse drug events and 61% of serious and life-threatening errors are associated with i.v. medications.³⁷ A Council of Europe report attributed these errors to the lack of unit-dose injectable medications and insufficient pharmacy staffing resources.⁴ In the United Kingdom, a study using observation methodology cited an error rate of 49% in the preparation or administration of i.v. doses.³⁸ An error rate of 73% was identified with bolus doses, which were given faster than the recommended time of three to five minutes. Lack of knowledge of preparation and administration and complex design of equipment were cited as the causes of the errors. In Australia, a study of i.v. administration identified an 18% error rate based on 687 observations.³⁹ The most common error was wrong rate, and the study recommended the use of i.v. administration devices and regular checking of administration rates using checklists. A Canadian study involving the preparation of infusions found that 34.7% of prepared infusions had concentration errors.⁴⁰

Another study evaluating i.v. preparation and administration errors demonstrated a rate of 13–84% in the United Kingdom, Germany, and France.⁴¹ In the United Kingdom, reported injectable medication errors are responsible for more deaths than any other category of events.³⁵ As a result, NPSA recommended that organizations conduct a risk assessment of injectable medication practices, provide current protocols and procedures, and ensure the availability of information in clinical areas.

In the United States, where i.v. drug preparation by the hospital pharmacy is the standard of practice and required by the Joint Commission, errors still occur with i.v. medications. An analysis of 73,769 i.v. administration errors reported over a five-year period to the United States Pharmacopeia (USP) Med-

marx program revealed that 3–5% were harmful.⁴² The authors concluded that calculation errors could be reduced by the implementation of standard concentrations and the use of “smart” pumps—infusion devices that include drug libraries with pre-established dose and rate limits based on standard concentrations. In Sweden, standard concentrations have been implemented for i.v. potassium chloride solutions, and standard concentrations for other medications are being developed.⁴³ In Hong Kong, the development of standard concentrations for high-risk medications was established as a goal for 2006–07.⁸

Infusion devices

Lack of understanding of how to operate infusion devices has been associated with errors in a number of countries. In Jordan, nurses reported confusion by the types and functions of infusion devices as one of the top three causes of administration errors.⁴⁴

The implementation of smart infusion devices has been shown to reduce errors associated with i.v. drug administration. One study demonstrated that smart pumps prevented 99 potential infusion errors over eight months.³⁷ A recent ASHP survey indicated that 54% of U.S. hospitals had adopted smart pumps.⁴⁵ Although smart pumps can reduce errors due to miscalculations and wrong rates, monitoring compliance with use of the “smart features” is essential, since clinicians can bypass the drug library as well as the alerts that signal that the rate is potentially subtherapeutic or toxic. One study found that alerts were bypassed 25% of the time.⁴⁶ Further, the way that drug names, rates, and concentrations are displayed in the smart pump can create confusion and increase the potential for errors. A study of 100 drug libraries used in smart pumps revealed substantial variability in drug names, concentrations, and dose units within the same

library, increasing the risk of errors.⁴⁷ For example, selections for magnesium sulfate included milligrams per hour, milligrams per kilogram per hour, grams per hour, micrograms per kilogram per hour, and milliequivalents per kilogram per hour. The need for standard dosing methods to reduce i.v. infusion errors is supported by ISMP.⁴⁸

Chemotherapy

The Global Hospital Pharmacy Population Survey found that chemotherapy preparation by the pharmacy is required in only 26.2% of countries and provided in the majority of hospitals in only 8.3% of countries.⁷ Countries in which the pharmacy prepares over 85% of chemotherapy doses include Austria, Germany, Norway, Spain, and Luxembourg.^{49,50} Education of nurses in chemotherapy preparation and administration is essential. A survey conducted in Turkey revealed that of 121 nurses, 14.2% used a safety cabinet for preparation and that only 7.4% of nurses had received education about chemotherapy.⁵¹

A number of countries have focused on improving chemotherapy safety. In Germany, oncology pharmacists are included as part of a multidisciplinary team.^{49,52} In Switzerland, a failure-mode effects and critical analysis demonstrated that pharmacist evaluation of orders to detect errors and use of central preparation resulted in a strong improvement in safety.⁵³ A USP Medmarx evaluation of 310 pediatric chemotherapy errors indicated that 48% occurred at the administration step, and 85% reached the patient. Actions to improve safety include education of nurses, use of order sets, and dose verification using multiple independent checks.⁵³ The Alberta Cancer Board is developing a comprehensive tool kit to improve chemotherapy safety.⁵⁴ ASHP has developed comprehensive guidelines on chemotherapy-error prevention.⁵⁵

Preventing wrong-route errors

Wrong route errors have been reported internationally as a critical concern. In the United Kingdom, deaths due to the administration of bupivacaine by the i.v. route instead of the epidural route resulted in an alert emphasizing the importance of implementing a double-check process before medication administration.⁵⁶

The USP Medmarx program has received over 300 reports of tubing misconnections, including epidural lines connected to IVs, oral cough syrup given via i.v. push, and tube feedings administered through peripheral i.v. lines.⁴² ISMP, the Council of Europe, and the U.K. National Health Service (NHS) have recommended the use of identification labels on tubing near the insertion site to prevent misconnections.^{3,12,57}

NPSA has also set deadlines to adopt enteral feeding catheters that cannot connect with i.v. or other parenteral lines.⁵⁸ In Wales, color-coded oral and enteral syringes with a new style of nasogastric tube have been implemented at the University Hospital.⁵⁹ In Israel, Hadassah Hospital has implemented color-coded labels for high-risk medications.⁶⁰

Use of i.v. syringes for oral medications can be harmful, especially in pediatric patients. It is recommended that oral syringes be available on patient care wards, especially in pediatrics, and that nurses be educated to not use i.v. syringes to measure and administer oral formulations.^{33,61}

Intrathecal misadministration of vincristine is the wrong-route error that has received perhaps the broadest attention internationally and prompted WHO to release an alert on the prevention of intrathecal administration of vincristine.⁶² This error has also been reported with asparaginase. Recommendations for prevention include dispensing of intrathecal chemotherapy on different days or times from other chemotherapy for the same patient, segregation on the wards, and performing independent

double checks by two professionals before administration.⁶³

Pediatrics

Pediatric patients are exposed to up to three times the rate of potentially dangerous medication errors as adults. Two studies of pediatric patients demonstrated that 60% of errors occurred at the medication administration step.^{64,65} A French observation study of medication administration errors revealed a 27% error rate in pediatric patients.⁶⁶ Recommendations for preventing errors include removing medications from packaging immediately before administration and not leaving medications in patients' room except for educational purposes. In a U.S. study of errors in a pediatric hospital, implementation of standard drug concentrations, use of smart pumps, and improved labeling resulted in a 73% reduction in reported errors.⁶⁷ In a recent NPSA report, 10.1% of errors involved children age four years or younger, even though this age group accounted for only 5.6% of all bed days in the NHS.⁵ An analysis of pediatric medication errors reported to Medmarx for 2006–2007 indicated the most common types of harmful pediatric medication errors were improper dose or quantity (37.5%), omission errors (19.9%), and improper drugs (13.7%).⁶¹ In this report, nearly 2.5% of pediatric medication errors led to patient harm. The Joint Commission recently released a sentinel alert on preventing pediatric medication errors, with several recommendations related to medication administration.⁶¹

Intensive care

Patients in the intensive care unit (ICU) are prescribed twice as many medications as non-ICU patients. The Critical Care Safety Study demonstrated that 78% of serious errors in ICU patients are attributable to medications.⁶⁸ Nearly two thirds of medications in the ICU are given by

the i.v. route, leading to a greater risk of errors due to miscalculation of doses and improper medication administration. A study of medication errors and adverse drug events in an ICU using observation methodology revealed one preventable error for every five doses administered.⁶⁹ Twenty-three percent of the preventable adverse drug events occurred at the administration stage. A 10.6% error rate in dosage calculation and administration was reported in a surgical ICU, which “suggests that one in every 10 intravenous infusions in an ICU are prepared or administered in error”.⁶⁸ In a French study, a 6.6% medication administration error rate resulted in placing pharmacist in ICU and standardizing medication preparation and dispensing.⁷⁰ A Dutch ICU observation study in two hospitals revealed a 33% administration error rate, primarily due to wrong technique.⁷¹ In this study, the ICU with approved pharmacy protocols for drug administration and full-time ICU physicians had an error rate of 21.5% versus 70.2% for the ICU without these components. Based on a literature review of errors in ICUs, Kane-Gill and Weber⁶⁸ made a number of recommendations to improve safety, including minimizing floor stock, especially concentrated electrolytes, standardizing i.v. medication preparation and administration policies, implementing pharmacy satellites, and using direct observation to evaluate medication errors. A U.K. evaluation to determine the attitudes and beliefs of ICU nurses on the causes of medication errors supports the role of the ICU pharmacist.⁷² Nurses stated that the unit pharmacist was the primary defense and prevented errors in 10 of 13 instances.

Bedside scanning

Although the use of bar-coded medication administration (BCMA) has not been widely adopted on an international scale, there is a grow-

ing body of evidence-based literature regarding the benefits as well as its unintended consequences. Information gleaned from this literature will be fundamental to the development of principles that can be used in the safe and effective deployment of bedside scanning globally. Most of the published work in the area of BCMA is based on experience in the United States; however, this technology is also being used in some European countries, including the Netherlands, Denmark, and Italy.⁷³⁻⁷⁷

A study to determine the impact of integrated clinical information technology (including BCMA) on medication errors demonstrated 73 administration-related errors intercepted/100,000 charted doses.⁷⁸ Wrong-time errors represented the majority of these, with 55.3 errors intercepted/100,000 charted doses, and wrong-patient errors represented 12.2 intercepted errors/100,000 charted doses. The authors estimated that BCMA prevents one wrong-patient error and almost five wrong-time errors each day.

Studies have also demonstrated the unintended consequences of BCMA, findings that have led to the development of best-practice recommendations.⁷⁹⁻⁸¹ A study of BCMA in a Dutch hospital found that nurses verified the bar codes for only 35.3% of parenteral drugs administered and for approximately 50% of all medications administered.⁸² From January 1, 2000, through December 31, 2005, 500 error reports related to bar coding were submitted to Medmarx.⁸³ Of these reports, 70 reports revealed that BCMA technology prevented an error from reaching the patient, and 445 reports revealed that an error was a consequence of BCMA technology. Twenty-two percent of these represented instances where the bar code was either not scanned, there was an override of a warning, or the clinician bypassed safety features of the system.

Most of the research to date has demonstrated that despite the availability of technology, human factors continue to be a frequent cause of errors since clinicians bypass safety measures, such as scanning the patient identification band or overriding alerts on a smart pump.^{46,84}

Observation methodology

As stated in a recent Council of Europe report, “the direct observation technique, originally developed in 1962 in the United States, is the most effective method to quantify the administration errors and has been used in more than 50 studies.”⁸⁴ A study of 36 hospitals and skilled nursing facilities was conducted to determine the validity of three methods for detecting medication errors.⁸⁵ The results demonstrated that observation methodology detected 300 errors, compared with 17 errors identified by chart review and 1 error detected by incident-report review. Observation of nurses does not appear to influence the medication administration error rate.^{4,85} The use of observation methodology for detecting medication administration errors is also recommended in a recent Institute of Medicine report.⁸⁶

Continuum of practice

This literature review revealed the wide spectrum of practice in the domain of medication administration, ranging from ward stock systems where nurses order, obtain, prepare, and administer medications with minimal pharmacy support to decentralized pharmacists, pharmacy-prepared i.v. solutions, chemotherapy and pediatric doses, and BCMA. The international literature also provides insight into key aspects of medication administration, including areas of vulnerability as well as best practices. These findings can serve as the basis for developing a plan to improve the safety of medication administration. The plan will vary from country to

country, since it is highly dependent on the availability of and support for hospital pharmacy services. However, this should not serve as a barrier to improving the medication administration process. Even in countries with limited pharmacy resources, opportunities exist for pharmacists to play a leadership role in ensuring the safety and accuracy of the medication administration process. It is time to begin.

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