ELSEVIER
SAUNDERS

Obstet Gynecol Clin N Am
35 (2008) 37–52

OBSTETRICS AND
GYNECOLOGY
CLINICS
OF NORTH AMERICA

Medication Safety

Carol A. Keohane, BSN, RN[a,*],
David W. Bates, MD, MSc[a,b]

[a]*Division of General Internal Medicine and Primary Care, Department of Medicine, Brigham and Women's Hospital, 1620 Tremont Street, Boston, MA 02120-1613, USA*
[b]*Harvard Medical School, 25 Shattuck Street, Boston, MA 02115, USA*

Since the 1999 landmark report by the Institute of Medicine, ''To Err is Human,'' increasing attention has been directed toward patient safety in the United States, and in fact world wide. This report estimated that approximately 44,000 to 98,000 patients die annually as a result of errors in the care received, and that more than a million patients are injured annually [1]. While the exact number of deaths is uncertain and remains controversial, with strong arguments being made that the true figure is lower [2], other recent reports have suggested that the actual figure might be even higher. For example, a 2004 report by Health Grades Incorporated, which evaluated 37 million patient records, estimated that between the years 2000 and 2002 as many as 195,000 people in the United States died as a result of potentially avoidable medical errors [3].

Medication errors occur in all clinical domains, affecting all patient populations from the tiny neonate to the frail elderly. In recent years, research has focused not only on the incidence of these errors but also on the circumstances and conditions leading to their occurrence. One of the first large studies to systematically examine the incidence of harm in the in-patient setting was the Harvard Medical Practice Study, published in 1991. In that study, which reported an adverse event rate of 3.7%, investigators found that medication errors were one of the most common causes of harm, causing 19.4% of the adverse events [4].

In 1995, the Adverse Drug Event (ADE) Prevention Study further assessed the incidence and preventability of both adverse drug events and potential adverse drug events in an effort to develop prevention strategies [5]. In two large academic centers, the adverse drug event rate was 6.5 per

* Corresponding author.
E-mail address: ckeohane@partners.org (C.A. Keohane).

0889-8545/08/$ - see front matter
doi:10.1016/j.ogc.2007.12.002 *obgyn.theclinics.com*

100 admissions, and 28% of the ADEs were determined to be preventable. In addition, for every preventable ADE, investigators found nearly three times as many potential ADEs or near-misses [5].

The epidemiology of medication errors has also been examined in the outpatient setting. The Improving Medication Prescribing Study by Gandhi and colleagues [6] studied four primary care practices to determine the rate of adverse drug events. Investigators found that 25% of patients suffered an adverse drug event, of which 13% were classified as serious. Of the ADEs, 11% were considered preventable and 28% were categorized as ameliorable.

Since this research conducted in the 1990s, there has been an increased focus in the United States at addressing actual and potential harm associated with medication use. The general public is also concerned. A national survey conducted by the American Society of Health-System Pharmacists in 2002 noted that 85% of Americans are concerned about at least one medication related issue. Among concerns expressed by respondents were: concern about being given the wrong medication, being given two or more medications that may interact in a negative way, concern over the cost of prescriptions, and worry over potential harmful side effects [7]. Medication safety research has shown that these concerns are valid and worrisome.

In 2005, at the request of the Center for Medicare and Medicaid Services, the Institute of Medicine (IOM) commissioned a group of scientific leaders to study the prevalence of medication errors and develop a national agenda aimed at reducing their occurrence. This report, ''Preventing Medication Errors,'' underscored the alarming rates of adverse drug events in various clinical settings. Among the key findings was the estimate of as many as 450,000 preventable ADEs per year. ADE rates among the elderly and those residing in long-term settings are also worrisome, with estimates reaching 800,000 ADEs per year. Because these studies did not account for errors of omission in their analysis, when a drug should have been prescribed for a particular patient condition but was not, the Committee felt these figures are likely underestimated. Based on review of scientific evidence to date, the Committee concluded that at least 1.5 million preventable ADEs occur each year in the United States in all settings combined. Medication errors—most of which have little or no potential for harm—are ubiquitous; the Committee estimated that the rate of errors in hospitalized patients is approximately one medication error per patient per day [8].

This IOM Committee also examined the costs associated with medication errors. The average increase to a patient's length of stay because of this complication is 4.6 days, with additional hospitalization costs of $5,857 [9]. Adjusting for the 2006 increase in expenditures, researchers estimate the additional hospitalization costs at $8,750. Using a conservative estimate of 400,000 preventable ADEs in hospitalized patients per year, this translates to a national burden of approximately $3.5 billion [8].

Defining medication errors and the medication use process

There are many factors that contribute to the complexity of the medication use process. When a medication error happens, it is often multifaceted in nature and can involve a combination of human factors and systems issues.

Researchers studying the epidemiology and prevention of medication errors have developed a standard nomenclature for defining medication errors and adverse drug events, and for classifying the impact in terms of degree of harm associated with these events [10]. The Committee on Data Standards for Patient Safety defines an error as "the failure of a planned action to be completed as intended (ie, error of execution) or the use of a wrong plan to achieve an aim (error of planning). An error may be an act of commission or an act of omission" [8].

Upon review of the of the Patient Safety report, by the Committee on Data Standards, the Committee on Identifying and Preventing Medication Errors adopted the following definitions [8]. A medication error was defined as any error occurring in the medication-use process [11]. Examples include wrong dosage prescribed, wrong dosage administered, or failure to give (by provider) or take (by patient) a medication. An ADE was defined as any injury caused by a medication [5]. The Committee on Data Standards states that "an adverse event results in unintended harm by the patient by an act of commission or omission rather than by the underlying disease or condition of the patient" [8]. Adverse drug events can be further classified based on preventability of the event. A preventable ADE is an injury caused by a medication that is caused by an error in the medication use process. An example of a preventable ADE would be if a patient develops an anaphylactic reaction to an antibiotic to which he or she is known to be allergic. A nonpreventable ADE, often referred to as an adverse drug reaction or ADR, is not the result of an error. An example of a nonpreventable ADE would be if a patient is prescribed amoxicillin for an ear infection and subsequently develops diarrhea during the course of treatment. In this case, assuming the medication is prescribed appropriately, there is no error associated with the event as diarrhea is a known side effect of this medication and thus, most likely the cause of the reaction. Some nonpreventable adverse drug events can be ameliorated if communicated to and acted upon by a patient's provider; an example would be a patient who develops a cough related to an angiotensin-converting enzyme inhibitor, which is treated promptly. While the ADE would not have been preventable, it would be considered ameliorable if it persisted for a long period of time (eg, 3 months). A potential ADE or near miss is a medication error that has the potential to cause harm but does not, either because it is intercepted or as the result of luck. An example of a near miss or potential ADE would be a pharmacist identifying and subsequently intercepting a tenfold overdose of morphine prescribed for a neonate. Fig. 1 further illustrates the relationship between medication errors, adverse drug events, and potential adverse drug events.

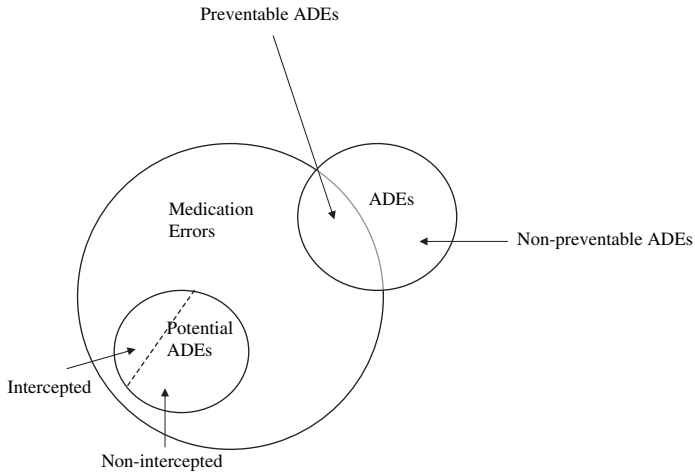

Fig. 1. Relationship between medication errors and adverse drug events. The preventable ADEs (errors resulting in patient harm) and the nonintercepted potential ADEs (errors that had the potential to cause harm and reached the patient) make up the serious medication errors. Patient safety efforts and prevention strategies focus on the serious medication errors. (*Adapted from* Bates DW, Boyle DL, Vander Vliet MB, et al. Relationship between medication errors and adverse drug events. J Gen Intern Med 1995;10:199–205; with permission.)

Assessing the stage at which a medication error occurs is important in the process of identifying and developing prevention strategies to mitigate their prevalence. As previously mentioned, a medication error can occur at any stage in the medication use process, including prescribing, transcribing, dispensing, administering, or monitoring. In the ADE Prevention study, which was performed in the in-patient setting, investigators reported the following distribution of errors among 264 preventable events [5]: the primary error associated in 49% of cases reviewed occurred at the ordering stage, 26% of errors occurred during administration, 11% occurred at the transcription stage, and 14% occurred during the dispensing process. The investigators concluded that error reduction strategies should be aimed particularly at stages where the greatest risk exists: in this instance, prescribing and administration. Subsequent studies assessed interventions aimed at these stages [12].

Although only a small minority of medication errors actually result in patient harm, the rate of incidence and frequency of those that do remain a major concern. In the above referenced study, among cases that were classified as life-threatening or serious, 42%, were preventable [5].

Medication safety in obstetrics

Specialty areas, such as obstetrics, present specific challenges with respect to medication safety, although the issues in gynecology parallel those in

many other surgical domains. In obstetrics, the frequent and often rapid transitions to and from various clinical areas within an obstetric unit require additional vigilance when administering and monitoring a patient's response to medications. In traditionally modeled units, patients are often admitted to labor and delivery, but then depending on the patient's clinical status, there is often a transition in the care environment and care may later be rendered in the operating room, obstetric recovery area, and postpartum unit. The only study that the authors are aware of, involving primary data collection that evaluated the frequency of ADEs in obstetrics, found relatively low rates of ADEs when compared with those found in medical and surgical units, in part because relatively few medications were used [11]. Nonetheless, data from spontaneous reporting have identified many serious events. Thus, the obstetrics setting still represents an environment with substantial risk when it comes to medication safety, and prescribing in the outpatient setting is clearly more complicated because of the concerns about adverse drug effects on the fetus.

According to data submitted to the United States Pharmacopoeia MedMarx program, 3,800 medication errors were reported in obstetric areas between 1998 and 2002. The MedMarx program is a voluntary, national, internet-accessible database that enables hospitals and health care systems to track and trend adverse drug reactions and medication errors [13].

The distribution of errors in cases reported found the greatest percentage of medication errors occurring in the labor and delivery area (49%). Approximately 41% of errors occurred in maternity units, while 10% occurred in obstetric recovery areas. Similar to data seen in other medication error studies, the majority of these errors did reach the patient but no harm ensued. The MedMarx analysis also revealed that among the medication errors that did result in patient harm, the highest proportion occurred in labor and delivery (5%), compared with 1.9% in the obstetric recovery area and 1.6% in maternity units. In the labor and delivery setting, the types of errors most common were errors of omission and administration of improper dose or quantity. The drugs most associated with these errors were cefazolin, ampicillin, magnesium sulfate, oxytocin, insulin, and penicillin G. In particular, magnesium sulfate, oxytocin, and insulin are known to be high-alert medications associated with a high frequency of serious adverse effects [13].

This analysis also noted recurring practice issues including misprogramming of infusion pumps, misconnected or disconnected intravenous tubing, erroneous administration of peripheral intravenous medications through epidural catheters, unavailable drug allergy information, and incomplete communication and documentation [13]. Among the contributing factors identified, nurse distractions and workload increases were most common. The labor and delivery setting represents a dynamic environment where fluctuating census often necessitates constant shifting of workload assignments based on the acuity of the patient and the intensity of care needed. Reasons

such as inexperienced staff, inadequate staffing, cross coverage, emergent clinical situations, and flawed dispensing systems were all contributing factors associated with medication errors [14].

As this examination demonstrates, errors in the medication use process are often the result of a combination of human factors and system issues. Failure in process design, task design, and equipment design are the three most common causes identified in system breakdowns [15]. In an analysis of ADEs and near misses by Leape and colleagues [16], investigators found over half of the errors were the result of system failures.

The following case studies are examples of serious medication errors that have occurred in labor and delivery settings.

In June 2006, an 18-year-old gravida died after receiving an overdose of magnesium sulfate that was prescribed for preterm labor tocolysis. Investigation into the error revealed that the patient was given a 16-g bolus of magnesium sulfate instead of the prescribed 4-g bolus. The intravenous (IV) solution contained 40 g of magnesium sulfate rather than an IV piggyback solution of 4 g. This administration error was attributed to a mathematic miscalculation [17]. The Institute of Safe Medication Practices notes that there were at least 52 prior cases of magnesium sulfate overdose reported before this death in Florida. Seven of these errors resulted in maternal deaths, and two women remain in a persistent vegetative state [14]. Because of the risk of serious harm associated with errors involving this medication, magnesium sulfate is now on the Institute of Safe Medication Practices ''List of High-Alert Medications.''

In Wisconsin, a perinatal nurse accidentally administered a bag of epidural analgesia intravenously, containing a combination of bupivacaine and fentanyl instead of the prescribed penicillin. This 16-year-old laboring patient died as a result of poisoning by the intravenous anesthetic. The nurse, with 16 years of experience, was charged with criminal neglect for ''failing to provide adequate medical care, creating a significant danger and causing great bodily harm'' [18]. The complaint asserted that the nurse did not follow the ''five rights'' of medication administration, failed to use an available bedside bar-code scanner, and did not read the label on the medication. The nurse faced a threat of 6 years in jail and a $25,000 fine [14]. In response to this indictment, the Wisconsin Nurses Association issued a statement opposing the pursuit of criminal prosecution of the nurse for an unintentional medical error. This position was supported by the Institute for Safe Medication Practice, the Wisconsin Medical Society, and the Wisconsin Hospital Association [18].

Investigation into the above incident revealed that the experienced nurse had worked two consecutive 8-hour shifts the day before the incident, with the latter shift ending at midnight. She then made arrangements to sleep at the hospital because she was scheduled to return to work the next morning for the 7 AM shift. The error occurred during this following day shift. The RN involved in this case had her license suspended for 9 months. Practice

limitations were also imposed, including restricting work hours to no more than 12 hours in any 24 consecutive hours and not working more than 60 hours in any 7 consecutive days. (However, no similar system-wide restrictions in work hours were implemented by the hospital) [18].

Recent studies have demonstrated the impact of fatigue on patient care [19]. The Accreditation Council on Graduate Medical Education has since enacted regulations reducing the allowable working hours for residents and interns to 80 hours per week, although the basic research suggests that this limitation does not address the core underlying issue, which is extended duty shifts [19]. Nurse researchers at the University of Pennsylvania have also demonstrated that nurses who work long hours and are sleep deprived place themselves and their patients at risk for injury [20,21]. Regulations need to be drafted to protect nurses from the risks of extended work hours [21]. In their report, ''Keeping patients safe: transforming the work environment of nurses,'' the Institute of Medicine recommended limiting nursing work hours to 60 per week [22].

This case also illustrates the effects of an equipment design failure. In this case, the nurse connected an epidural catheter to a syringe filled with medication prepared for intravenous use. A forcing function design similar to that used with nitrous oxide and oxygen connections could have prevented this error. The connection between the IV syringe and the epidural catheter could have been incompatible, preventing misconnections similar to what is now standard for gas line connections [15]. Furthermore, while bar-coding was in place at the institution, there were still many potential issues, and it was not being used in all cases.

Medication safety in the ambulatory setting

Medication errors are also common in the ambulatory setting. The study by Gandhi and colleagues [6], revealed a preventable ADE rate of three per 100 patients studied. In a study of ADEs among elderly patients in ambulatory care settings, researchers identified 421 preventable ADEs, of which medication errors occurred in the prescribing stage in over half of the cases identified (246 out of 421) [8,23].

The National Center for Health Statistics (2004) reported that clinicians wrote more than 1.6 billion prescriptions in 2004. This equates to 5.4 prescriptions per United States resident. Seven out of 10 office visits result in a written prescription [24]. Although there are a variety of medications administered in the ambulatory setting, few safeguards exist to prevent errors.

Unlike the inpatient setting, medication orders are not routinely reviewed in an electronic system or in paper form by either pharmacists or nurses before dispensing and administration. For in-patient medication administrations, a nurse must follow a standard protocol verifying the patient's identity, the correct drug name, dose, route, and time. In the office setting, a medication is usually ordered by the clinician and retrieved from an onsite

stock area by the clinician or other medical staff personnel and subsequently administered to the patient. Although efficient, this process lacks the necessary safeguards to prevent medication errors from occurring. Ambulatory practices often lack policies for the administration of high hazard drugs. (ie, double checks for insulin) or read back of verbal orders [24].

Suggestions for improving medication safety in the office setting include use of prescribing writing aids to help ensure that prescriptions are accurate and complete, electronic prescribing that include standardized fields to prevent the use of unsafe abbreviations, medication-related computer alerts and warnings, evidence-based guidelines and standardized protocols, educational programs for physicians in training, and point-of-care reference material [8]. Routine monitoring of medication-related supplies and elimination of samples are also helpful for improving the safety of the medication environment in the ambulatory setting.

Provider strategies for improving medication safety

Providers should take an active role in maintaining safe medication practices. There are several steps they can to do to improve the medication use process. For example, they can verify the patient's current medication list for appropriateness at each encounter, to ensure that this list is accurate and up to date, particularly during times of transition. They can educate their patients about their medication regimen, understanding that patients need different kinds of information at different times and for different purposes. Providers should also take time to instruct patients on when and how to take medications and discuss potential side effects and drug-drug interactions. Partnering with patients and engaging them in the medication use process can also serve as an additional layer of safety in the ambulatory care area [24].

When prescribing, providers should seek to avoid missing any essential components of a medication order. Complete, legible medication orders should contain the following components: name of drug, dose, route, frequency of administration, reason or conditions for which the medication should be administered, and the patient's weight and age (when relevant to dosing, as with elderly patients). Verbal communication of prescriptions or medication orders should be limited to urgent situations where immediate written or electronic communication is not possible. It is important for health care organizations to develop policies explaining situations when it is acceptable to use verbal orders, as well as defining limitations for their use. Establishing guidelines for clear and effective communication and documentation of verbal orders is also important [25,26].

Medication reconciliation

Medication reconciliation involves obtaining a complete and accurate list of medications a patient is taking at each new encounter, and comparing this

to the active medication list present in the patient's ambulatory medical record. This process of reconciliation aims to prevent errors of transcription, omission, duplicate therapy, and potential drug-drug and drug-disease interactions [8]. This process is particularly important during transitions, when a patient's vulnerability to medication errors increases. In a study by Moore and colleagues [27], investigators reviewed the in-patient and out-patient medical records of 86 patients at 2 months after discharge and noted that 42% of in-patients had at least one medication continuity error. In this study, a medication continuity error was defined as a discharge medication that was documented in the hospital chart, but not in the medication list of the first post-discharge primary care provider visit. Investigators also note that the 42% rate of medication continuity errors identified in this study is similar to studies of patient nonadherence with intended discharge medications. The study investigators concluded that the primary care providers in this study may be documenting what the patient reports they are currently taking, while being unaware that the current medication regimen is different from the intended discharge plan [27].

Partnering with patients to improve medication safety

Establishing and maintaining a strong provider-patient partnership represents a key to reducing medication error rates [8]. The Institute of Medicine report advises consumers to maintain a current list of both prescription and nonprescription drugs, and other natural products such as vitamins or minerals they are currently taking, and present and review this list with their provider at every visit [8]. Engaging patients in their care improves compliance, satisfaction, and reduces error. Communication between the provider and patient is paramount to safe medication practices. Providers should never assume that information is shared among different providers. Education is also centrally important and can be provided in a variety of concurrent formats: oral, written, and video. Patients should be provided with written information, as well as verbal instructions, about medications prescribed. An additional layer of safety involves including family members who will assist in the patient's care in these discussions and review.

Information technology strategies for improving medication safety

Advances in information technology are rapidly becoming one of the most effective strategies for reducing medication errors and thus improving the quality of patient care. In recent years, computerized tools have been developed to assist clinicians in a number of ways, including improving communication, making knowledge more readily accessible, providing key elements of information as well as decision support at the point of care, assisting with drug dose calculations, performing checks in real time, and

assisting with monitoring the patients response to drugs and other therapies [28].

One of the major problems in current medication systems is the inability to access pertinent patient and drug information at the time when it is needed most, at the point of care [16]. In 1995, Leape and colleagues [16] performed an analysis of system failures that lead to errors causing ADEs and potential ADEs. In this study, investigators found 16 major system failures as the underlying cause among the 264 preventable ADEs and potential ADEs. Twenty-nine percent of medication errors were attributed to failures in disseminating drug information to providers. In addition, inadequate availability of patient information, including important laboratory results, was associated with18% of errors.

Computerized physician order entry

Computerized physician order entry (CPOE) is one prevention strategy with strong evidence base support for its effectiveness [29], and it has been endorsed by many, including the federal government's Quality Interagency Coordination Task Force, the Institute of Medicine, and major stakeholders including the Leapfrog Group, as a key intervention for reducing medication error rates and improving medication safety [15]. Basic CPOE involves electronic entry of a medication order. Basic electronic prescribing eliminates errors created by illegible handwriting. Fig. 2 illustrates an example of this in the gynecologic setting. CPOE with decision support streamlines and structures the prescribing process by allowing clinicians to choose medication dosing from programmed drop down menus, thus improving

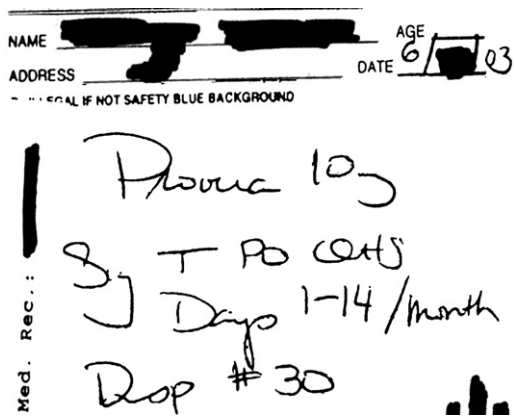

Fig. 2. Prescription illustrating the dangers of poor handwriting. The medication to be dispensed was misinterpreted by the pharmacy and dispensed as Prozac (Eli Lilly and Company, Indianapolis, IN), instead of the intended Provera, (Pfizer Inc., New York, NY), which has a similarly spelled trade name.

accuracy. Use of this technology aids in decreasing transcription and ensures completeness of the medication order. Decision support features embedded in this technology allow providers access to relevant patient laboratory data, as well as specific drug guidelines and guided dose algorithms (see Fig. 3 for an example of this decision support tool). An additional benefit of computerized order entry is the ability to perform important safety checks, such as drug-allergy, drug-drug, drug-laboratory, and drug-patient characteristics.

While CPOE appears beneficial in the aggregate, there has been much recent discussion related to the unintended consequences [30,31], which can be substantial. The IOM Committee reviewed the results of ten investigational studies that evaluated the effectiveness of CPOE with decision support capabilities. In their report, the IOM concluded that all ten studies showed a statistically significant reduction in medication errors. The report notes that medication error rates were reduced between 13% and 86%, and preventable adverse drug events decreased by a rate of 17% to 62% [8]. The IOM did acknowledge that the adoption of computerized systems can themselves introduce errors, and in some instances even contribute to worse outcomes. However, these consequences

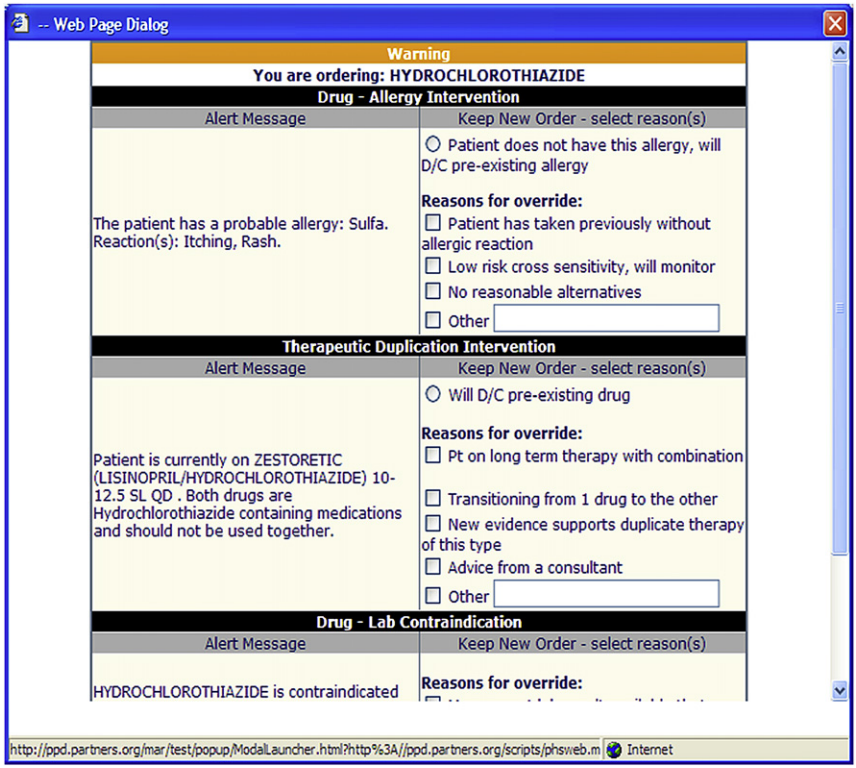

Fig. 3. Example of advance decision support alerts within computerized provider order entry.

tend to occur when flaws exist in the planning and implementation process [8]. Thorough planning, redesign of the health care delivery process that includes careful integration of the technology with existing hospital systems, continuous monitoring of problems that arise during and after implementation, and immediate response to these issues are all key factors in the effectiveness this technology has as a patient safety intervention.

Bar-coding

Barcode technology with an electronic medication administration record (eMAR) is another major advance recently introduced to improve medication safety. Benefits of this technology are that it allows for matching of medication orders with drug products, provides verification of drugs at the dispensing and administration stages, and automates the "five rights" of medication administration: verifying the who/what/when/dose/route. Bar-coding streamlines workflow by updating the eMAR immediately, ensuring accuracy and saving time that would otherwise be spent documenting the administration on a paper medication administration record. Several research efforts are underway to evaluate and validate the effectiveness of this technology on reducing medication errors and ADEs and assessing the impact on clinician workflow. Early studies suggest that there will be benefits at the dispensing and administration stages, as well as from a cost perspective. One study has shown that before barcode medication administration (BCMA) implementation, nurses spent 26.5% of their time on medication administration. After BCMA implementation, this proportion remained statistically unchanged at 24.5% [32]. In a recent study by Maviglia and colleagues [33], researchers performed a cost benefit analysis of a BCMA system in a large academic institution. Investigators found that the major cost benefit was achieved through the decrease of dispensing errors leading to ADEs (517 events). This decrease translated into an annual cost savings of $2.20 million. The study's investigators also reported that the break-even point for the hospital's investment of $2.24 million occurred within 1 year of when bar-coding became fully operational.

In September of 2006, three preterm infants in an Indiana hospital died as a result of lethal overdoses of intravenous heparin. The error was the result of a pharmacy technician accidentally stocking the drawer in the nursery with the adult dosage of the heparin. Fig. 4 shows that the doses for adults and infants were similarly packaged, contributing to the error. The use of barcode scanning at the dispensing and administration stages might have prevented these errors.

Smart pumps

Medications delivered by intravenous infusion are of vital importance in the care of hospitalized patients, and are quite important in the care of

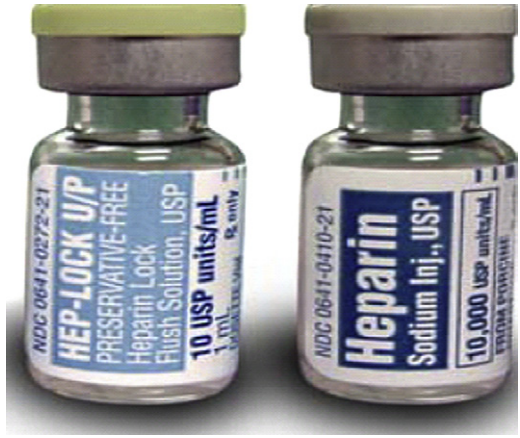

Fig. 4. Similar vials of heparin involved in fatal dispensing error in neonatal setting.

obstetric and gynecologic patients. Often intravenous infusions involve potent drugs, such as oxytocin and magnesium sulfate, with narrow safety margins that require frequent dose adjusting to respond to a patient's clinical condition [34]. Although barcode technology can verify the right drug for the right patient, these technologies lack safety features to ensure accurate programming of drug delivery by intravenous route. Smart infusion systems have been developed to assist in averting IV medication errors at the point of care. The role of ''smart'' technology is to remember the rules that apply (eg, dosing limits and clinical advisories) by incorporating them into the safety software. The following case illustrates an intercepted error at this level of medication administration: A patient was ordered for a heparin bolus dose of 4,000 units, followed by an infusion of 890 units per hour. The nurse administered the 4,000-unit bolus dose appropriately; however the nurse misinterpreted the order and programmed the infusion device to deliver 4,000 units per hour instead of 890 units per hour. The medication was being administered through an infusion device, which had the smart technology software, and subsequently the smart pump alerted nurse that the dose exceeded maximum limits defined in drug library, thus intercepting the error before administration.

Electronic prescribing in the ambulatory setting

Electronic prescribing involves writing an outpatient prescription with the use of a computer. Basic electronic prescribing systems ensure prescription completeness (avoiding errors of omission) and allow for printed copies of prescriptions (avoiding legibility issues). Advanced electronic prescribing systems incorporate decision support tools into the prescribing process. One important benefit is that e-prescribing systems are often integrated into

electronic health records, thus making patients' active medications more readily accessible to clinicians. Electronic submission of prescriptions directly into the pharmacy system is ideal, but not all pharmacies have this capability yet. Upon receipt of electronic submission (often by fax), many pharmacies still manually enter the prescribing information into their systems [35]. Because of the known benefits of e-prescribing, the IOM Committee on Prevention of Medication recommends that by 2010 all prescribers and pharmacies use e-prescribing.

Barriers to adoption

Although advances in health information technology are showing tremendous promise in mitigating and averting serious medication errors, there are many barriers that have impeded their widespread adoption. Among these are financial barriers. Physicians are typically rewarded for excellent billing capabilities, not improvements in clinical care. Most applications are commercially funded, making customization and integration into existing clinical systems more challenging. While national standards exist for most types of clinical data, many are not yet in wide use. Among the cultural barriers that inhibit implementation efforts are lack of physician comfort with adopting new technology, desire to maintain the status quo, lack of recognition, and understanding and concerns about privacy and security [36]. Furthermore, any changes that the physicians regard as increasing work instead of reducing work is certain to be met with resistance.

Creating a culture of safety

Creating a culture of safety is a key component in improving medication safety. It requires an organizational commitment at all levels to continuously monitor, report, and develop processes toward improving safety. Senior management must make safety a priority and remain engaged in activities directed toward this goal. This includes committing necessary resources to implement prevention strategies that have been demonstrated to be effective in reducing medication errors and harm [8]. Efforts toward promoting a culture of safety can be achieved by establishing a shared vision within an organization, where everyone aims toward a common goal in which patient safety is the primary tenet of patient care, including medication safety [37].

Summary

Medication safety represents an important problem in obstetrics and gynecology, as in other domains. Achieving substantial improvement in

medication safety in obstetrics and gynecology will require adopting a number of technologies, including computerized physician order entry, bar-coding, and smart pump technology in the hospital, and computerized prescribing and use of electronic health records in the outpatient setting. However, patient safety is a state of mind, not technology. All these technologies represent tools that must be properly designed, used well, assessed on an on-going basis, and the associated decision support needs to be refined and updated. Moreover, in all settings, building a culture of safety is pivotal for improving safety, and many nontechnologic approaches, such as medication reconciliation and teaching patients about their medications, are also essential.

References

[1] Institute of Medicine. To err is human. Building a safer health system. In: Kohn L, Corrigan J, et al, editors. Committee on Quality of Health Care in America. Washington, DC: National Academy Press; 1999.
[2] Hayward RA, Hofer TP. Estimating hospital deaths due to medical errors: preventability is in the eye of the reviewer. JAMA 2001;286(4):415–20.
[3] Health Grades Inc. Patient safety in American hospitals. Golden, CO: Health Grades Inc.; 2004.
[4] Leape LL, Brennan TA, Laird NM, et al. The nature of adverse events in hospitalized patients: results from the Harvard Medical Practice Study II. N Engl J Med 1991;324:377–84.
[5] Bates DW, Cullen D, Laird N, et al. Incidence of adverse drug events and potential adverse drug events: implications for prevention. JAMA 1995;274:29–34.
[6] Gandhi TK, Weingart SN, Borus J, et al. Adverse drug events in ambulatory care. N Engl J Med 2003;348(16):1556–64.
[7] American Society of Health System Pharmacists. Survey reveals patient concerns about medication-related issues. 2002. http://www.ashp.org/s_ashp/article_press.asp. Accessed May 11, 2007.
[8] Institute of Medicine. Preventing medication errors: quality chasm series. Washington, DC: The National Academies Press; 2006. (pgs 4–5, 15, 36–37, 124–125, 167–168, 414, 417, 428).
[9] Bates DW, Spell N, Cullen DJ, et al. The costs of adverse drug events in hospitalized patients. Adverse Drug Events Prevention Study Group. JAMA 1997;277(4):307–11.
[10] Kizer KW, Nishimi RY, Power EJ. Standardizing a patient safety taxonomy. Washington, DC: National Quality Forum; 2006.
[11] Bates DW, Boyle DL, Vander Vliet MB, et al. Relationship between medication errors and adverse drug events. J Gen Intern Med 1995;10(4):199–205.
[12] Bates DW, Leape LL, Cullen DJ, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. JAMA 1998;280(15):1311–6.
[13] U.S. Pharmacopeia. USP Patient Safety CAPSLink. USP Center for the Advancement of Patient Safety 2004. http://www.usp.org/pdf/EN/patientSafety/capsLink2004-11-01.pdf.
[14] Mahlmeister LR. Best practices in medication administration: preventing adverse drug events in perinatal settings. J Perinat Neonatal Nurs 2007;21(1):6–8.
[15] Cohen MR. Medication errors. 2nd edition. Washington, DC: American Pharmacists Association; 2007. p. 9–10.
[16] Leape LL, Bates DW, Cullen DJ, et al. Systems analysis of adverse drug events. ADE Prevention Study Group. JAMA 1995;274(1):35–43.
[17] Simpson KR. Minimizing risk of magnesium sulfate overdose in obstetrics. MCN Am J Matern Child Nurs 2006;31(5):340.
[18] Wright L. Voluntary overtime, unsafe nursing practice, and the quest for institutional accountability. JONAS Healthc Law Ethics Regul 2007;9(2):50–3.

[19] Landrigan CP, Rothschild JM, Cronin JW, et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. N Engl J Med 2004;351(18):1838–48.
[20] Hughes RG, Rogers AE. Are you tired? Am J Nurs 2004;104(3):36–8.
[21] Hughes RG. First, do no harm. Avoiding the near misses. Am J Nurs 2004;104(5):83–4.
[22] Institute of Medicine. Keeping patients safe: transforming the work environment of nurses. Washington, DC: The National Academies Press; 2003.
[23] Gurwitz JH, Field TS, Harrold LR, et al. Incidence and preventability of adverse drug events among older persons in the ambulatory setting. JAMA 2003;289(9):1107–16.
[24] Weingart SN. Web M&M case commentary: it's all in the syringe. Agency for Healthcare Research and Quality 2006. Agency for Healthcare Research and Quality; http://psnet.ahrq.gov/index. Accessed May 11, 2007.
[25] American College of Obstetricians-Gynecologists. ACOG Committee Opinion. Safe use of medication. Number 331, April 2006. Obstet Gynecol 2006;107(4):969–72.
[26] Safe use of medication. ACOG Committee Opinion No. 331. American College of Obstetricians and Gynecologists. Obstet Gynecol 2006;107:969–72.
[27] Moore C, Wisnivesky J, Williams S, et al. Medical errors related to discontinuity of care from an inpatient to an outpatient setting. J Gen Intern Med 2003;18(8):646–51.
[28] Bates DW, Gawande AA. Improving safety with information technology. N Engl J Med 2003;348(25):2526–34.
[29] Kaushal R, Shojania KG, Bates DW. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. Arch Intern Med 2003;163(12):1409–16.
[30] Han YY, Carcillo JA, Venkataraman ST, et al. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. Pediatrics 2005;116(6):1506–12.
[31] Koppel R, Metlay J, Cohen A, et al. Role of computerized physician order entry systems in facilitating medication errors. JAMA 2005;293(10):1197–203.
[32] Poon EG, Keohane C, Featherstone E, et al. Impact of barcode medication administration technology on how nurses spend their time on clinical care. In: AMIA Annual Symposium Proceedings/AMIA Symposium; 2006. p. 1065.
[33] Maviglia SM, Yoo JY, Franz C, et al. Cost-benefit analysis of a hospital pharmacy bar code solution. Arch Intern Med 2007;167(8):788–94.
[34] Rothschild JM, Keohane CA, Cook EF, et al. A controlled trial of smart infusion pumps to improve medication safety in critically ill patients. Crit Care Med 2005;33(3):533–40.
[35] Finkelstein JB. E-prescribing first step to improved safety. J Natl Cancer Inst 2006;98(24):1763–5.
[36] Steiger B. Special report: quality of care survey. Doctors say many obstacles block paths to patient safety. Physician Exec 2007;33(3):6–14.
[37] Simpson KR, Knox GE. Common areas of litigation related to care during labor and birth: recommendations to promote patient safety and decrease risk exposure. J Perinat Neonatal Nurs 2003;17(2):110–25 [quiz 126–7].