Emerg Med Clin N Am
21 (2003) 141–158

EMERGENCY
MEDICINE
CLINICS OF
NORTH AMERICA

Medication errors in the emergency department
A systems approach to minimizing risk

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> Be not the first by whom the new is tried; nor yet the last to lay the old aside.
>
> —Alexander Pope (1688–1744)

As many as 98,000 Americans die each year as a result of medical errors [1], and there is mounting evidence that medical errors are a leading cause of death in the United States. To illustrate, this loss of life is greater than the death toll that would accrue if two Concorde jets were to crash every day of the year.[1] Whether or not these figures are entirely accurate, they draw attention to the occurrence, if not the incidence, of medical errors as a cause of adverse patient events [2–5].

Drug complications

Drug complications are the most common type of adverse patient event, accounting for 19% of adverse events overall [6], and as many as 4% of all inpatients experience some type of medication error [7]. In addition, adverse drug events are a significant presenting complaint of patients seeking treatment in emergency departments (EDs) [8,9]. Not all adverse drug events, however, are caused by medical error, nor do all medication errors result in an adverse event [10]. In addition to the human toll exacted by medication errors, preventable drug-related morbidity and mortality represent an enormous economic burden on society. For example, cost-averaging statistics place the drug-related morbidity and mortality financial

[1] On July 25, 2000, 113 people were killed when Air France Flight 4590 crashed shortly after takeoff.

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PII: S0733-8627(02)00085-8

tab at $76.6 billion in the ambulatory setting, the largest component of this total going toward drug-related hospitalizations [11–13]. There is persuasive evidence that the number of deaths from medication errors is increasing: deaths attributed to medication mistakes more than doubled between 1983 and 1993 [14], and there are no signs that this trend will not continue. In recognition of the important role medication errors play in patient injury the Joint Commission for the Accreditation of Healthcare Organization (JCAHO) now requires its 17,000 member organizations to have specific procedures in place that target the prevention of medication errors.[2]

The explosion of new drugs appearing in the marketplace has made it virtually impossible for physicians, nurses, and pharmacists to keep abreast of all of the latest data concerning the indications, contraindications, drug interactions, and adverse effects associated with each new drug. Moreover, all medications have side effects, and rare but potentially fatal side effects are unlikely to show up in preliminary clinical trials. Examples of some recent Food and Drug Administration (FDA) drug recalls associated with death or serious illness, identified after completion of clinical trials, include the following drugs: cisapride (Propulsid), associated with cardiac problems; troglitazone (Rezulin), associated with liver toxicity; astemizole (Hismanal), associated with cardiac problems; terfenadine (Seldane), associated with cardiac problems; and trofloxacin and alatrofloxacin (Trovan), associated with liver toxicity.

Solution lies in detailed systems analysis

To reduce the injuries caused by medication errors, the systems in which emergency clinicians operate and that have fostered the hazards to which patients are exposed must be evaluated. In the past, much focus has been placed on individual culpability for the occurrence of medication errors, and health care organizations have taken a punitive approach to adverse drug events. The traditional "name, blame, shame, and train" approach has not effectively dealt with the problem of medication errors and has probably served to exacerbate the problem. One of the great ironies of this method of dealing with error is that professionals who have more education and training than most others are subjected to additional training in the hope that the "error" is not repeated. As long as the underlying latent defects remain undetected and as long as humans continue to make errors, there are tens of thousands of other clinicians poised to commit the same "error," often with catastrophic results. It is much more effective to create a work environment in which the errors clinicians inevitably commit are neutralized

[2] See the 2003 JCAHO National Patient Safety Goals: Practical Strategies and Helpful Solutions for Meeting these Goals at http://www.jcrinc.com/subscribers/patientsafety.asp?durki=154 for an excellent model on preventing medication errors.

and intercepted [15]. Professionals in industry have learned that most workplace errors occur because of underlying systems defects and that individual conduct serves only as a common final pathway to an adverse event. Cook et al [16] have highlighted the fact that systems operations are rarely trouble-free, and there is considerable evidence that the low rates of failure observed within settings of high failure potential are produced largely by human practitioners.

The specialty of emergency medicine is characterized by unique systems challenges that place patients at increased risk for medication errors. First, patients present to the emergency physician (EP) as strangers. Unlike physicians in pediatrics or internal medicine, EPs are rarely familiar with their patients' medical histories, medication lists, allergy history, renal function, and so on, and it is likewise rare that EPs have immediate access to the medical records of patients who present to the ED. In addition, off-hours contact with physicians who may be familiar with ED patients' medical histories is often not possible. Second, EPs provide service every day and night of the year. They are often required to dispense drugs directly from the ED at hours when pharmacists may not be available to serve as a crucial safety check in the drug-ordering and delivery scheme. Third, EPs must often administer a potentially dangerous medication on an emergency basis to a critically ill or injured patient, increasing the risk that critical safety checks may be omitted. In addition, the route of administration used in an emergency can lead to a greater risk of an adverse event (eg, when a medication is given intravenously or via a central line, the risk of an adverse event rises dramatically). Finally, a reliance on oral orders, which is inherent in emergency medicine, increases the risk that a potentially ambiguous medication order is misinterpreted or misunderstood.

Some adverse drug events cannot be prevented. For example, appropriately prescribing penicillin to a patient with no known medicinal allergies and who breaks out in a rash on the third day of treatment constitutes a nonpreventable adverse drug reaction. Obviously, such a prescription to a patient known to be penicillin allergic is a preventable adverse drug reaction.

The five stages of drug ordering and delivery

There are five stages of drug ordering and delivery: (1) prescribing, (2) transcribing, (3) dispensing, (4) administration, and (5) monitoring. Each of these stages represents a vulnerable link in a chain along which any variety of errors can occur—in large measure explaining the complexity involved in preventing adverse drug events. A breach along any one of the links in the chain may lead to an adverse drug event. Although it appears that certain individuals may have greater responsibility along certain links in the chain and other individuals may have a greater role elsewhere along the chain,

a team approach is strongly recommended for the successful outcome of each of these stages.

Prescribing errors

Seventy-one percent of serious medication errors occur at the prescribing stage of the drug-ordering and delivery system [17], and nearly one patient in five suffers an adverse drug reaction, irrespective of whether a medication error occurred [18]. It should come as no surprise that patients who suffer adverse drug events are less satisfied with their care and medication errors comprise a significant percentage of medical malpractice suits against physicians, nurses, and hospitals. One contributing factor is the fact that physicians are writing more prescriptions for medications than ever before. In 1998, nearly 2.5 billion prescriptions were dispensed by US pharmacies at a cost of about $92 billion [1]. In 2000, retail pharmacies filled 2.9 billion prescriptions at a cost of $131.9 billion [19], and in 2001, this cost increased 17%, to $154.5 billion. On average, each physician wrote 2060 prescriptions in 1999; three of four patients who visited their physicians walked out with a prescription.

The two most common factors associated with prescribing errors are lack of knowledge pertaining to the drug prescribed and lack of knowledge regarding the patient for whom the drug is prescribed [20,21]. As discussed later, new advances in information technology hold great promise in countering the effects of these two important factors. Other important factors, discussed later under "Transcribing errors," include problems related to the use of calculations, decimal points, unit or rate expression, and nomenclature factors, such as incorrect drug name, dosage form, or abbreviation (Box 1).

Inadequate knowledge base for medication prescribed

An inadequate knowledge base pertaining to the use of medications has been cited as one of the most common causes of medication prescription errors. The number of medications available on the market has skyrocketed in the past few decades, and it is impossible for physicians, nurses, and pharmacists to master the important details of every drug used in emergency medicine. Furthermore, each year dozens of new drugs are added to physicians' armamentarium, each with its own side effects profile and potential for toxicity. In addition to each drug having its own potential for toxicity, the occurrence of adverse drug interactions when two or more medications are combined can be difficult to predict. This can be especially problematic for geriatric patients presenting to the ED, who are usually taking two or more concurrent medications before treatment is administered in the ED [22–24].

Because of the difficulty inherent in remaining current in the drug information necessary for safe medical and nursing practice, it is essential

Box 1. Systems interventions at the prescribing stage of drug ordering and delivery

Have a drug reference system in place to assist physicians and nurses in the appropriate uses, applications, and dosages of drugs.
Make liberal use of pharmacists' expertise in prescribing medications, especially when the drug is unfamiliar.
Take a careful medical history, medication history, and allergy history on all patients. If available, refer to the patient's previous medical records.
Order appropriate laboratory studies to identify patient characteristics that may place a particular patient at risk for an adverse drug event.
When caring for pediatric patients, always have an accurate weight in kg recorded on the patient's chart and on the prescription.
When caring for geriatric patients consider the following:
The possibility of drug-drug interactions when prescribing any new medications
The possibility of a fall occurring because of any new medication you prescribe
The patient's renal and hepatic function when prescribing new medication
The possibility that concomitant disease states may be adversely affected by any new medications
The patient's financial or mental status interfering with his or her ability to comply with the newly prescribed drug regimen
Use extra caution when prescribing for pregnant patients: use category C drugs only if the anticipated benefits of the drug clearly outweigh the danger to the mother and/or baby of not using the drug.

that every ED have access to appropriate reference materials on drug usage [35].[3] The clinician should consult a reference when prescribing or administering a drug with which he or she is not completely familiar.

[3] For example, the *United States Pharmacopeia Dispensing Information*; *AHFS Drug Information*, published by the American Society of Health-System Pharmacists; *MicroMedex*; and *GenRx*, published by Mosby. In the pediatric and neonatal prescribing arena, the *Harriet Lane Handbook* and *Neofax* (Acorn Publishing) are excellent sources of reliable drug information. In addition, there are many excellent textbooks of pharmacology and toxicology. Clinicians should not depend on advertising literature, representations by pharmaceutical representatives, package inserts, or the *Physicians' Desk Reference*.

Under many circumstances, a hospital pharmacist can assist the EP or nurse by providing useful information about a drug's proper indications, dose, route of administration, adverse effects, contraindications, and other important information. In general, it is prudent for physicians to follow Alexander Pope's advice and use a more familiar, older drug than to experiment with a newer, unfamiliar drug. As mentioned previously, some drugs have rare but catastrophic side effects that do not manifest themselves during premarketing drug trials, and it is only when millions of post-marketing prescriptions have been dispensed that these serious and potentially fatal side effects become apparent.

Lack of familiarity with the patient

The second most common systemic factor contributing to prescription errors is a lack of familiarity with the unique individual patient factors at play in the therapeutic plan. This problem is particularly acute in emergency medicine, in which patients are unknown to the physicians. For example, crucial information, such as a patient's medical history, current medications, and allergy history, is often unavailable to the EP. This problem is compounded by the fact that EPs often have no access to their patients' medical records in the ED. Although there are no simple solutions to these problems, EPs must start by obtaining as accurate and complete a past medical history as possible. Most EPs and nurses have witnessed the confusion their patients have when communicating information about their medications. For example, a patient may tell an EP that he or she takes "one little pink pill" for the heart, "a big blue pill" for the blood pressure, and "a gray and red" pill his or her neighbor provided for "an infection." Or worse, the patient might not know what the "blue pill" is for. In the geriatric patient population, the presence of dementia may preclude an accurate medication history. It is clear that the inherent nature of emergency medicine may handicap EPs when it comes to identifying the patient-related factors vital to safe medication practice.

Patients and family members should be encouraged to bring all of their medications to the ED. Furthermore, paramedics must be trained to bring all medications into the ED when they transport patients to the ED. Private physicians should be consulted about their patients' drug regimens and allergy history, but this is difficult or impossible after hours and on weekends. Old medical records should be reviewed when available. Finally, the patient should be prompted to provide as many details of his or her medical history as possible. The EP and nurse should then proceed with an appropriate physical examination. Valuable clues in the patient's vital signs may indicate the use of a β-blocker; an elevated blood pressure or elevated serum glucose level may indicate noncompliance problems. An appropriate laboratory workup should be initiated, looking in particular for clues to renal or hepatic insufficiency. For example, intravenous (IV) contrast should be withheld in the presence of an elevated creatinine level.

Pediatric challenges

Pediatric patients pose a unique set of challenges to EPs and nurses for two reasons: (1) most medications prescribed and administered to pediatric patients are weight-based doses and (2) some medications are contraindicated in children younger or older than a certain age.[4]

Pediatric patients are vulnerable to the same medication errors to which adults are exposed, with the added risk of receiving a toxic dose based on a calculation error [25,26].Overdosing pediatric patients is the most common type of medication error in pediatric emergency medicine [27]. Every pediatric patient presenting to the ED must be weighed prior to receiving any medication, and the weight in kg must be recorded on the medical record. It is wise to rid the ED of any scales that record the child's weight in pounds as a way of eliminating at least one potential mistake.

Many medications used in pediatric emergency medicine have not been approved by the FDA for use in children [28]. Such use, called "off-label" prescribing, is entirely appropriate in the pediatric emergency patient. Drug companies often fail to perform premarketing drug trials in the pediatric age range and hence a wide variety of drugs never receive FDA approval for use in children. It is important to distinguish safe drugs that have not received specific FDA approval for use in children (many) from unsafe drugs that are contraindicated in children younger than a certain age (very few).

Transcribing errors

Transcribing errors occur when there is a breakdown in communication between the prescriber and the person dispensing or administering the medication. In the ED, this may be caused by an oral order being misinterpreted or ambiguous. In an outpatient pharmacy, it may from poor penmanship. Transcribing errors constitute a serious breakdown in the system of drug delivery, but they are 100% preventable.

One of the difficulties leading to transcribing errors is related to problems of nomenclature that arise because each drug has a multitude of names: there is the drug's formal chemical name; the United States Adopted Name (USAN), also referred to as its generic name; and there is its proprietary name or drug manufacturer's trademark name. To make matters more confusing, a drug may have two or more proprietary names. A drug with the same brand name may be further characterized by initials such as "CR," "LA," "XL," and other designations that add to potential ambiguities, which may result in serious overdoses of a medication. Another difficulty arises because various manufacturers use similar sounding names for their drugs, such as the drugs Celexa, Celebrex, and Cerebyx [29]. Finally, poor

[4] For example, quinolones are contraindicated in children younger than 18 years, tetracyclines are contraindicated in children younger than 8 years, and ketamine is contraindicated in children older than 15 years.

penmanship is a problem in at least 15% of all prescriptions and inevitably leads to problems, especially when drug names are similar.

Eliminating transcription errors

The following tips will help eliminate transcription errors:

- Write clearly and neatly: print or type if necessary.
- Prescribing vocabulary must be standardized: do not use apothecary terms.
- Manufacturers should avoid or eliminate ambiguities in drug names and dosing information.
- Include the drug's indication on all prescriptions to assist the pharmacist or nurse in dispensing the correct medication.
- Avoid acronyms and abbreviations.
- Take steps to avoid sources of confusion in written orders, such as trailing zeros: a misplaced or misread decimal point can result in a tenfold medication error.
- Minimize or eliminate oral orders: writing orders whenever possible and limiting verbal orders to urgent or emergency situations will eliminate many medication errors.
- Always include the prescriber's telephone or pager number on the medication prescription to enable the pharmacist or nurse to clarify any areas of confusion that may contribute to a transcription error.

In addition, using electronic medical records and e-mail prescriptions can virtually eliminate transcription errors (Box 2).

Dispensing errors

Dispensing medication is the process of providing the medication to the person who will administer the drug. This stage is the last chance to correct a medication error for patients who have been discharged from the ED, and many studies have illustrated the vital role, for inpatients and outpatients, pharmacists play in correcting an imminent prescription error [30,31]. Pharmacists should not fill prescriptions that are incomplete or at all questionable. On some occasions, especially after hours, it may be necessary to dispense a drug directly from the ED, with the subsequent loss of the invaluable pharmacist safety net. Several safety checks are therefore necessary to prevent errors at this stage of drug delivery (Box 3).

Safety checks for dispensing in the ED

- Arithmetic errors. Double-check your arithmetic, or better yet, have a second nurse do the arithmetic with you to confirm accuracy.
- Decimal points placement. If decimal points are used, confirm proper placement with the prescribing EP.

- Accurate weights. Confirm that the recorded weight is in kg, and that it is accurate.
- Confirmation of patient's allergy history. Confirm one last time that the patient is not allergic to the medication you are dispensing.
- The prescribing physician should not also dispense the medication. It is best to have two people prescribe and dispense any medication dispensed from the ED to enable one additional safety check in the process.
- Dispense only the quantity of medication necessary to carry the patient through to the time when he or she can properly have their prescription filled by a pharmacist.
- Keep proper records. Record all narcotics dispensed from the ED in your narcotics log and write all drugs dispensed from the ED in the patient's medical record.
- Confirmation of right patient. Always check the patient's wrist band before dispensing medication. Patients are often moved from one bed to another in the ED, creating the potential that a medication intended for the "patient in Bed A" is given to another unintended patient if patients have been moved.

Fortunately, the prescribing EP is immediately available to the dispensing nurse for questions should any problems or confusion arise in the process of dispensing medication from the ED. The use of bar codes has been shown to greatly reduce the incidence of dispensing errors.

Administration errors

Administration of a drug is the act of physically placing the drug into the body of a patient. Administration errors occur when either the wrong drug is administered, or the right drug is administered in the wrong dose or via the wrong route, or with an incompatible coadministered drug. An administration error may also occur when the right drug is given to the "wrong" patient, such as a patient who plans to drive home but is given a narcotic injection.[5] When administration errors occur, they can be very serious, especially when they occur via the IV route.

The wrong drug may be administered when a transcription error occurs, when two drugs with similar sounding names are confused with each other, or when two drugs are packaged alike and the wrong drug is pulled off of the shelf. Whenever possible, drugs not needed on an emergency basis should be stocked out of the ED[6] and in the hospital pharmacy to prevent the administration of the wrong drug (Box 4).

[5] This can also be classified as a prescription error, but if the patient requires narcotics for pain relief, the oral route might be more appropriate than the IV or intramuscular route because the patient may safely take the medication after arriving home.

[6] Some medications, such as potassium chloride, should never be stocked in the ED.

Box 2. Systems interventions at the transcribing stage of drug ordering and delivery

Transcription errors are 100% preventable.
Use good penmanship or computer-generated prescription.
There should be a space between a number and its units because it is easier to read. There should be no periods after the abbreviations mg or mL (10 mg not 10 mg.).
Never place a decimal and a zero after a whole number (2 mg is correct, 2.0 mg is incorrect). If the decimal point is not seen because it falls on a line or because individuals are working from copies where the decimal point is not seen, this causes a tenfold overdose.
Just the opposite is true for numbers less than one. Always place a zero before a naked decimal (0.5 mL is correct, .5 mL is incorrect).
IU is not a safe abbreviation for international units. It can look like IV.
There is no safe abbreviation for once daily. It must be written out.
Do not abbreviate drug names (eg, 5FC, 6MP, 5-ASA, MTX, HCTZ, CPZ, PBZ) because they can be misinterpreted and cause error.
Do not use chemical names such as 6-mercaptopurine or 6-thioguanine, because sixfold overdoses have been given when these were not recognized as chemical names. The proper names of these drugs are mercaptopurine or thioguanine.
Do not use the apothecary system or symbols.
Do not abbreviate microgram as μg; instead use mcg because there is less chance of misinterpretation.
A legible prescription should contain the following:
The patient's full name
For pediatric patients, their weight (in kg)
For geriatric patients, their age
The strength of the medication, even if only one strength exists
Number or amount to be dispensed
Complete instructions for the patient, including the purpose of the medication (''as directed'' is not acceptable)
Where there are recognized contraindications for a prescribed drug, indicate to the pharmacist that you are aware of this fact (eg, when prescribing potassium salt for a patient receiving an angiotensin-converting enzyme inhibitor, write ''K serum level being monitored.''

From Davis NM, Cohen MR. Safe writing. Lecturers and consultants for safe medication practices.

Box 3. Systems interventions at the dispensing stage of drug ordering and delivery

The dispensing stage is often the last chance to correct or prevent an impending medication error.
Pharmacists should not fill prescriptions that are incomplete, illegible, or at all questionable.
Phone and pager numbers must be included with each prescription so that pharmacists and nurses can contact the prescriber to clarify a medication prescription.
Because many drugs are dispensed (or administered) directly from the ED, implement a dose verification system with as many checks as possible. Establish dose limits and set up a review process for doses that exceed the limits.

Like the dispensing stage, the administration stage may be the last chance to employ important safety checks to prevent a medication error. Unfortunately, many administration errors occur when critical safety checks are ignored because there is a rush to administer the drug in an emergency. Nevertheless, it is rarely the case in emergency medicine that the administration of a drug cannot be delayed for the few minutes necessary to perform vital safety checks to protect the patient from injury.

Safety checks for preventing administration errors

In addition to verifying the patient's allergy history, accurate weight, and other items listed previously, the following must be confirmed:

- Correct patient. Because EPs and nurses care for multiple patients concurrently, verify that the medication is being administered to the correct patient. Elimination of oral orders can prevent ambiguities that result in the administration of the "right" drug to the "wrong" patient.
- Correct drug. Verify that you are administering the correct drug; it is wise to double-check with the ordering physician.
- Correct dosage. Verify that you are administering the correct dosage.
- Compatibility. Verify that the drug you are about to administer is compatible with any coadministered drugs.
- Double-check IV lines. If the drug is ordered via IV, ensure that the patient has adequate IV access to avoid problems with infiltration of the drug.
- Confirm your arithmetic. Have a second nurse or a pharmacist do the calculation with you.
- Correct route of administration. Verify that the route of administration is correct; make liberal use of references and consult your hospital pharmacist when in doubt.

- Correct rate of administration. Verify that you are about to administer the drug at the correct rate of infusion; some drugs can be given IV push, others slow IV push over minutes, others must be infused over hours.
- Verify patient weight in kg.
- Confirm proper placement of decimal points.
- Confirm patient's allergy history.

Monitoring

Emergency medicine faces substantial obstacles at the monitoring stage of medical therapeutics and patients who present to the ED may be especially vulnerable to complications at this stage. Two types of monitoring are important in the safe administration of medications: (1) When a drug is

Box 4. Systems interventions at the administration stage of drug ordering and delivery

The administration stage is the absolute last chance to correct or prevent an impending medication error.
Nurses should not carry out orders that are illegible, potentially dangerous, or over which there is any confusion. Clarify all questionable orders with the ordering physician.
Consult reference materials if in doubt about how to safely administer a medication.
Consult with a hospital pharmacist on a liberal basis regarding proper route of administration (eg, IV, oral, subcutaneous, rectal), compatibility of agents being coadministered, rates of administration, drug concentrations, and so forth.
Implement a systematic format for reviewing orders: this is the last chance to correct a mistake and therefore the stage at which safety checks are most critical.
Safety checks should be in place to guarantee accuracy with regard to the following:
Confirming patient's allergy history
Arithmetic errors
Decimal points displacement
Accurate weights
Administer medications based on an oral order only in case of a truly urgent or emergent situation.
Eliminate barriers to reporting administration errors, such as fear of punitive action or burdensome paperwork.

administered in the ED, appropriate monitoring of the patient for side effects and toxicity should be initiated. The level of monitoring required will vary with the patient circumstances and with the nature of the pharmacologic agent employed. For example, intensive, one-on-one monitoring is vital with such high-risk interventions as pediatric conscious sedation. Likewise, an infant who has received racemic epinephrine for croup and the patient who has been given an IV antibiotic require close monitoring in the ED prior to discharge. (2) Certain medications require outpatient monitoring to confirm efficacy or to identify complications. For example, some drugs, such as warfarin, require periodic laboratory studies whereas other drugs, such as propylthiouracil, which can cause a fatal granulocytopenia, mandate that the patient self-monitor for symptoms of fever or sore throat.

It is imperative that patients are given appropriate discharge instructions about their medications, including information about the purpose of each drug, the nature of any indicated drug monitoring, and harmful side effects associated with the use of each drug. This is particularly important if a medication is dispensed directly to a patient by ED staff. Ideally, medication information given to patients is clearly printed and written at an appropriate level of comprehension (Box 5).

Box 5. Systems interventions at the monitoring stage of drug ordering and delivery

Always monitor the patient for an appropriate time period in the ED following administration of medications for signs of an adverse drug reaction and/or toxicity.

Be alert to the adverse effects profile of each prescribed medication and monitor for those side effects appropriately.

Clearly inform ED patients of all potentially serious adverse drug effects that mandate return to the ED.

Provide detailed yet simple to understand written instructions to all ED patients about their medications' purpose, proper mode of administration, and side effects profile.

Inform all ED patients of the importance of any necessary monitoring tests (eg, protime/international normalized ratio (INR), electrolytes, renal or liver function tests, drug levels) in clear, easy to understand written instructions.

Arrange for appropriate follow-up to insure that proper monitoring is performed.

To the extent possible, communicate with the patient's primary care physician regarding changes you make in the patient's drug regimen.

Discussion

Medication errors that lead to adverse events require full disclosure to the patient's treating physician and to the patient. Hospitals should implement a confidential system for reporting all medication errors as part of their quality assurance programs.[7] Each medication error should be viewed as a valuable learning exercise on the road to a zero-defects system, and hospital management should avoid taking punitive action against individuals involved in medication errors. Punitive action discourages reporting of medication errors and many valuable learning opportunities are thereby lost. In many cases, the complications arising from an adverse drug event require timely and specific interventions and full disclosure is essential to the patient's recovery. There should be an institutional bias in favor of preventing future errors rather than punishing past ones.[8] Patients must know about the adverse drug events they experience to assist their subsequently treating health providers with future therapeutic decisions. Finally, details pertaining to medication errors must be clearly documented in the patient's medical record.

The future is now

Analysis of the many potential vulnerabilities inherent in the continuum of drug prescribing and delivery has resulted in the development of several effective systems interventions that can reduce or eliminate medication errors, including newly developed information technology, utilization of a ward-based clinical pharmacist, and standardized bar coding.

Information technology

The electronic medical record is a major advance toward the elimination of medication errors and reduction of adverse drug events. By recording the patient's pertinent medical history, medication and allergy history, and copies of prior EKGs, X rays, and recent laboratory results, the electronic medical record can provide the EP and nurse with immediate on-line access to vital patient information. In addition, changes in drug regimen

[7] There are two ways to anonymously report medication errors: USP Practitioners' Reporting Network at 800-233-7767, Web address: http://www.usp.org and MedWatch FDA at 800-FDA-1088 (fax, 800-FDA-0178; Web address, www.fda.gov/medwatch/report/hcp.htm).

[8] "Root cause analysis" is a process for identifying the basic or causal factors that underlie variation in performance, including the occurrence or possible occurrence of a "sentinel event." A root cause analysis focuses primarily on systems and processes and identifies potential improvements in processes or systems that would tend to decrease the likelihood of such events in the future, or determines after analysis that no such improvement opportunities exist. See, for example, http://www.jcaho.org/sentinel/se_form.html.

implemented by the EP can be recorded instantly in the electronic record, along with documentation of a patient's response to a particular medication, including an adverse drug event. Many current information technology systems provide access to invaluable drug information that facilitates cross-referencing of pertinent patient data (eg, medical history, renal and hepatic function, weight, current drug regimen) with the pharmacologic characteristics and safety profile of the drug being prescribed. Computerized physician order entry can automatically match a physician's order to a patient's weight, age, renal function, or medical history; identify possible drug-drug interactions based on the patient's medication list; prevent allergic reactions; and prompt the physician or nurse to initiate any appropriate monitoring measures necessary for a particular drug [32,33]. Many clinicians now use personal digital assistants, or PDAs, in conjunction with computerized physician order entry systems to reduce the incidence of medication-prescribing errors [34].

The electronic medical record can also provide for prescriptions via e-mail directly to a hospital or outpatient pharmacist. E-mail prescriptions eliminate medication errors caused by lost prescriptions and bad penmanship.

Ward-based clinical pharmacists

Ward-based clinical pharmacists have proved to be an invaluable resource to neonatal, surgical, and medical intensive care units for years, and are particularly effective in preventing adverse drug events caused by dosing and administration errors. In at least one study, ward-based clinical pharmacists were credited with a 94% reduction of potential adverse drug events [32]. Economic constraints have generally precluded the incorporation of ED-based clinical pharmacists, but because the enormous economic burden associated with adverse drug events, it may be more cost effective to use the high-level expertise of an in-house clinical pharmacist. This is fertile territory for future research.

Standardized drug bar codes

Standardized drug bar codes can prevent medication errors by ensuring that the right medication is pulled off the shelf and administered to the right patient. Inadvertent selection and administration of "sound a like" drugs or of drugs with similar packaging may result in the administration of the wrong medication to the wrong patient. Scannable bar codes on all medication packages, patient's wristband, and nurse's ID badge can help guarantee that the right drug is administered to the right patient in the right dose. At a minimum, uniform bar codes should include the National Drug Code, the lot number, and the expiration date. Additional items of information that may be contained in a bar-coding system include a drug's side effects, drug-drug interactions, look-alike drug names, laboratory tests suggesting that the dosage should be adjusted, and the patient's allergy and medication history.

The FDA is currently considering making prescription drug bar codes mandatory at the drug manufacturing stage, and it is likely that all drug manufacturers will be required to create a drug bar code on all medications within the next year. Abbot Pharmaceuticals will voluntarily begin creating drug bar codes on all of its prescription drug products in 2003.

Summary

Adverse drug events caused by medication errors represent a common cause of patient injury in the practice of medicine. Many medication errors are preventable and hence particularly tragic when they occur, often with serious consequences.

The enormous increase in the number of available drugs on the market makes it all but impossible for physicians, nurses, and pharmacists to possess the knowledge base necessary for fail-safe medication practice. Indeed, the greatest single systemic factor associated with medication errors is a deficiency in the knowledge requisite to the safe use of drugs. It is vital that physicians, nurses, and pharmacists have at their immediate disposal up-to-date drug references. Patients presenting for care in EDs are usually unfamiliar to their EPs and nurses, and the unique patient factors affecting medication response and toxicity are obscured. An appropriate history, physical examination, and diagnostic workup will assist EPs, nurses, and pharmacists in selecting the safest and most optimum therapeutic regimen for each patient. EDs deliver care "24/7" and are open when valuable information resources, such as hospital pharmacists and previously treating physicians, may not be available for consultation. A systems approach to the complex problem of medication errors will help emergency clinicians eliminate preventable adverse drug events and achieve a goal of a zero-defects system, in which medication errors are a thing of the past. New developments in information technology and the advent of electronic medical records with computerized physician order entry, ward-based clinical pharmacists, and standardized bar codes promise substantial reductions in the incidence of medication errors and adverse drug events. ED patients expect and deserve nothing less than the safest possible emergency medicine service.

Acknowledgments

The author gratefully acknowledges the assistance of Richard A. Moore, PharmD, Pharmacotherapy Coordinator, Pharmacy Services, University of Missouri Healthcare, who read the manuscript and offered invaluable suggestions.

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