

A SYSTEMS APPROACH TO REDUCING ERRORS IN INSULIN THERAPY IN THE INPATIENT SETTING

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ABSTRACT

Objective: To highlight the importance of insulin-related medical errors in causing poor outcomes in a hospital setting and to propose a systems approach for improvement.

Results: Evidence reported in the medical literature has identified insulin therapy errors as a large and clinically important problem. Insulin has been labeled as one of the top five “high-risk medications” in the inpatient setting. Although insulin therapy can be lifesaving in the hospital setting, it can be life-threatening if used inappropriately. Widespread major systemic problems, such as heavy patient loads for physicians and nurses, absence of backup checks in critical areas, defective communication and coordination, illegible handwriting, and unawareness of the importance of blood glucose control, create obstacles to appropriate and safe care of patients receiving insulin in the hospital. With thorough analysis of the setting, additional training, collective establishment of goals focused on patient safety, insertion of backup checks in areas susceptible to errors, encouragement of sharing of key clinical information, and, where possible, implementation of electronic medical records, systemic and knowledge-based problems will be minimized and outcomes will improve in insulin-treated hospitalized patients.

Conclusion: Analysis and redesign of systems to develop a “culture of safety” will ultimately reduce insulin-related medical errors, provide a safe inpatient environment, and yield better outcomes. (*Endocr Pract.* 2004;10[Suppl 2]:100-108)

Abbreviations:

ICU = intensive-care unit; IOM = Institute of Medicine; JCAHO = Joint Commission on Accreditation of Healthcare Organizations

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INTRODUCTION

Although the literature documenting medical errors in diabetes care is sparse, sufficient evidence is available in the published literature to identify insulin therapy errors as a large and clinically important problem. The Institute of Medicine (IOM) report entitled “To Err Is Human” (1) identified medical errors as one of the leading causes of death in the United States. The IOM estimated that 98,000 persons die each year as a result of preventable medical errors. Although the methods used in arriving at that number have engendered considerable controversy, the number of people dying as a result of medical errors has been generally agreed to be large and unacceptable.

Drug-related medical errors are one of the leading causes of patient injury. Published data by Leape et al (2) support this observation. Insulin is one of the most complex and powerful agents in our pharmacy armamentarium. In fact, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) considers insulin to be one of the top five “high-risk medications” in the inpatient setting (3). These five medications account for about a third of all major drug-related, injurious, inpatient medical errors.

Personal data confirm and extend the observation of JCAHO on the potential dangers of insulin therapy. In 1997, my colleagues and I (4) published data on the use of intensive and comprehensive therapy to improve clinically significant diabetes outcomes. In a subsequent analysis of our data, first reported in 1999 (5), we delineated the frequency of medical errors and their adverse effect on diabetes outcomes. We found that insulin-related errors in both the inpatient and the outpatient setting were common and caused excessive morbidity, complications, disability, and even death.

The data on inpatient events were particularly striking. In our analysis, we found that 33% of the medical errors that caused death within 48 hours of the error involved insulin therapy and administration in the care of a hospitalized patient. Our findings highlight the potential lethality of errors in insulin therapy and their importance in causing poor outcomes in a hospital setting.

ANALYSIS OF MEDICAL ERRORS

During the past 20 years, a gradual paradigm shift has evolved in our understanding of medical errors. Although the current malpractice law focuses on the individual health provider as the focus of accountability (in retrospect) for any injury to the patient, a more modern and scientific analysis points in a different direction. In complex systems, it is apparent that catastrophic errors often have very complicated roots involving multiple individuals. In fact, the design of the system may, in itself, have latent flaws that may make human error likely and, at times, even predictable (Fig. 1).

In numerous industries—from aviation to nuclear safety—it has become clear that improvement in the safety of the system and the development of a “culture of safety” may depend more on an analysis of the system and a redesign than on a focus aimed at an individual who may have made the most visible error (1,6).

A culture of safety prevails when a system of care establishes a collective point of view among all the members, who then work together as a team to protect the patient from accidental injury due to a medical error (Fig. 2). Among the many characteristics of such a culture are timely communication of important clinical information and the presence of “backup” checks in more critical settings.

Advances in human factor engineering, as well as in cognitive psychology, have resulted in substantial improvement in safety in many areas. Medicine appears to have been influenced much less by the past 30 years of research into systemic analyses of error reduction and development of a culture of safety. Some systemic factors that may indirectly increase the frequency of medical errors are summarized in Table 1.

TYPES OF MEDICAL ERRORS

Most errors never cause injury but are identified and corrected by a member of the health-care team. A recent study in two hospitals for a 6-month period (7) found that nurses were responsible for intercepting 86% of all medication errors made by physicians, pharmacists, and others involved in providing medications for patients. I suspect, however, that the error rate was actually higher—in light of human propensity for brief lapses and slips that are quickly self-corrected—and that the physicians and pharmacists caught most of the errors themselves. These slips and lapses, the so-called *skill-based errors*, are ubiquitous, and most individuals make them but also readily identify and correct them before an adverse outcome ensues (8).

Rule-based errors are more troublesome. For example, the term “strong but wrong” is used to denote when a rule is applied in an inappropriate situation (for example,

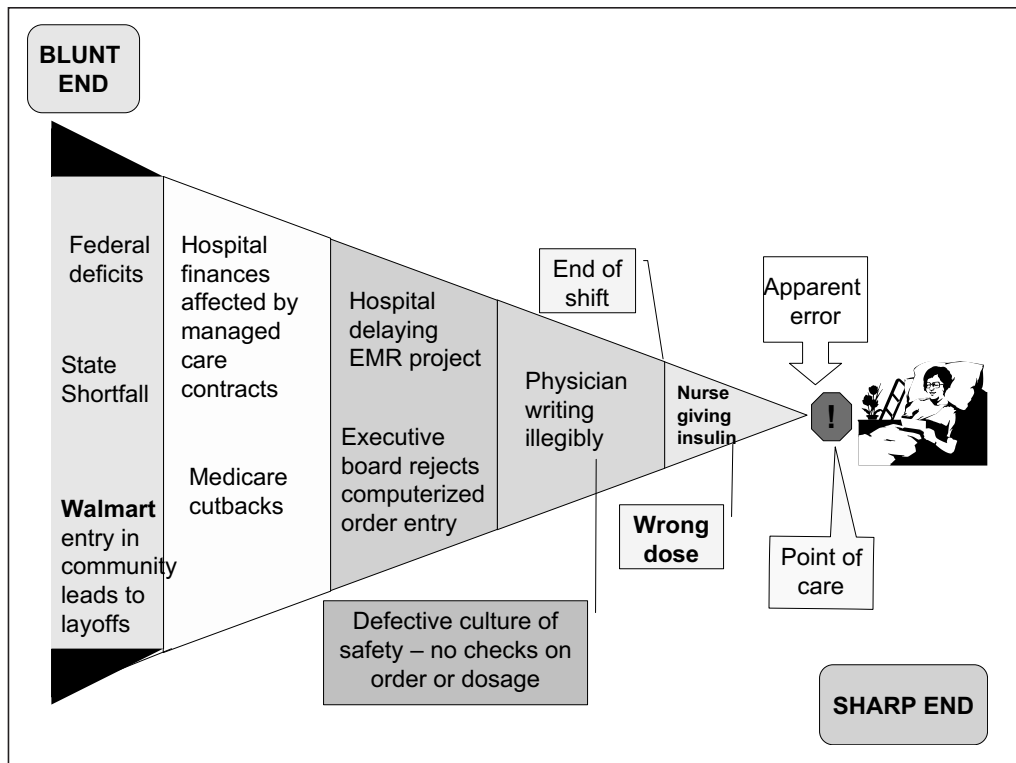


Fig. 1. In a systems perspective of medical errors, numerous factors can be identified as potentially contributing to an adverse result, including an absence of backup checks in vulnerable areas (also see Table 1). *EMR* = electronic medical record.

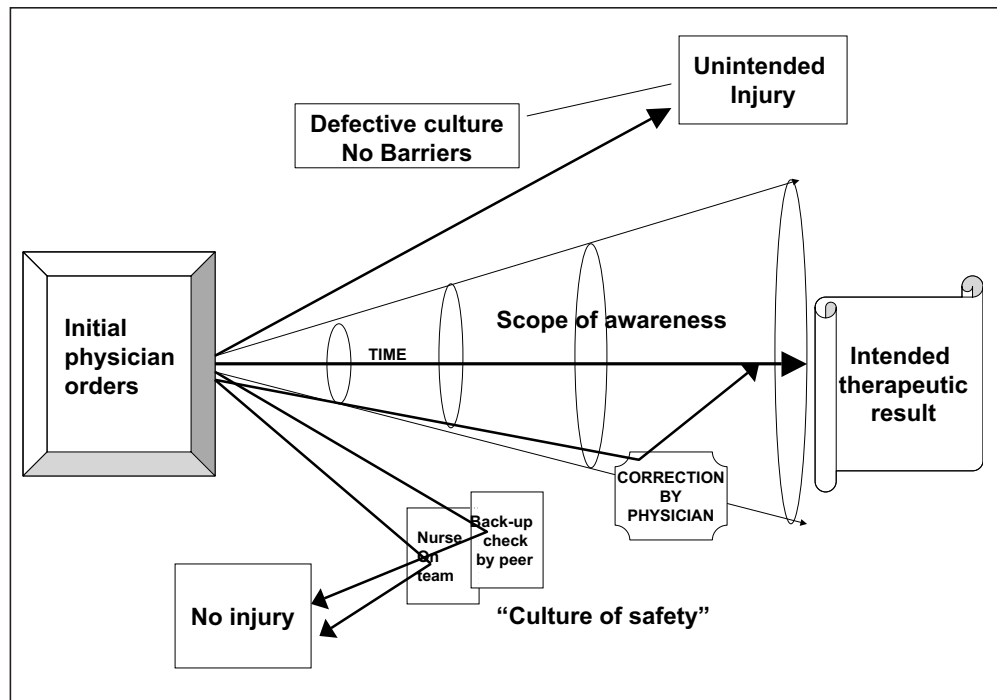


Fig. 2. A "culture of safety" exists in the health-care setting with a wide scope of awareness about patient-specific clinical information and with backup assessments present in critical areas. In such a setting, teamwork protects the patient from accidental injuries attributable to medical errors.

use of a sliding scale for insulin administration in a patient with vascular collapse). *Knowledge-based errors*, such as a failure to diagnose ketoacidosis, are perhaps the most difficult for clinicians to correct on their own because of their lack of familiarity with the subjective and objective findings (Table 2).

In our data on medical errors that led to a catastrophic outcome (5), the most common combination was a diagnostic error by a physician in a setting with a defective culture of safety, in which no one was either aware of or felt empowered to correct the ultimately fatal error (Fig. 3). Lack of communication regarding critical issues in patient care is one of the most important systemic defects of many American health-care systems (9). Moreover, patient-specific clinical information often is not readily accessible throughout the system of care, particularly at the point of care. Compounding these deficiencies is the existence of many semiautonomous units in the inpatient setting. The establishment of "territorial domains" often results in fragmented communications among the key health-care providers, to the detriment of patient care.

Errors in Inpatient Insulin Therapy

Hyperglycemia

Abundant data now show the increased risk to hospitalized patients from hyperglycemia. One report correlates the presence of hyperglycemia on admission and an increased risk of a poor outcome (10). The work of Van den Berghe et al (11,12) clearly shows the improvement of

clinical outcomes when normoglycemia is achieved. In contrast, with grossly inadequate administration of insulin to patients with hyperglycemia, intrahospital deaths can occur. Earlier, we (5) discussed four such cases in which the error was followed by death within 48 hours. In fact, we are aware of many so-called near misses—examples of potentially lethal levels of hyperglycemia occurring in many community hospital settings. One common scenario is the withholding of insulin from an insulin-dependent patient before a procedure or surgical intervention and the subsequent failure by the physician to resume the insulin therapy. In this setting, severe hyperglycemia or even ketoacidosis results.

Another useful activity is to analyze "latent" errors (8,13), which are not clearly errors that injure patients; rather, they are decisions that increase the probability that a serious event will escape early detection, when it can be more easily corrected. A striking example is the issue of monitoring of blood glucose levels. From a safety perspective, glucose monitoring can be thought of as a "safety net" because it will warn the health-care provider of deviations in glucose levels from the safe range. In this sense, it is analogous in value to an oximeter in an intensive-care unit (ICU).

In this view, a common latent physician error would be inappropriately infrequent bedside monitoring of blood glucose levels. Curiously, such a decision is often justified as a patient advocacy position—for example, "to avoid causing pain to the patient." In fact, however, the needed frequency of glucose monitoring should be a clinical deci-

Table 1
Some Systemic Factors That Potentially May Indirectly Increase Frequency of Medical Errors

Decreased financial resources

Governmental cutbacks

Medicare

Medicaid

Decrease in community resources

Loss of industry and jobs

Philanthropic losses because of value of investments and competition for dollars

Liability issues

Decreased access to care—for example, malpractice crisis

Increased cost of providing services

Decreased communications

Decreased safety improvement efforts

*Lack of “culture of safety”**

Decreased resources

Inadequate planning and implementation

Low priority in assessment of leaders

Physician and nurse overload

Hierarchical and professional issues

*See text for further details.

sion based on the evidence obtained about both the degree of variability of patient glucose levels and the degree of the patient's sensitivity to insulin. Another factor that should be considered in the overall equation is the sum total of the therapeutic maneuvers that will tend to increase or decrease the patient's glucose levels, including the amount and type of insulin and the route of administration. Rapidly changing clinical settings may necessitate very frequent monitoring, in order to facilitate prompt correction of any deviation of blood glucose concentrations from the expected range.

Less experienced physicians often seem to have an excessive fear of causing hypoglycemia in a patient in a critical-care setting and an underappreciation of the dangers imposed by hyperglycemia. Moreover, patients in a critical-care setting, in general, are more insulin resistant than usual, and their insulin requirements may be higher even though their oral intake may be less. The error of undertreating hyperglycemia may be compounded by defective communication among the physicians and nurses, so that rapidly changing blood glucose levels are not treated appropriately. In addition, the physician may be unaware of the risks to the patient from hyperglycemia in the ICU setting and in patients with cerebrovascular accidents, myocardial ischemia, sepsis, or other conditions in which normoglycemia has been shown to be of benefit.

The analysis of the correct amount of insulin to be administered is not a trivial task. The correct analysis of the initial amount of insulin needed by the patient often requires a relatively high degree of skill, and this expert assessment will need frequent revision as medications that may change the computation, such as corticosteroids, β agonists, and parenteral nutrition (particularly lipid solutions), are added or withdrawn during the care of the patient in the ICU.

Frequently, the physician who may be most knowledgeable about the optimal methods of administration of insulin (the endocrinologist) is not a member of the team caring for a critically ill inpatient. In general, a sophisticated health-care team should include the most expert and experienced physician in the specific area applicable to strategic management of a patient in the critical-care setting.

Hypoglycemia and Administration of Insulin

Although hypoglycemia seems to be a less frequent contributor to hospital mortality and severe morbidity in comparison with hyperglycemia, it is a common condition in an inpatient setting and has many underlying causes. Comorbid conditions are particularly important, and among the reported factors that considerably increase the possibility for hypoglycemia are advanced age, decreased

Table 2
Taxonomy of Medical Errors: Individual Error Types

Skill-based errors

- Routine automatic actions (strong but wrong), often due to inattention
- Slips (forgetting)
- Lapses (forgetting)
- Omission after an interruption
- Perceptual confusion
- Willful violations (deliberate)

Rule-based errors

- Strong but wrong—misapplication of good rule or application of bad rule
- Slips
- Lapses

Knowledge-based errors

- Mistake in diagnosis
- Therapeutic errors
 - Overconfidence
 - Unwarranted selectivity
 - Similarity matching
 - Rule of matching
- Fixation errors
 - This and only this
 - Everything is okay
- Faulty prediction of future

Data from Reason (8).

oral intake, chronic renal failure, liver disease, β -adrenergic blocking agents (14-16), and, to a lesser degree, drug interactions between a wide variety of medications and insulin.

Hypoglycemia is a commonplace occurrence in many hospital settings because of a lack of coordination between the timing of insulin injections and the food service. In many hospitals, there is little connection between the order to administer insulin, the time the dose is actually administered by the nurse, and the timing of the food delivery from the kitchen. Furthermore, despite the fact that insulin requirements may need to be changed because of alterations in other medications and oral or parenteral feedings, adjustments in insulin dose may not be appropriately made, and the result is an unacceptable and (potentially) dangerously high frequency of hypoglycemia in some clinical settings.

The *true* incidence of hypoglycemia in hospital settings is unknown; nevertheless, inappropriate insulin dosing in a setting with sparse blood glucose measurements is

commonplace. When sufficiently frequent glucose monitoring is available, however, hypoglycemia occurs very often. The potential risks for patients for even mild episodes of hypoglycemia are considerable; accidents including falls, nausea, vomiting, and hypertensive responses with accompanying myocardial ischemia are only a few of the potential hazards.

Importantly, no published data have shown that carefully administered insulin infusions are associated with severe hypoglycemia. Although earlier literature (17) had not reported as clear-cut results (perhaps because of the less rigorous insulin infusion protocols), the data from Van den Berghe et al (11,12) clearly address this issue. The incidence of severe hypoglycemia was very low despite the fact that insulin infusions were used and normoglycemia was their target, which they routinely achieved. My colleagues and I, who have had experience with more than 20,000 insulin infusions, have also noted that the incidence of hypoglycemia is very low. We also found that the incidence of hyperglycemia is low, as long

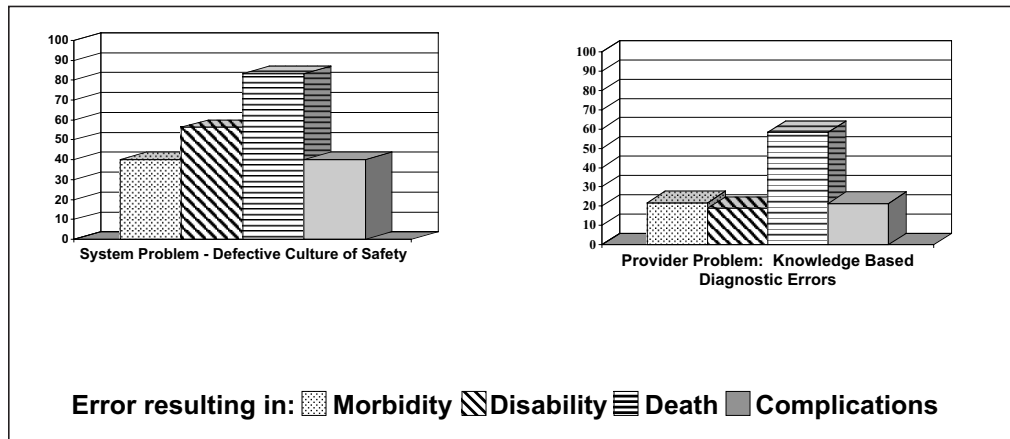


Fig. 3. Factors most frequently associated with death from medical errors. In this analysis, the most common combination was a diagnostic error by a physician in a setting with a defective “culture of safety” (see Figure 2 and text for further details).

as blood glucose monitoring is sufficiently frequent and the clinical team members have been trained to administer insulin infusions and are given clear and appropriate algorithms.

Cognitive Issues Regarding Glucose Control and Insulin Therapy

In many inpatient clinical settings, physicians in specialties that do not normally focus on blood glucose control (for example, anesthesiologists, surgeons, oncologists, and orthopedists) are assigned the sole responsibility for decisions about insulin administration and glucose control. Particularly in a critical-care setting, they are more likely to *undertreat* the patient for hyperglycemia, feeling that the hyperglycemia was not a sufficiently important influence on the clinical outcome to warrant much attention. Moreover, the more severely ill the patient, the more often the issue is ignored. This error is being changed in the practice of surgery, especially cardiac surgery, and in cardiology, but further sharing of information between the specialties will be needed to prevent poorer outcomes from occurring. With the recent data from Van den Berghe et al (12) and many other investigators, the scientific evidence supports the importance of maintenance of normoglycemia in critical-care settings. Unfortunately, the translation of the scientific evidence into behavioral changes of physicians at the bedside currently remains, at best, problematic and uncertain.

Lack of a Culture of Safety

A recent IOM report (7) highlights the current work environment of nurses as a threat to patient safety. This report points out that most hospitals fail to provide a culture of safety (see Fig. 2) to support the central role of nursing care. Because 34% of the medication errors in the hospital setting are made by the nurses alone (7), and almost all the insulin given in the hospital is administered either directly or controlled (insulin infusions) by them,

the fact that the work environment of nurses is unsafe is a major problem.

The fact that nurses are overworked and, with respect to insulin therapy and administration, undertrained is not the only reason why the system of care involving insulin administration in the hospital setting often can be “an accident waiting to happen.” Few hospitals have any training program whereby nurses can gain expertise in diabetes care. Inpatient diabetes units have essentially disappeared from the hospital setting (18). Likewise, in-service education has become nonexistent for many of the essential participants in the provision of insulin therapy in the inpatient setting, including physicians, nurses, pharmacy technicians, food service employees, surgical technicians, and even receptionists in radiology waiting rooms. As a result, few of these individuals understand what would be helpful in the care of the patient receiving insulin therapy in the hospital. Even the intellectual resources of clinical pharmacists and endocrinologists are unlikely to be available to the inpatient units when their counsel may be most needed.

Communication

The order to administer insulin to a patient is most often given orally or handwritten into the medical record. Consequently, the nurses may often initiate their response to the physician’s order for one of the most dangerous medications with an ambiguous or nearly indecipherable note in hand, without the benefit of a clearly structured order. Rarely is a computerized order entry for administration of insulin used, a method of proven value in patient safety (19). Also seldom available to the nurses are structured, preprinted orders for which the staff has provided in-service training for implementation. The higher the complexity of the insulin orders, the more likely it is that ambiguity or lack of clarity will take its toll in patient injury.

Patient Communication

Too often, decisions about insulin administration are made by rote, without first obtaining input from the patient. The patient's appetite or degree of nausea may be an important factor in determining the dose or route of insulin administration. In addition, the patients and their families or friends, if they are educated about the plan of insulin therapy, can help ensure that problems with either food delivery or timing of insulin administration are either minimized or identified. Moreover, care should be centered on the patient (20); thus, the patient should be involved as much as possible.

Part of the communication problem is the paper medical record itself (21). Most hospitals do not have electronic medical records; accordingly, many of the notes of physicians and nurses are indecipherable and indefinite. Moreover, with less expert individuals making major decisions, the importance of communication of key items of clinical data may not be understood. For example, a worsening serum creatinine concentration may be unknown to those who order the insulin doses; thus, an erroneously excessive dose may be prescribed without knowledge of the change in renal function.

"Handoffs"

Because the physician who dismisses the patient from the hospital (often the physician on call or hospitalist) may be unaware of the prehospital care of the patient or even of the earlier course in the hospital, the dismissal orders may be incomplete or inaccurate. Furthermore, in the hospital setting, the handoffs from one physician to another are often done hurriedly and without communication of complete details. The late Dr. John Eisenberg, the past director of the Agency for Healthcare Research and Quality (9), identified handoffs as one of the critical areas where failure to provide adequate transmission of information can lead to patient injury.

SYSTEMS APPROACHES TO IMPROVED INPATIENT INSULIN THERAPY

Nurses need more training regarding insulin therapy than they now receive (7). Hospitals and the physicians who staff them should provide nurses with standards for insulin administration that would enable nurses to do their jobs better. Computerized physician order entry should be added, or preprinted, approved, unambiguous standard order sheets for insulin administration should be used. Use of only relatively few order sets for insulin administration will reduce implementation errors. Therefore, each physician cannot have a personalized method of insulin administration; instead, all staff physicians should agree on use of a common set or sets of orders for insulin administration.

Errors that are due to name confusion or confusion because of similar appearance are the cause of many serious events in hospital settings. For example, the use of

abbreviations, such as "U" for units, should be forbidden because of the potential for confusion (9). Wherever possible, insulin bottles should be clearly labeled, specified for a given patient, and not stored near other similar-appearing bottles such as multidose heparin vials. These precautions will help avoid a catastrophic error, such as that described by Bates (20). Clinical pharmacists and hospital pharmacists, working together with endocrinologists, should have a more central role in both education and troubleshooting regarding insulin administration on the inpatient units (18,19,22). They should also be part of a hospital staff committee that helps focus on safety issues and reports to the executive committee of the hospital.

The nurses should receive adequate in-service training and should be provided opportunities for refresher courses. Their supervisors should work together with physician groups to identify nurses who are making errors in care and should encourage improvement in their performance. Their patient ratios and their hours on the job will continue to be issues that cannot be relegated to the hospital administrator and comptroller for decisions (7).

Coordination of the insulin therapy with food service would be an improvement over the current general lack of coordination. The issue of patient safety warrants at least as much attention as the issues of profitability and efficiency. Ideally, an inpatient forum involving the teams that care for hospitalized patients receiving insulin—physicians, nurses, and other related parties—should address problems collectively. Objective scorecards should be maintained for measurement of progress and achievement of goals. Being accountable should not be thought of simply as a retrospective issue but rather as a prospective goal. An example of being accountable in a prospective fashion would be working together to establish goals of patient safety in their system.

Hospitals should establish multidisciplinary committees to evaluate procedures in insulin administration and therapy for safety issues. For instance, protocols for insulin therapy may be unsafe if the nurse received ambiguous orders, and if the orders are unclear at all, misapplication may occur. In addition, if the frequency of glucose monitoring is insufficient for the potential rate of decline of blood glucose levels as a result of the rate of insulin given, then the protocol is unsafe. Does the protocol have fail-safe provisions, such as clarity regarding when the physician should be called? Does the protocol have provisions for changes in insulin requirements or, lacking that, clarity regarding who decides the initial rate of insulin administration for the patient? Is the minimal concentration of insulin in the infusion sufficiently low for the patient's anticipated insulin requirements so that the patient will not be hypoglycemic at the lowest possible insulin delivery level? Will oral intake of calories or interruption of oral intake adversely affect the effectiveness of the protocol? Is the language of the orders clear, and have the orders been field-tested in the hospital before general

use? A rigorous inspection of each of the orders will allow for improvement of some order sets and will provide reassurance that safety issues have been addressed.

The multidisciplinary standing committee that evaluates the insulin infusion protocols should also review the data on the effectiveness and safety of insulin use as well as review the frequency of bedside glucose monitoring and the outcomes. In some hospitals with at least partially automated data sets of laboratory findings, the blood glucose levels can easily be evaluated and collated electronically. This process will aid in troubleshooting for glucose control, and suggestions for optimization can be obtained.

We need to encourage, wherever possible, the use of electronic medical records and the sharing of important clinical data, while following the guidelines established by the Health Insurance Portability and Accountability Act of 1996 (21). When any such guidelines adversely affect patient safety, modification of the guidelines should be pursued. Common standards must be used, in accordance with the emerging guidelines of the National Health Information Infrastructure Project (21). In addition, considerable efforts must be invested in making relevant clinical information available, particular at the point of care. The lead of the British effort of the National Health Service to provide nationwide electronic medical records is laudable.

Endocrinologists need to encourage and develop methods to help educate the physicians caring for hospitalized patients requiring insulin in the use of more modern techniques of insulin administration, both in critical care and in the hospital setting overall. Hospitalists may become much more important in this setting, and close collaboration with these specialists will be important. We also need to help develop more robust systems of analysis and to help create electronic decision support systems in settings where their use is safe and logical. Our specialty society needs to provide additional training and encouragement for endocrinologists, who are usually experts in inpatient insulin therapy, so they can enhance their skills further. They should become part of the multidisciplinary patient care team in their hospitals to help develop or adapt their protocols, educate the team members, and help evaluate the performance of the team in the role of maintenance of euglycemia in more critical settings. We should consider innovative solutions, such as the development of clinical simulators, for the purpose of education of not only endocrinologists but other members of the patient care team as well.

CONCLUSION

In the hospital setting, insulin therapy can be life-saving, but if it is suboptimally provided or monitored, it may instead be life-threatening. At present, widespread major systemic problems are deterrents to good patient care and often create an unsafe environment for hospitalized patients. Rather than being a problem of a careless

physician who unintentionally injures a patient or a nurse who negligently fails to implement clear insulin orders, the most serious problems are almost always more complex, more subtle in their cause, and more stubbornly resistant to improvement than first thought.

Although available evidence, some of which is from personal studies, indicates that far more serious medical errors in insulin therapy occur in the outpatient setting than in the inpatient setting, analysis of the inpatient setting is a good place to begin improvement of this situation. Analysis of medical errors that injure patients is appropriately undergoing a gradual paradigm shift from the current malpractice model, which is punitive with a retrospective view of accountability, to a different method of managing the problems of patient injury, such as analysis and redesign of systems. This paradigm shift, well described in a recent Hastings Center report (23), will allow health-care providers to have open and frank discussions of optimal approaches for correction of the current potentially unsafe environment and, ultimately, to reduce errors and risks in the use of insulin therapy and develop a safe inpatient setting.

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