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ORIGINAL RESEARCH

Evaluation of medication errors via a computerized physician order entry system in an inpatient renal transplant unit

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Background: Medication errors are a prime concern for all in healthcare. As such the use of information technologies in drug prescribing and administration has received considerable attention in recent years, with the hope of improving patient safety. Because of the complexity of drug regimens in renal transplant patients, occurrence of medication errors is inevitable even with a well adopted computerized physician order entering (CPOE) system. Our objective was to quantify medication error type and frequency in an inpatient renal transplant unit.

Methods: Systemic evaluation of all medication errors during an initial 10-day audit and a 28-day follow-up audit in an inpatient renal transplant unit. Each error was concurrently evaluated for potential to result in adverse patient consequences (category), error type and associated medication class.

Results: A total of 103 clinically significant medication errors were detected during the 10-day (43 errors) and 28-day audit (60 errors) time periods. The most common errors were wrong medication dose ordered and wrong time of drug administration. Thirty-six out of 66 prescribing/ordering errors reached the patient.

Conclusions: Even with utilization of computerized physician order entry system in an inpatient renal transplant unit, post-kidney transplant patients are at risk for adverse outcomes due to medication errors. The risk factors may be multifactorial and will require both organizational and technical approaches to resolve.

Keywords: medication errors, CPOE, inpatient, renal transplant patients

Introduction

Medication errors are among the most common medical errors, harming at least 1.5 million people every year and costing an additional US$3.5 billion dollars a year in extra hospitalization costs.[1,2] Dozens of studies conducted worldwide to date provide irrefutable evidence that medical and medication errors occur every day in every healthcare institution. A study by Barker et al performed at 36 hospitals demonstrated that inpatients are probably subjected to about 2 medication errors every day.[3] Medication errors occur under one of the following conditions: omission, wrong dose, wrong dosage form, wrong time, wrong route, unordered drug, deteriorated drug, wrong administration technique, wrong rate of administration, and wrong dose preparation, which can be classified further as prescribing/ordering errors, dispensing errors, and administration errors. Healthcare institutions that use computerized physician order entering (CPOE) systems for medication prescribing and ordering have demonstrated significant reductions in prescribing/ordering errors. Using an internally developed CPOE system, Brigham and Women's Hospital in Boston in 1998 and 1999

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Table 1 Medication errors at the three different medication delivery stages

Medication stages	No. of all errors	No. reached patient
Prescribing/ordering	66	36
Dispensing	13	9
Administration	24	23
Total	103	68

reported an initial 55% reduction in overall medication error rates, with a subsequent 86% reduction in serious medication errors following refinement.[4,5] Similarly, LDS Hospital in Salt Lake City realized a 70% reduction in preventable adverse events upon implementation of CPOE.[6] To our knowledge medication error rates have not been evaluated in an inpatient renal transplant unit.

However, with or without CPOE, patients in specialized units such as an inpatient transplant unit have a significantly high risk for medication error due to the complex medication regimen and specialized skills required to ensure safe and appropriate use of medications in such units. The care of a renal transplant recipient just like medication usage is a multidisciplinary process, which begins with the doctor's prescription, is followed by the review and provision of medications by a pharmacist, and ends with administration of the medication to the patient by a nurse. Inadvertent errors occur if there is a breakdown at any stage in this process. CPOE has generated tremendous interest in the past few years as a key strategy to significantly reduce prescribing and ordering medication errors. The overall goal of this evaluation was to track medication errors encountered in an inpatient renal transplant unit via an in-house CPOE system. To our knowledge assessment of medication errors in an inpatient renal transplant unit where CPOE is used for medication prescribing and ordering has not been done.

Methods

Medication error was defined according to the definition of the National Coordinating Council for Medication Error Reporting and Prevention: "A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient or consumer. Such events may be related to professional practice, health care products, procedures, and systems including prescribing; order communication; product labeling, packaging and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use".

CPOE is a computer application that accepts physician orders electronically rather than a handwritten recording on hospital order sheets, including orders for medications, diagnostic examinations, and other medical treatments. The software programs have the ability to compare the physician's order against key elements of the patient's history, standards for dosing, and potential drug–drug interactions. The CPOE system used at our institution offers "decision support system" type warnings about toxic doses. It also allows for pull down menus indicating dosing and route, online information system with formulary, side effects, and intravenous drug administration guide. During an initial 10-day audit period and a 28-day follow-up period, recipients of kidney allograft followed by the transplant service at Montefiore Medical Center encountered by the Transplant Pharm D were included in this observational review. These time points were randomly selected. Clinical care was not altered for the purposes of this evaluation. Inpatient medication profile in CPOE of encountered patients was prospectively reviewed for medication errors relating to prescribing/ordering, dispensing, and administration. Medication error was documented when the event deviated from the standard in written transplant protocols.

Results

A total of 103 confirmed clinically significant medication errors were identified in 68 kidney transplant recipients. These errors were associated with medications routinely prescribed in kidney transplant recipients. They include antidiabetics, antihypertensives, immunosuppressants, and prophylactic agents for *Pneumocystis carnii* pneumonia and cytomegalovirus. In both the 10-day and 28-day audits, medication errors associated with immunosuppressants were the most common compared with all the other medication classes (Figures 1A and B). Prescribing/ordering errors were errors pertaining to wrong dose, wrong frequency, omission, and duplication of therapy (polypharmacy). Furthermore, wrong drug verified and wrong timing pertained to dispensing and administration errors respectively. From the initial 10-day audit, prescribing/ordering errors were 66% of the 43 medication errors encountered (Figure 2A). Dispensing and administration errors were 19% and 16% respectively. In the follow-up 28-day audit, a similar prescribing/ordering error rate of 57% was identified in the 60 medication errors (Figure 2B). Of the 103 medication errors identified, 68 resulted in a clinical consequence to the patient. None of them caused permanent harm or resulted in death.

Five medication errors were identified as having potential for causing harm, and requiring hospitalization or an increase in length of stay (Figure 3B). The most significant was a patient who inadvertently received induction immunosuppressive therapy with antithymocyte globulin without premedication with acetaminophen, diphenhydramine, and methylprednisolone instead of indicated basiliximab resulting in an anaphylactic reaction. This occurrence was characterized as both prescribing and administering error. The patient was admitted to the surgical intensive care unit from the operating room for observation and was later transferred to the transplant unit 48 hours later. Her follow-up care was uneventful and was maintained on standard immunosuppressive therapy for kidney allograft rejection prophylaxis.

Discussion

Post-kidney transplant patients are at risk for medication errors due to the complex medication regimen required for prevention of rejection, infection, and management of acute illness and chronic disease. Since the broad spectrum of transplant team members includes physicians, nurses, physician assistants, and pharmacists, and with adoption of CPOE, the entire sequence of events in the medication delivery process is represented. A very minimal occurrence of medication errors was anticipated because of established clinical protocols and over a decade of use of CPOE at our medical center. The majority of the medication errors evaluated were prescribing and ordering errors. On average, post-kidney transplant patients are taking 10 other medications in addition to triple/dual combination immunosuppressive medications during any inpatient hospital stay. Besides the immunosuppressive agents, other medications may include 2 or 3 different antihypertensive, antidiabetic, antiviral, and antibiotic agents. Due to the complexity of this regimen, medication errors pertaining to overdose/underdose, omission, and time of administration, frequency, and duplication of therapy

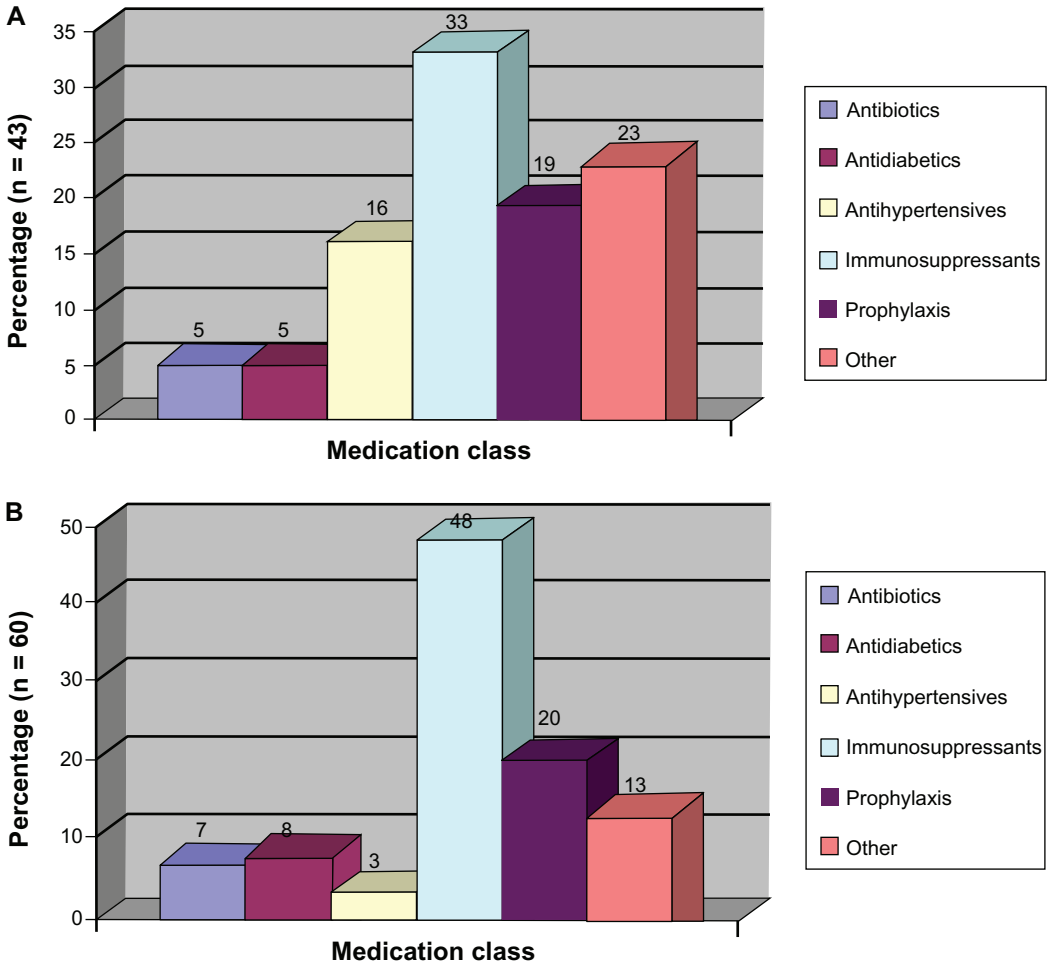


Figure 1 A) Percentage of errors by medication class, 10-day audit. **B**) Percentage of errors by medication class, 28-day audit.

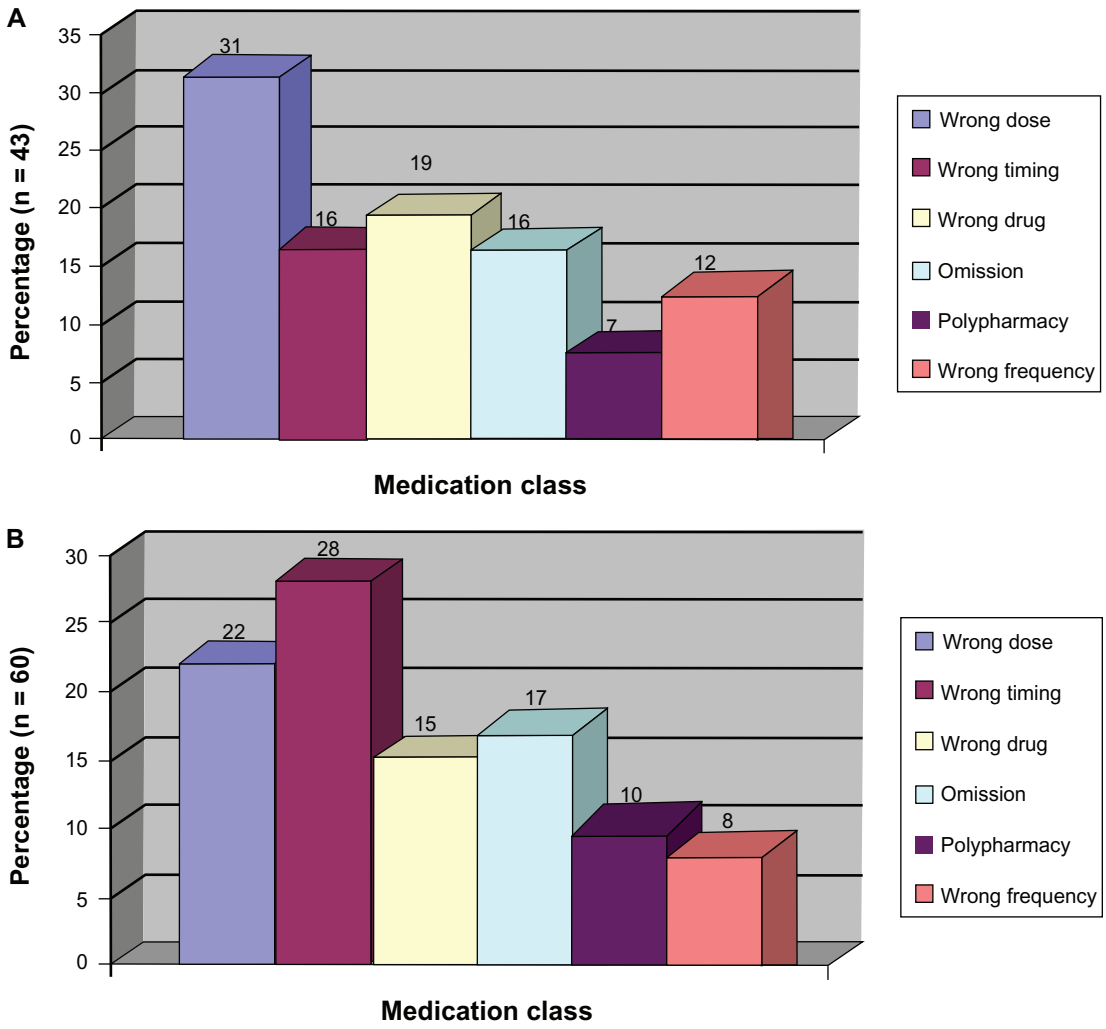
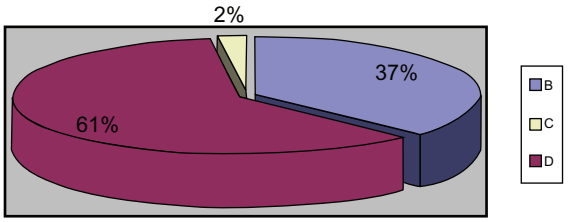


Figure 2 A) Medication errors by type of error, 10-day audit. **B**) Medication errors by type of error, 28-day audit.

are common. We recognized a high incidence of prescribing/ordering errors. Prescribing errors that result in underdosing, or omission of a component of these regimens, may result in treatment failure leading to allograft rejection, and occurrence of cardiovascular and/or infectious complications. Furthermore, prescribing errors that result in overdosing especially with immunosuppressive agents increase the likelihood of adverse effects, as well as poor compliance as a result of adverse effects. Unless the error is recognized, resultant non-compliance may lead to allograft rejection and graft loss.

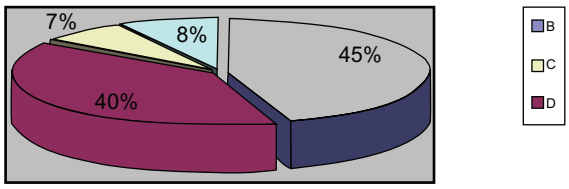
Medication errors occur for many reasons. Knowing and understanding the factors contributing to these errors will assist in implementation of more effective error prevention strategies. In our study, the major contributors to risk of errors were a complex medication regimen and failure to comply with established protocols. Another contributor to the prescribing/ordering errors in this evaluation was the limited knowledge of surgical house staff in managing transplant patients. In previous studies, other contributing factors associated with medication errors included inadequate knowledge and skills, communication failure, lack of accessibility to a convenient database, poor taking of medication history, medications with look-alike or sound-alike names, medication dosage forms, use of abbreviations, poor teamwork, and psychological and environmental stressors such as fatigue and anxiety.[7–25] Besides the complexity of the medication regimen and inadequate knowledge of the house staff in managing transplant patients, unintended consequences including changes in workflow, staff roles, and patient outcomes could have contributed to some of these errors. Some of our limitations include the small sample size, lack of statistical power to detect the effect of the identified adverse events, and lack of a control group. We conclude that clinical protocols and CPOE systems may be inadequate for preventing medication errors in an inpatient renal transplant unit. Based on these findings, we

A



Category A	There was no error, possibility of it being produced
Category B	Error that did not reach the patient; did not cause harm
Category C	Error that reached patient, but it is not likely to cause harm
Category D	Error that reached patient and would have required monitoring and/or intervention to prevent harm
Category E	Error that could have caused temporary harm
Category F	Error that could have caused harm that would require hospitalization or extension of the stay
Category G	Error that could have caused permanent harm
Category H	Error that could have required life support
Category I	Error that could have resulted in death

B



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Category G	Error that could have caused permanent harm
Category H	Error that could have required life support
Category I	Error that could have resulted in death

Figure 3 A) Medication errors by category, 10-day audit. **B**) Medication errors by category, 28-day audit.

developed a transplant unit-specific order-set to lessen the cognitive workload. Further research is needed to assess the impact of CPOE systems in the transplant unit on clinical endpoints and cost-effectiveness.

Disclosure

The authors have no disclosures to make concerning the content of this manuscript.

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