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ORIGINAL ARTICLE

Retrospective Evaluation of the Outcomes of Applying the Renal Dosing Monitoring System in a Medical Center

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Background: The administration interval and dosage of the drugs must be adjusted properly according to patients' renal functions to diminish adverse effects. The computerized monitoring system was established to modify drug dosing for patients with impaired renal function. The Renal Dosing Monitoring (RDM) system was officially operated in April 2007. Only one pharmacist was assigned to assess the reports and to offer the appropriate recommendations in the beginning of operation. The duties have been taken up by the individual pharmacist in each ward since January 2008.
Purpose: A retrospective analysis of the annual outcomes of applying the RDM system was conducted in March 2008. The goal of the study was to assess the outcome of the application of the RDM system.
Method: The computerized RDM system was established and applied for screening patients with renal dysfunction. Recommendations for frequency and dosage adjustments were made according to the renal function evaluated. Ranks of the drugs, physicians' acceptance rates, and time to modify prescriptions were assessed by reviewing the documentation of pharmacy interventions. The savings of medication cost was also calculated.
Results: The physicians accepted 173 (86%) of the 202 recommendations provided by the pharmacists. Most of the recommendations were related to antibiotics, and gentamicin was the most frequently involved drug. The durations for the physicians to modify their prescriptions were as follows: 142 cases were accomplished within 0–1 day (82%), 26 cases were modified within 2–3 days (15%), and five cases were done after more than 3 days (3%). The total saving was US$5377. The physicians declined the pharmacists' recommendations in 29 cases because of serious infectious conditions in 14 cases (48%), the advice of infection specialists was followed in six cases (21%), and the rest of the cases (31%) had other reasons, such as unwilling to change patients' long-term medications.
Conclusion: The study showed that the RDM system could be an aid for pharmacists to evaluate the appropriateness and safety of medication more precisely and effectively.

1. Introduction

The kidney is the major organ for maintaining homeostasis of fluid and electrolytes and, in particular, plays an important role in the disposition of many drugs. Most antibiotics or many drugs are extensively excreted by the kidney, and therefore, they will accumulate in patients with poor renal function and cause profound adverse effects.[1] For example, seizures can be caused by the setting of an overdosing of carbapenems. In addition, dosage of some drugs, such as aminoglycosides, with high renal toxicity, should be properly adjusted based on the renal function of the patients. Therefore, the patients with renal dysfunction must be closely monitored for the drugs that require modifications of dosages or frequencies to prevent adverse effects.[2] However, taking care of more than 100 patients per day is common for a Taiwan inpatient pharmacist. Under the heavy workload, there is a need to implement a computerized system with real-time support for assisting pharmacists to offer appropriate assessment and prevent adverse drug events.

This study was conducted by a retrospective analysis of outcomes of the computerized renal dosing monitoring (RDM) system, to monitor drugs with high renal excretion rate and adverse effects associated with insufficient renal function in a northern medical center in Taiwan. Inpatients using monitored drugs and with high serum creatinine were detected by using this established system. The physicians were suggested to modify dosages or frequencies of the drugs based on the data provided by the system and patients' clinical conditions. The system has been

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operated for more than 1 year. Therefore, an annual evaluation was performed to assess the outcome of the RDM system implementation and to investigate the potentially ameliorable factors of the system.

2. Methods

2.1. Study design and patients

The RDM system has been officially operating since April 2007. In the beginning of the operation, only one pharmacist was assigned to take the responsibility to evaluate patients and to make recommendations on dosage adjustments. The pharmacists in each ward took over the responsibility until January 2008. We only included patients in the general wards in this study. Patients in medical or surgical intensive care units were excluded because they were assessed intensively by critical care pharmacists everyday. On average, each intensive care unit pharmacist took care of only 21 patients per day. However, each inpatient pharmacist in general wards was responsible for around 100 patients daily. The main goal of initiating this system was to efficiently assist pharmacists in selecting patients requiring pharmacy evaluation under limited manpower in general wards.

To evaluate the outcomes of applying the RDM, ranks of the drugs, physicians' acceptance rates, and time to modify prescriptions were analyzed from the documentation of pharmacists' recommendations between April 2007 and March 2008.

2.2. The computerized RDM system

The target patients were selected by the RDM system based on their ages and renal functions. The criteria for inclusion were as follows: (1) patients older than 60 years, with the most recent serum creatinine level of 1.1–6.0 mg/dL; (2) patients aged 41–60 years, with the most recent serum creatinine level of 1.3–6.0 mg/dL; (3) patients 40 years old or younger, with the most recent serum creatinine level of 1.5–6.0 mg/dL; and (4) patients with no serum creatinine level measured for more than 1 month. The system can generate lists of patients who fulfilled one of the aforementioned criteria and using any of the 28 drugs shown in Table 1.[3] The following information was automatically collected by the system: bed numbers, patient names, medical record numbers, ages, genders, drugs used, dosing frequencies, dosage units, starting dates, the most recent serum creatinine levels, and the physicians giving prescriptions. The appropriateness of dosage and frequencies of the medications were evaluated by pharmacists according to *Drug Information Handbook*,[4] *The Sanford Guide To Antimicrobial Therapy*,[5] *Micromedex Healthcare Series 1.0* (Thomson Reuters Healthcare Incorporated), and package inserts of individual drugs. The details of the process are shown in Figure 1.

2.3. Calculation of cost saving in medication expenditure

The cost saving of medication was calculated by multiplying the price difference between the initial and adjusted dosage by the duration of adjusted dosage administered, as demonstrated by the following formula[6]:

$$\text{Medication cost saving} = (\text{initial dosage} - \text{adjusted dosage}) \times \text{price of the drug per unit} \times \text{total days of adjustment}$$

The following example demonstrates the cost saving calculation: vancomycin 500 mg/vial was adjusted from one vial every 12 hours to one vial once daily; hence, one vial was saved everyday. Date of modification initiated was March 21, and date of treatment discontinuation was March 27. If the price of vancomycin was US$6.95 per vial, the saved medication fee was US$48.65 (one vial saved daily × US$6.95 per vial × 7 days' dosing adjustment).

The drugs were not included for calculation in the condition of discontinuation based on the recommendations of pharmacists because the originally intended duration of the treatment was no longer available. The unit cost of drug was estimated from the database of the National Health Insurance drug price in 2008.

Table 1 Drugs monitored by the renal dosing monitoring system and the number of cases recommended by inpatient pharmacists in general wards in a medical center

Classification	Name of drug	Recommended cases, *n* (%)
Antibiotics		
Aminoglycosides	Gentamicin	56 (27.7)
	Amikacin	6 (2.9)
	Isepamicin	2 (0.9)
Glycopeptides	Vancomycin	16 (7.9)
	Teicoplanin	2 (0.9)
Carbapenems	Imipenem	0 (0)
	Meropenem	3 (1.4)
Fluoroquinolones	Ciprofloxacin	1 (0.49)
	Levofloxacin	33 (16.3)
Cephalosporins	Cefmetazole	0 (0)
	Cefuroxime	1 (0.49)
	Ceftazidime	5 (2.4)
	Flomoxef	5 (2.4)
	Cefpirome	18 (8.9)
Antivirus	Ganciclovir	0 (0)
	Acyclovir	0 (0)
Others	Sulfamethoxazole 400 mg, trimethoprim 80 mg	0 (0)
	Amphotericin B	0 (0)
	Fluconazole	4 (1.9)
	Ethambutol	0 (0)
Antidiabetic agent		
Biguanide	Metformin	24 (11.8)
Cardiovascular agents		
Angiotensin-converting enzyme inhibitors	Lisinopril	2 (0.9)
Diuretics	Amiloride 5 mg, hydrochlorothiazide 50 mg	0 (0)
	Trichlormethiazide	4 (1.9)
Others		
H2 blockers	Famotidine	16 (7.9)
	Ranitidine	2 (0.9)
	Cimetidine	0 (0)
Antigout agents	Allopurinol	2 (0.9)

3. Results

3.1. Recommendation acceptance by physicians

A total of 12,057 cases were screened by the computerized monitoring system during the period of analysis. As a result, pharmacists made recommendations to 202 cases, and 173 of the suggestions were accepted by physicians with an acceptance rate of 86% (Figure 2). The reasons for the recommendations being declined by physicians included the following: patients were in severe infectious condition (48%); the doses and frequencies were suggested by the infection specialists (21%); and the other factors (31%) were mainly related to long-term prescriptions; hence, dosage change was deemed unnecessary by physicians' evaluation (Figure 2). The average age of the patients requiring recommendations was 75.5 years, and they comprised 115 males and 87 females. The