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The impact of clinical pharmacist interventions on medication errors management in the postoperative cardiac intensive care unit

Naser Safaie[1], Hanieh Azizi [2], Sajad Khiali[2] Taher Entezari-Maleki[1, 2*]

[1]*Cardiovascular Research Center, Tabriz University of Medical Sciences, Tabriz, Iran*

[2]*Depaatment of clinical Pharmacy, Drug Applied Research Center, Faculty of Pharmacy, Tabriz University of Medical Sciences, Tabriz, Iran*

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*Corresponding author:

Taher Entezari-Maleki, Drug Applied Research Center and Cardiovascular Research Center, Faculty of Pharmacy, Tabriz University of Medical Sciences, Tabriz, Iran

Address: Daneshgah St. Tabriz, Iran, P.O. Box: 51664-14766

E-mail: tentezari@gmail.com, entezarim@tbzmed.ac.ir

Tel & Fax: +98-41-33363317

Abstract

Background: Medication errors (MEs) frequently occur in intensive care unit (ICU) admitted patients. The present study aimed to evaluate the frequency and types of MEs in an open heart surgery heart ICU and clinical pharmacists' role in the management of them.

Methods: This cross-sectional, observational study was performed from October 2016 to March 2017 in the Shahid Madani Heart Center. A clinical pharmacist reviewed patients' files, laboratory data, and physician orders during morning hours. All of the MEs and the clinical pharmacies' recommendations for the management of them were analyzed.

Results: A total of 311 MEs were observed in the medical files of 152 patients. The rate of MEs was 2.04 errors per patient and 0.19 errors per ordered medication. The acceptance rate of MEs was 72.6%. The most type of MEs was 'forgot to order' (75 cases, 24.1%) followed by "wrong frequency" and "adding a drug" in 56 (18%) and 49 (15.8) patients, respectively. Most MEs were insignificant.

Conclusion: MEs occur at different stages of the therapeutic process in the postoperative cardiac intensive care unit, and clinical pharmacists play an essential role in detecting and managing MEs.

Keywords: Medication error, Clinical pharmacist, Drug-related problems, ICU

Introduction

Polypharmacy and improper pharmacotherapy among intensive care unit (ICU) patients could increase the risk of adverse drug reactions secondary to medication errors (MEs), drug-disease interactions, and drug-drug interactions. MEs are defined as a failure in the treatment process that leads to or has the potential to harm the patients. These errors can occur at different treatment stages, such as compounding, preparation, prescribing, transcribing, dispensing, administration,

and monitoring.[1] Based on the Institute of Medicine's hallmark report, in the United States, MEs occur in 2–14% of hospitalized patients with 44,000 to 98,000 annual deaths.[2] Data also reported that MEs are essential causes of iatrogenic morbidity and mortality during hospitalized patients' care. [3,4] The rates of MEs are higher in ICU wards due to complicated situations of patients such as polypharmacy, renal and hepatic dysfunction, and impaired absorption. [5]

During recent years, with the implementation of clinical pharmacy, the pharmacists' role has expanded in the patient care process and reduced MEs. Accordingly, based on the Federal Department of Health in Germany's decision in 2015, all patients taking at least three prescribed medicines can receive a medication plan from a pharmacist or a physician.[6]

Based on the Infective Diseases of Society of America (IDSA), clinical pharmacists are a core member of the multidisciplinary team in treating infective diseases. [7] Several studies have indicated the critical role of clinical pharmacists in reducing prescribing errors. For example, in the Netherlands, a survey conducted by Joanna E Klopotowska et al. implicated that ward participation of a hospital pharmacist reduces prescribing errors and related patient harm at an adult medical and surgical ICU in an academic hospital. [8] A retrospective database review from September 2014 to November 2015 in the USA's ICUs indicated that thromboembolic or infraction-related events mortality and the length of stay were lower in hospitals with clinical pharmacy services than hospitals without this service. [9] According to a controlled interventional study by Nora Kessemeier et al. in an adult 12-bed surgical ICU in a tertiary-care hospital in Germany, clinical pharmacist screening of medical records and discussion with physicians with or without participation in ward round leads to a significant reduction in prescribing errors (both $p < 0.001$). [10]

Despite clinical pharmacists' significant role in multidisciplinary teams and active participation in the USA and the UK treatment process, clinical pharmacy services are not still developed adequately in other countries. Given the harmful effect of MEs on the treatment process, the higher rates of MEs in ICU wards, the critical role of clinical pharmacists in the prevention of MEs, and poorly developed clinical pharmacists' services in the developing countries, this study was performed to assess the prevalence and severity of MEs as well as the influence and effectiveness

of clinical pharmacists in the management of MEs in a postoperative cardiac ICU in a tertiary referral cardiac hospital. [1-12]

Materials and Methods

Study design and setting

This cross-sectional, observational study was carried out from October 2016 to March 2017 in a 24-bed open-heart surgery ICU in Shahid Madani Heart Center (the largest referral hospital for cardiovascular disorders in the northwest of Iran), affiliated to Tabriz University of Medical Sciences, Tabriz, Iran. The numbers of physicians and nurses were 14 and 52, respectively. Patients who underwent open-heart surgery and were admitted to the postoperative cardiac ICU were considered in our study. The attending clinical pharmacist visited all patients who underwent open-heart surgery by three attending cardiac surgeons in the ICU, and drug consultations were given to clinically ill patients with complex conditions such as patients with renal and/or liver dysfunction, patients with multiple drug-regimen and background diseases. Patients with good condition with no MEs were excluded from the study.

Study protocol

During the study period, patients' files, laboratory data, and physician orders were reviewed by a clinical pharmacist during morning hours. Demographic and clinical data of patients as well as detected MEs, and clinical pharmacists' interventions were documented.

The classification of MEs was done based on the definition of the Pharmaceutical Care Network Europe Foundation and the Society of Clinical Pharmacists of Australia. Furthermore, the interventions' clinical significance was assessed based on the Society of Hospital Pharmacy of Australia's guideline via a clinical pharmacist and an internal medicine physician independently.[13,14] Based on The Pharmaceutical Care Network Europe Foundation, prescribing MEs included inappropriate drug, inappropriate dosage form, medication duplication, presence of any contraindication, no clear indication for a drug (unauthorized drug), no drug administration despite obvious indication (omission drug), low or high drug dose or frequency, too short or long treatment duration, drug interactions and electrolyte monitoring. Based on the guideline of the Society of Clinical Pharmacists of Australia, prescribing MEs were including wrong frequency,

wrong time, incorrect drug selection, forgot to order, overdose, underdose, drug discontinuation, management of drug interaction, adding a drug, changing from one to another drug, changing dosage form, wrong route, and electrolyte monitoring.

Study outcome

Detection and management of MEs in postoperative cardiac ICU based on the guidelines of the pharmaceutical Care Network Europe Foundation, and Society of Clinical Pharmacists of Australia

Statistics

Data analysis was performed in SPSS 23.0 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corporation). The Spearman correlation coefficient was used to find out any correlation between the numbers and incidence of MEs, and the study variables included demographic data, drugs and background diseases, medical laboratory data, and habitual history. To explain the relationship between the numbers and incidence of MEs and the study variables, the Linear Regression test was conducted. The Logistic regression model was used to show any relationship between predictor variables and the incidence of MEs. P-values less than 0.05 were considered to be statistically significant level.

Results

A total of 152 patients (41 females and 111 males) with the mean age of 56.8 ± 12.2 years old were evaluated by the clinical pharmacist for detecting MEs in the ICU ward of Shahid Madani hospital. Baseline demographic and clinical data are shown in Table1.

The clinical pharmacist detects 311 MEs among 152 patients and made recommendations for correcting them. No errors were recorded in 27 patients. The number of recommendations for each patient was summarized in Table 2. The mean number of MEs per patient and ordered medication was 2.04 and 0.19, respectively. Data analysis showed that MEs' incidence was significantly higher among patients with a history of heart failure. A total of 161 reported MEs related to 68 patients were not seen by the physicians, 150 recommendations related to 57 patients were seen by physicians, and 109 (72.6%) were accepted. According to The Pharmaceutical Care Network

Europe Foundation and The Society of Clinical Pharmacists of Australia, the most common type of MEs were drug selection and forgetting to order, respectively. Type, frequency, and examples errors in the medicine process were shown in Tables 2, 3, 4, and 5, respectively. The frequency of MEs based on the pharmacological category is reported in Fig1. Most of the MEs happened on antibiotics (20.2%), followed by PPI and H2 blockers, beta-blockers, and statins. The significance of MEs was categorized based on the guideline of the Society of Clinical Pharmacists of Australia. Due to the active presence of a pharmacist in the ICU ward during weekly morning visits, interventions, follow-ups to prevention, and correction of MEs in the early stages, a large number of MEs (289 MEs, 93%) were insignificant (Table6).

Discussion

The present study was carried out to assess clinical pharmacists' role in the ICU admitted patients after open-heart surgery. It is indicated that clinical pharmacists' collaboration with the health care team can improve the treatment outcome by preventing MEs and adverse drug reactions. Our study had some key findings. First, we revealed the prevalence of MEs in different medication stages. Second, we demonstrated that MEs can be interrupted by clinical pharmacists before the patient's harm and can decrease the rate of MEs. Third, this is the first study that was conducted in an open heart surgery heart ICU in Iran. According to The Pharmaceutical Care Network Europe Foundation and The Society of Clinical Pharmacists of Australia, the most common type of MEs were drug selection and forgetting to order, respectively.

It has been shown that having a pharmacist in the ICU improve clinical outcomes such as morbidity and mortality as well as decrease adverse drug events, drug prescribing errors, and costs worldwide. [8-10]

According to an interrupted time series in a tertiary pediatric intensive care unit in the Netherlands, implantation of medication audit and feedback by a clinical pharmacist as part of the multidisciplinary team decrease MEs ($\beta = -.21$; 95% CI, −0.41 to −0.02; $P = .04$). A total of 153 MEs corresponding with 2.27 per 100 prescriptions, and 90 MEs corresponding with 1.71 per 100 prescriptions were observed before and after clinical pharmacist interventions, respectively. [15]Furthermore, a retrospective study was done in a hematology unit of National Taiwan University Hospital to compare the economic impact and number of pharmacist interventions before and after

clinical pharmacist deployment. It is indicated that the benefit-cost ratio increased after clinical pharmacist deployment (0.77 and 3.19). Also, the pharmacist interventions rate in medication orders were 0.34% and 1.87%, before and after clinical pharmacist deployment, respectively (P<0.00001). [16]

Recently, a systematic review and meta-analysis of six studies, including 29 291 hospitalized pediatric patients, showed that direct pharmacist involvement in education, therapeutic drug monitoring, and patient care led to significant decreases in the rate of MEs occurrence (OR 0.27; 95% CI 0.15 to 0.49). [17]

According to a study in a pediatric intensive care unit in Saudi Arabia, MEs types were as follow: wrong dose (2.1%), wrong route (12%), errors in inscriptions (11.4%), wrong frequency (5.4%), drug interactions (9.1%), incorrect drug selection (1.7%) and repetitive drug prescription (1%). These data were gathered through observing 2380 ordered medicines by specialists. Examining 2380 orders demonstrated that the overall error rate was 56 per 100 medication orders. [18] Furthermore, according to the recent systematic review and meta-analysis, dosing errors are the most common MEs in hospitalized pediatric patients [17]. Based on a study by Gharekhani et al. in a nephrology ward, MEs took place in more than 85% of patients. The rate of ME per patient was higher than our study (3.5 vs. 2.04). In contrast, the rate of ME per ordered medication was slightly lower in comparison with our study (.18 vs. .19). Furthermore, they reported the omission drug (26.9%) as the most common ME. [19] These findings are in agreement with the results of our study, but differ from the finding of two studies [20, 21] by Khalili et al. in a 60-bed infectious ward in Emam hospital at Tehran. In the first study, which was carried out from December 2008 to December 2009, numbers (percent) of each type of MEs were as follow: dosing 44 (39.3%), choice 44 (39.3%), use 22 (19.7%), and interaction problems 2 (1.7%). In the second study, which was carried out between September 2010 and September 2011, it is revealed that the most frequent errors were the wrong dose (35.5%). The next more frequent errors were drug omission (24.3%). However, the wrong frequency was the most common type of ME in Vessal et al. study in the nephrology ward. [22] The next more frequent errors were wrong drug selection (19.8%), and the third rank errors occurred due to overdose (12.8%).

Based on a prospective observational study of 681 patients, 221 MEs occurred in 29.22% of patients. Among them, prescribing errors were 82.8%, followed by administration, dispensing, monitoring errors in 82.80%, 10.40%, 3.61%, and 3.16%. [23] Various factors might account for the different rates of MEs in studies such as paper-based prescription systems (instead of computerized systems), setting, classifications, and detection methods. Furthermore, the variations in ME rate could be explained by differences in the study design, setting, ME definitions and classifications, detection method, and source of reporting ME.

In a Chinas study at an ICU of a university hospital, the clinical pharmacist made 232 interventions for 416 admitted patients, which is lower than 311 interventions for 152 patients. The acceptance rate was 87.1% in comparison with 72.6% in our study. [24]The physician acceptance rate of clinical pharmacist intervention in the current study (72.6%) was close to the range reported from European studies, but less than American reports (85%–99%). This can be justified by the fact that despite illustrated advantages in North America and the UK reports, clinical pharmacy services are still poorly developed in Europe. Clinical pharmacy residency programs have been started in Iran since 1994 and similar to Europe. Moreover, clinical pharmacy is a new profession in Iran. Furthermore, in the present study, 161 reported MEs related to 68 patients were not seen by the physicians. [6, 12, 17]

Based on the mentioned study in the pediatric ICU, 17.2% of MEs were related to electrolytes, 13.2% of them were about antibiotics, and 12.9% of errors were related to bronchodilators. Furthermore, 50.2% of errors occurred in the group of injectable drugs. [18] Opposing to Majed Al-Jeraisy's study, in our study, errors were mostly related to antibiotics. Antibiotics prescription is common in ICU settings, so it was expectable that most errors were related to this group. The rest of the errors are mostly detected in PPI and H2 blockers, beta-blockers, and statins.

According to Cortejoso et al. study, 2,307 interventions associated with a ME in 15,282 medical orders for 1,859 patients were recorded. According to a modified version of the scale developed by Overhage et al., 68.1%, 24,8, and 7.2% of MEs were significant, minor significance, and clinically serious, respectively. The importance of MEs was categorized based on the guideline of the Society of Clinical Pharmacists of Australia. Due to the active presence of a pharmacist in the ICU ward during weekly morning visits, interventions, follow-ups to prevention, and correction

of MEs in the early stages, the majority of MEs (93%) were insignificant, and neither major nor life-threatening error was detected during the study. [6, 25]

Limitations

The present study includes some limitations. First, this study was carried out in the postoperative cardiac intensive care unit with a small sample size due to the time and cost limitation. Second, we did not compare our results with patients in that ward. Third, because of indirect costs of nursing services and pharmacist visit for MEs were not established by the hospital administration during the study period, the economic and cost-saving effects of pharmacotherapy interventions in the health system were not evaluated in the present study. Further studies should be conducted to realize how MEs' rate will be changed when guidelines and protocols are put into effect in clinical pharmacists' presence. Our study can be supposed as an opening for future discussions with physicians leading to improve prescription errors in the hospitals.

Conclusion

In line with the previous studies, the present study indicated that MEs occur at different stages of the therapeutic process, and these errors are an integral part of the therapeutic process. The results emphasize the importance of the presence of clinical pharmacists in different departments of the health care centers and provide educational information for them to prevent the occurrence of drug errors.

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Ethical Issues

This study was approved by the Regional Ethics Committee of Tabriz University of Medical Sciences ID: TBZMED.REC.1394.644. The study was done based on the declaration of Helsinki on ethical principles for medical research, including human subjects. [26] The patients' information kept being confidential to the researchers.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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Table 1. Baseline Demographic and Clinical Data of Patients under Study

Demographic /Clinical Data	
Age(year), mean ± SD	56.8 ± 12.2
Sex (female/male), n (%)	41(27%)/ 111(73%)
Weight (kg), mean ± SD	75.6 ± 13.7
Height (cm), mean ± SD	164.7 ± 8.5
BMI (kg/m2), mean ± SD	28.9 ± 11.0
CABG, n (%)	125 (82.2%)
Heart valve surgery patients, n (%)	18 (11.8%)
DM, n (%)	44 (29%)
CHD, n (%)	135 (88.8%)
Hypertension, n (%)	73 (48%)
CHF, n (%)	15 (10%)
Alcohol, n (%)	3 (2%)
Smoking, n (%)	37 (24.3%)
Total number of ordered drugs	1603
Prescribed drugs for each patient, (mean ± SD)	10.5 ± 3.3

BMI indicates body mass index; CABG, coronary artery bypass graft; DM, diabetes mellitus; CHD, coronary heart disease; CHF, congestive heart failure; SD, standard deviation

Table 2. Type and frequency of the medication errors based on the Pharmaceutical care network Europe Foundation. (n = 311)

Type of error	Sub-category	Numbers	Frequency (%)
Drug selection	Inappropriate drug (drug is not the best option in terms of indication)	22	7
	Inappropriate medication duplication	5	1.6
	No drug administration in spite of obvious indication (omission drug)	124	40
	Inappropriate dosage form	34	11
	presence of any contraindication	3	1
	No clear indication for drug (unauthorized drug)	5	1.7
Wrong dose	High doses or excessive intake	66	20.5
	Low dose or frequency less than needed	17	5.4
	Excessive length of treatment	3	1
	Inadequate length of treatment	2	0.7
Drug interaction	Appeared interference	4	1.2
	The potential for interference	8	2.5
Electrolyte monitoring	-	20	6.4

Table 3. Type and frequency of the medication errors based on the Society of Clinical Pharmacists of Australia (n = 311).

Type of ME		Patients (n= 152)	Frequency (%)	Medication errors (n=311)	Frequency (%)
Wrong frequency		33	21.7	56	18
Wrong time		0	0	0	0
Wrong drug selection		2	1.3	2	0.6
Forgot to order		59	38.8	75	24.1
Wrong dose	Over dose	10	6.6	16	5.1
	Under dose	19	12.5	20	6.4
Drug discontinuation		7	4.6	11	3.6
Management of drug interaction		10	6.6	12	3.9
Adding a drug		44	28.9	49	15.8
Changing from one to another drug		22	14.5	22	7
Changing dosage form		27	17.8	28	9
Wrong rout		0	0	0	0
Electrolyte monitoring		15	9.9	20	6.5

Table 6. Frequency of the medication errors based on the clinical significance

clinical significance	Description	frequency	Percent
Insignificant	No harm or injuries	289	93
Minor	Minor injuries, minor treatment required, no increased length of stay or re-admission	17	5.4
Moderate	Major temporary injury, increased length of stay or re-admission, cancelation or delay in planned treatment/procedure	5	1.6
Major	Major permanent injury, increased length of stay or re-admission, morbidity at discharge	0	0
Life-threatening	Death or large financial loss	0	0

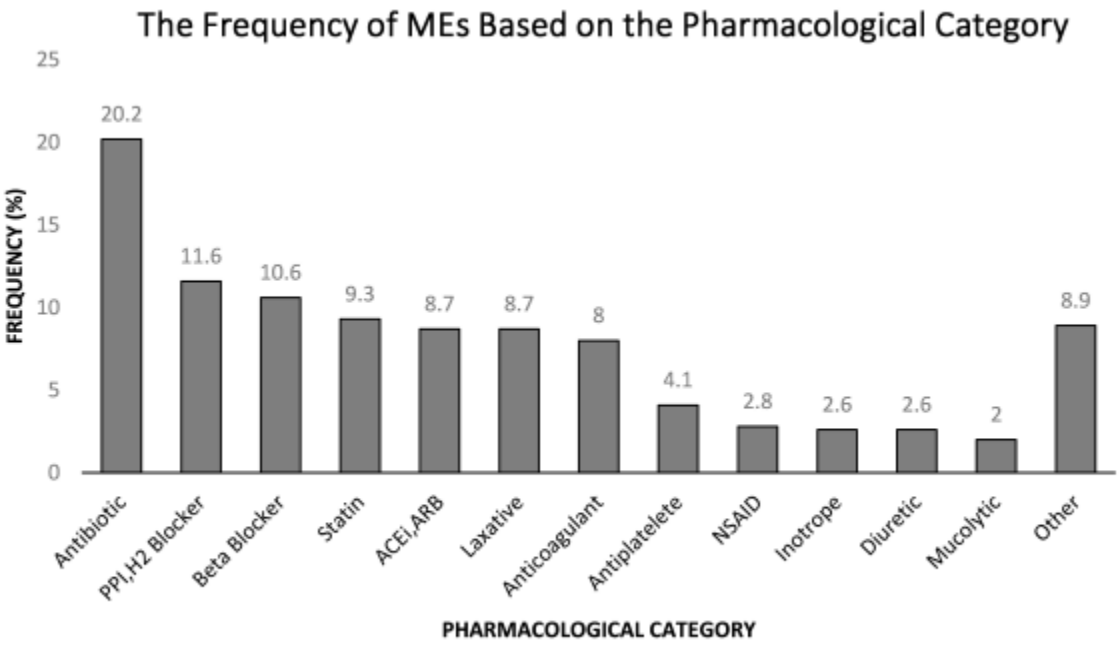

Fig 1. The frequency of medication errors (MEs) based on the pharmacological category PPI, proton pomp inhibitor; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; BB, beta-blocker; NSAIDs, Non-steroidal anti-inflammatory drugs.