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Application of the FASTHUG-MAIDENS mnemonic and evaluation of its impact on a pharmaceutical intervention in an intensive care unit for adults

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Abstract

Objective: To evaluate the impact of the application of the FASTHUG-MAIDENS mnemonic by clinical pharmacists to optimize critically ill patients' pharmacotherapy. **Methods**: Cross-sectional study performed on an adult intensive care unit of an University Hospital, between august and november 2019, where 155 patients were followed by three clinical pharmacists during hospital stay. Patients who stayed less than 24 hours in the hospital or whose stay was during weekends or holidays were excluded. The interventions were performed together with a multidisciplinary team using FASTHUG-MAIDENS, as well as technical analysis of medical prescription and patients' clinical evaluation. The clinical evaluation included analysis of laboratory tests, nursing records and medical prescription, all registered in an institutional spreadsheet. The pharmaceutical interventions were registered in the pharmaceutical section of both physic and electronic medical records, and the data were later evaluated, classified, and submitted to descriptive analytical analysis. **Results**: 1.145 pharmaceutical interventions were performed, with an acceptance rate of 99,3%. The number of pharmaceutical interventions were increased by 104,4% with the application of the FASTHUG-MAIDENS mnemonic, compared to the period before the research. The main interventions performed were: inclusion of a drug (25,2%), exclusion of a drug (17,9%), dose adjustment (12,2%), change of the administration timetable to avoid intravenous incompatibility (11,4%), inclusion of infusion rate (7,3%), dilution adequacy (5,8%), inclusion of reconstitution (3,5%), microbiological culture request (3,4%), drug interaction monitoring (2,7%), adequacy of infusion rate (2,6%) and others (7,4%).Pharmaceutical interventions showed clinical (96,9%), preventive (99,3%) and economic (21,6%) impact. **Conclusion**: The application of the FASTHUG-MAIDENS mnemonic extended the pharmaceutical care to critically ill patients, enabling an accurate evaluation of the pharmacotherapy, clinically impacting critical patient care and reducing errors and adverse drug events.

Keywords: pharmaceutical services; critical care; pharmacists; patient safety; drug-related side effects and adverse reactions; pharmacy service, hospital.

Aplicação do mnemônico FASTHUG-MAIDENS e avaliação do seu impacto nas intervenções farmacêuticas em unidade de cuidados intensivos adulto

Resumo

Objetivo: Avaliar o impacto da aplicação do mnemônico FASTHUG-MAIDENS por farmacêuticos clínicos na otimização da farmacoterapia em pacientes críticos. **Métodos:** Estudo transversal realizado na unidade de cuidados intensivos adulto de um hospital universitário, no período de agosto a novembro de 2019, onde foram acompanhados 155 pacientes por três farmacêuticos clínicos, durante internação hospitalar. Não foram incluídos pacientes com internação inferior a 24h e durante os finais de semana e feriados. As intervenções farmacêuticas foram efetivadas em conjunto com a equipe multidisciplinar a partir da aplicação do FASTHUG-MAIDENS, análise técnica da prescrição médica e avaliação clínica dos pacientes. A avaliação clínica baseou-se nos exames laboratoriais, balanço de enfermagem e prescrição médica, sendo os dados registrados em planilha institucional. As intervenções farmacêuticas foram registradas na evolução farmacêutica no prontuário físico e eletrônico, e, posteriormente, os dados foram avaliados e classificados e submetidos a análise estatística descritiva. **Resultados:** Foram realizadas 1.145 intervenções farmacêuticas, com taxa de aceitação das intervenções de 99,3%. A aplicação do mnemônico FASTHUG-MAIDENS aumentou em 104,4% o número de intervenções farmacêuticas realizadas, comparado com o período anterior a pesquisa. As principais intervenções farmacêuticas foram inclusão de um medicamento (25,2%), exclusão de um medicamento (17,9%), ajuste de dose (12,2%), orientação de aprazamento devido incompatibilidade medicamentosa (11,4%), inclusão de velocidade de infusão (7,3%), adequação de diluição (5,8%), inclusão de reconstituição (3,5%), solicitação de culturas (3,4%), monitoramento de interação medicamentosa (2,7%), adequação de velocidade de infusão (2,6%) e outros (7,4%). As intervenções farmacêuticas realizadas tiveram impacto clínico (96,9%), preventivo (99,3%) e econômico (21,6%). **Conclusão:** A aplicação do mnemônico FASTHUG-MAIDENS ampliou o cuidado farmacêutico ao paciente crítico, possibilitando avaliação de pontos essenciais da farmacoterapia, impactando clinicamente o cuidado ao paciente crítico, reduzindo erros e eventos adversos relacionados a medicamentos.

Palavras-chave: assistência farmacêutica; cuidados críticos; farmacêuticos; segurança do paciente, efeitos colaterais e reações adversas relacionados a medicamentos; serviço de farmácia hospitalar.

Introduction

Resolution 585/2013 of the Federal Pharmacy Council defines that the clinical attributions of the pharmacist aim at health promotion, protection and recovery, in addition to the prevention of diseases and other health problems at all health care levels.[1] The pharmacists working in intensive care are specialists in pharmacotherapy and contribute positively to the care of critically-ill patients, focusing on the clinical assessment and pharmacotherapy of the patients, intervening in the management of antimicrobials, vasoactive drugs, electrolytes, neuromuscular blockers, sedation and analgesia, in addition to the analysis and provision of safe, efficient and rational pharmacotherapy, contributing to a reduction in medication costs.[2] Resolution 675/2019 regulates the attributions of the clinical pharmacists in intensive care units and defines as one of their duties to analyze the patient's prescription regarding the legal and technical aspects, so as to promote the adequate use of medications, nutrients and other health products.[3]

The inclusion of pharmacist specialized in critical care in an intensive care unit results in an increase in the number of pharmaceutical interventions in comparison to a non-specialized pharmaceutical service, improving the quality of the assistance provided to the patient.[4] However, there is no standardized and structured approach to assist pharmacists in intensive care units, which can cause delay in the identification of Drug-Related Problems (DRPs) and therapy optimization.[5]

The FASTHUG mnemonic was developed by intensive care physicians with the aim of ensuring that important aspects of care are addressed in the daily assessment of the patient.[6] However, there are no aspects in this mnemonic that specifically evaluate pharmacotherapy, being then modified to FASTHUG-MAIDENS.[6] FASTHUG-MAIDENS assesses diet, analgesia, sedation, thromboembolism prophylaxis, delirium, stress ulcer prophylaxis, glycemic control, medication reconciliation, antimicrobials, medication indication, medication dose, electrolytes, hematology and laboratory tests, absence of drug interactions, allergies, duplicates or adverse reactions and stop dates, and can assist clinical pharmacists who work in intensive care as a daily checklist for patient evaluation, to guide clinical pharmacists without experience in intensive care, and as a learning tool for residents and interns.[5]

The use of the FASTHUG-MAIDENS tool in conjunction with pharmaceutical interventions can increase ventilator-free time, decrease the time for empirical antibiotic therapy, reduce the duration of central venous catheters, and increase rates of adherence to therapies for the prevention of deep venous thrombosis and prophylaxis for stress ulcers.[7] In addition, it is necessary to ensure open communication between clinical pharmacists and the medical team regarding guidance for the selection, evaluation and monitoring of pharmacotherapy, in order to support the description or reduction of the use of drugs for clinical conditions without strong indications and based on evidence, thus promoting safety and cost reduction in health institutions.[8]

Thus, this study aims to assess the impact of the FASTHUG-MAIDENS mnemonic in pharmaceutical interventions in critically-ill adult patients, using it as a daily clinical checklist to optimize the pharmacotherapy of patients admitted to the Clinical Intensive Care Unit for Adults (*Unidade de Cuidados Intensivos Clínico Adulto*, UCICA) of the University Hospital of the Federal University of Maranhão (*Hospital Universitário-Universidade Federal do Maranhão*, HU-UFMA).

Methods

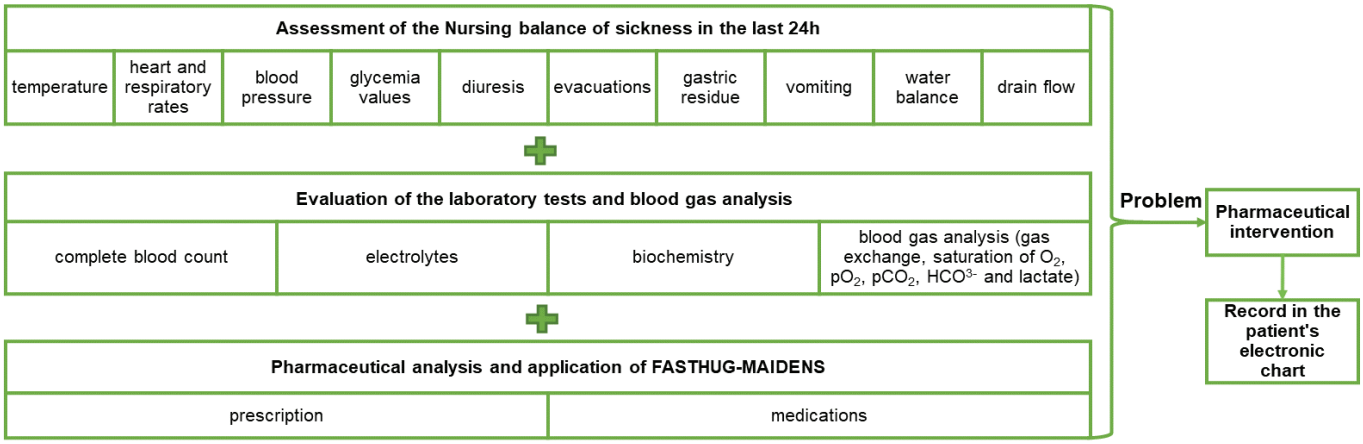
This is a cross-sectional study conducted in the period from August to November 2019 in the UCICA/HU-UFMA by clinical pharmacists. The UCICA/HU-UFMA consists of 10 beds, where mainly surgical patients are served, in addition to clinical patients admitted to the HU-UFMA.

For sample calculation, the number of patients hospitalized (n=195) at UCICA/HU-UFMA between February and May 2019 was considered, sampling error of 5%, 95% confidence level, and a proportion of DRPs in the population of 62%, with a sample of 127 patients estimated. The inclusion criteria were all the patients (clinical and surgical) monitored by clinical pharmacists during the research period. The exclusion criteria were patients with a hospital stay of less than 24 hours and during weekends and holidays, as there was no clinical pharmacy service in these hours.

For daily data collection, a physical spreadsheet was used for each patient, elaborated by the clinical pharmacy unit of HU-UFMA. The clinical evaluation of each patient was carried out by three clinical pharmacists (two specialists in clinical pharmacy and an intensive care resident), on working days, during the morning and afternoon periods, which was based on the analysis and monitoring of vital signs and 24-hour controls (temperature, blood pressure, heart rate, respiratory rate, blood glucose, oxygen saturation, pain, diuresis, gastric waste, vomiting, evacuation, use of blood components and flow of drains and ostomies), in addition to analysis of laboratory tests (complete blood count, biochemistry, coagulogram and blood gas analysis). After collecting the clinical data, the clinical pharmacists applied FASTHUG-MAIDENS and performed a pharmaceutical evaluation of the electronic medical prescriptions, the following being analyzed, respectively: F =Feeding, A = Analgesia, S = Sedation, T = Thromboembolic prophylaxis, H =Hypoactive or hyperactive delirium, U = Stress ulcer prophylaxis, G = Glucose control, M = Medication reconciliation (depending on the patients' clinical and hemodynamic status), A = Antimicrobials, I = Indication of the medications, D = Dose of the medications, E = Electrolytes, hematology and other laboratory tests, N = No drug interactions, allergies, duplications and adverse reactions and S = Stop dates, in addition to the absence, presence or adequacy of the reconstitution, dilution, infusion time and scheduling of the prescribed medications. Figure 1 systematizes the work process conducted daily by the clinical pharmacists on each patient. The identification of the drug interactions and incompatibilities was performed by means of the *Micromedex*® database. The pharmaceutical interventions were made in person as suggestions, during the medical prescription process and *round* with a multidisciplinary team, on working days, in the morning and afternoon shifts, being subsequently recorded in the daily pharmaceutical evolutions of each patient (physical and electronic medical records) and available to all members of the multidisciplinary team.

The interventions recorded in the pharmaceutical evolutions were then identified and transferred daily to an electronic spreadsheet in *Microsoft Access*, developed by the Clinical Pharmacy unit of HU-UFMA, which records and classifies medication errors (MEs) according to what was described by Otero,[9] a retrofit of the work published in 1998 by the National Coordinating Council for Medication Error Reporting and Prevention,[10] being classified as inadequate pharmaceutical presentation, wrong dose, wrong treatment duration, administration error, scheduling error, prescription error, incorrect pharmaceutical form, intravenous incompatibility, potential interaction, incorrect medication,

Figure 1: Flowchart of the clinical activities carried out daily by pharmacists in UCICA/HU-UFMA.



insufficient treatment monitoring, dose or medication omission, reconstitution and dilution prescription absent or inadequate, incorrect or absent administration time and speed. The outcomes of the pharmaceutical interventions were classified according to Hepler & Strand,[11] being categorized into curing illness, stopping or slowing down the disease process, eliminating or reducing symptoms, preventing an event, and preventing a disease or symptom. The interventions that aimed at increasing the effectiveness of pharmacotherapy were considered to have a clinical impact, those that prevented adverse drug events (ADEs) were considered preventive, and the interventions that directly reduced the cost associated with the medications were classified as having an economic impact. The sociodemographic variables were obtained from EPIMED reports referring to the months of the research (August to November 2019), those of interest being the following: gender, age, length and type of hospitalization, being classified into two types, surgical (patients in immediate postoperative period) and clinical (patients from the wards). The pharmaceutical interventions recorded in medical records were categorized as accepted, not accepted with reason and not accepted without reason, being subsequently grouped to identify the percentage of acceptance of pharmaceutical interventions by the multidisciplinary team. All the data obtained from the research were analyzed in Microsoft Excel® and the absolute and relative frequency statistical tests were carried out, as well as calculations of arithmetic means and standard deviations.

To assess the impact of applying the mnemonic FASTHUG-MAIDENS on the pharmaceutical interventions, secondary data from the clinical pharmacy service of UCICA/HU-UFMA, obtained in the period prior to application (April to July 2019) were used. There were no changes in the type of prescription (electronic), of the pharmaceutical and medical team from UCIC/HU-UFMA before and during the research. The UCICA/HU-UFMA medical team consisted of a fixed intensive medical diarist in the morning, fixed medical on-call staff and medical residents who rotated monthly in the areas of clinical medicine, general surgery, anesthesiology, cardiothoracic surgery, gynecology and obstetrics. This research was submitted to the Research Ethics Committee (*Comitê de Ética em Pesquisa*, CEP) of HU-UFMA for its appreciation, and was approved under opinion No. 3,462,857.

Results

From August to November 2019, 221 were admitted at UCICA/HU-UFMA; of this total, 166 were surgical patients (75.1%) and 55, clinical (24.8%), with a mean age of 52.1 years old (SD 18.77), 126 being female (57%) and 95, male (43%). The length of stay in the unit was 4.89 days (SD 6.62). Of the total number of patients admitted during the research period, 155 (70.1%) were followed-up by clinical pharmacists, with the conduction of 1,145 pharmaceutical interventions related to the pharmacotherapy review, FASTHUG-MAIDENS and pharmaceutical analysis of the prescription.

The main information related to the sociodemographic data, type of hospitalization, MEs, pharmaceutical interventions, therapeutic class involved, and objectives of the pharmaceutical interventions are detailed in Table 1. Among the 1,145 pharmaceutical interventions performed, the main ones were inclusion of medications (25.2%), exclusion of medications (18%), dose adjustment (12.2%), incorrect treatment duration (10.9%) and incorrect or absent administration speed (10.2%). A total of 1,119 MEs were found among the total interventions; the main ones were medication omission (24.3%), wrong dose (12.5%) and drug incompatibility (11.4%). The therapeutic class with the highest number of pharmaceutical interventions was that of the antimicrobials, with emphasis on interventions to include reconstitution of lyophilized powder (41; 100%), adequacy of infusion rate (53; 63.1%) and adequacy of dilution (45; 67.1%). Electrolytes were the second therapeutic class with the highest number of interventions, requiring inclusion of therapy (120; 41.5%), exclusion of therapy (43; 20.9%) and adjustment of the infusion rate (8; 26.7%). The main objectives of the pharmaceutical interventions carried out were preventing an event (55.5%), controlling the disease process (14.7%) and preventing a disease (13%).

The distribution of the pharmaceutical interventions carried out according to FASTHUG-MAIDENS, the clinical outcomes and the accepted and unaccepted interventions are described in Table 2. Applying the FASTHUG-MAIDENS mnemonic , 860 pharmaceutical interventions were carried out, the main ones being the identification of drug interactions and incompatibilities (18.8%), evaluation of laboratory tests with indication of initiation, maintenance or interruption of electrolyte replacement (18.7%),

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Table 1. Main pharmaceutical interventions, medication errors, related therapeutic classes, and sociodemographic data of the patients during the period from August to November 2019 in UCICA/HU-UFMA.

Information	Descriptive statistics
Sociodemographic	**N = 221**
Age (years old) - Mean (SD)	52.1 (18.8)
Female gender - n (%)	126 (57.0)
Male gender – n (%)	95 (43.0)
Hospitalization	**N=221 (100.0)**
Length (days) - Mean (SD)	4.9 (6.6)
Type of hospitalization - n (%)	
Surgical patient	166 (75.1)
Clinical patient	55 (24.9)
Medication errors n (%)	**N=1,119 (100.0)**
Omission of medication	278 (24.8)
Incorrect dose	140 (12.5)
Drug incompatibility	130 (11.6)
Incorrect treatment duration	122 (10.9)
Incorrect/Absent administration speed	114 (10.2)
Incorrect medication	80 (7.2)
Inadequate reconstitution and/or dilution	71 (6.3)
Reconstitution and/or dilution absent	64 (5.7)
Insufficient treatment monitoring	49 (4.4)
Potential interaction	38 (3.4)
Others	33(3,0)
Main pharmaceutical interventions and related therapeutic classes n (%)	**N=1,145 (100.0)**
Inclusion of medication	289 (25.2)
Electrolytes	120 (41.5)
Antimicrobials	27 (9.3)
Heparins	21 (7.2)
Exclusion of medication	206 (18.0)
Electrolytes	43 (20.9)
Antimicrobials	40 (19.4)
Dose adjustment	140 (12.2)
Antimicrobials	54 (38.6)
Antiulcerous	29 (20.7)
Scheduling guidance	131 (11.5)
Antiepileptics	29 (22.1)
Diuretics	23 (17.5)
Inclusion of infusion speed	84 (7.3)
Antimicrobials	53 (63.1)
Opioids	11 (13.1)
Adequacy of the dilution	67 (5.8)
Antimicrobials	45 (67.1)
Corticosteroids	3 (4.5)
Inclusion of reconstitution	41 (3.6)
Antimicrobials	41 (100)
Request for cultures	40 (3.5)
Blood cultures	25 (62.5)
Tracheal secretion	11 (27.5)
Monitoring of drug interaction	32 (2.8)
Prokinetics	9 (28.1)
Antimicrobials	5 (15.6)
Adequacy of the infusion speed	**30 (2.6)**
Antimicrobials	21 (70.0)
Electrolytes	8 (26.7)
Others	85 (7.5)
Objective n (%)	**1,145 (100.0)**
To prevent the event	635 (55.5)
To stop or delay the disease process (control)	169 (14.7)
To prevent a disease or a symptom	148 (13.0)
To eliminate or reduce the symptomatology	102 (8.9)
To cure the disease	91 (7.9)

Table 2. Distribution, impact and acceptance rate of the pharmacological interventions according to FASTHUG-MAIDENS during the period from August to November 2019 in UCICA/HU-UFMA.

	Pharmaceutical interventions - mnemonic	All N=860 n (%)	Outcome n (%) N=1,145			Intervention n (%) N=1,145	
			Preventive N=1,138	Clinical N=1,110	Cost reduction N=248	Accepted N=1,137	Not accepted N=8
F	Feeding	23 (2.7)	23 (2.0)	23 (2.0)	-	23 (2.0)	-
A	Analgesia	16 (2.1)	16 (1.4)	16 (1.4)	-	16 (1.4)	-
S	Sedation	8 (0.9)	8 (0.7)	8 (0.7)	-	8 (0.7)	-
T	Thromboembolic prophylaxis	32 (3.7)	32 (2.8)	32 (2.8)	9 (3.6)	32 (2.8)	-
H	Hypoactive/Hyperactive delirium	8 (0.9)	8 (0.7)	8 (0.7)	-	8 (0.7)	-
U	Stress ulcer prophylaxis	10 (1.2)	10 (0.8)	10 (0.9)	6 (2.4)	10 (0.8)	-
G	Glucose control	17 (2.0)	17 (1.5)	17 (1.5)	-	17 (1.5)	-
M	Medication reconciliation	30 (3.5)	30 (2.6)	30 (2.7)	-	30 (2.6)	-
A	Antimicrobials	103 (12.0)	103 (9.0)	103 (9.3)	40 (17.0)	103 (9.0)	-
I	Indication of the medications	100 (11.6)	100 (8.8)	100 (9.0)	48 (19.3)	100 (8.8)	-
D	Dose of the medications	140 (16.27)	140 (12.3)	140 (12.6)	46 (18.5)	140 (12.3)	-
E	Electrolytes, hematology and other laboratory tests	161 (18.7)	161 (14.1)	161 (14.5)	43 (17.3)	161 (14.1)	-
N	No drug interactions, allergies, duplicities or adverse reactions	162 (18.8)	157 (13.8)	129 (11.6)	6 (2.4)	154 (13.5)	8 (0.6)
S	Stop dates	50 (5.81)	50 (4.4)	50 (4.5)	50 (20.1)	50 (4.4)	-

dose adjustment (16.2%), interventions related to the use of antimicrobials (12%) and indication of medications (11.6%). The main outcomes of the interventions were clinical (96.9%), preventive (99.3%) and cost reduction (21.6%), with an acceptance rate of 99.3% by the multidisciplinary team. Eight pharmaceutical interventions with the suggestion of drug suspension, due to contraindicated drug interactions, were not accepted by the multidisciplinary team, although clinical and laboratory signs of the patients were monitored that showed possible clinical manifestations of drug interactions.

The total number of pharmaceutical interventions carried out from April to June, the period prior to the research, was 560 interventions. Considering the interventions from August to November, the period after the research, the total interventions were 1,145, resulting in a 104.4% increase of pharmaceutical interventions after the daily application of FASTHUG-MAIDENS.

Discussion

The application of the FASTHUG-MAIDENS mnemonic increased by 104.4% the number of interventions performed during the research, ratifying the importance of the application of this mnemonic by clinical pharmacists in critically-ill patients. The increase in the number of pharmaceutical interventions after applying the mnemonic is similar to studies that show that daily interventions from a checklist improve several care processes, which can reduce mortality and length of stay in critically-ill patients.[12]

The main therapeutic class in need of pharmaceutical intervention was that of the antimicrobials (364), of which the following stand out: adjustment of sub-therapeutic dose (11.2%), supra-therapeutic (3.5%), beginning, choice, escalation or de-escalation as institutional protocols, infection site and antimicrobial sensitivity test (12.9%), incorrect treatment duration (10.9%), adjustment of infusion time (17.8%), drug interactions (1.3%), drug incompatibilities (10.1%), dilution and reconstitution adjustments (27.4%). In addition to that, 40 culture collections were suggested in patients using antibiotic therapy considering sepsis management protocols and pharmacotherapy monitoring. The importance of these interventions related to the antimicrobial therapy is reinforced by a multicenter study that demonstrated that there is a reduction in the consumption of antibiotics when all prescriptions were reviewed by pharmacists, in addition to when pharmacists acted as antibiotic consultants, highlighting that pharmaceutical interventions have a positive impact in reducing the consumption of antibiotics and that they must be supported.[13] In addition to that, clinical pharmacists play a key role in antimicrobial stewardship, providing impacts on reducing prescription and consumption of antibiotics, reducing the proportion of surgical prophylaxis and increasing the rational use of antimicrobials.[14] In addition, the review and intervention in the microbiology results by the clinical pharmacist positively impact on the treatment of patients, reducing treatment failure rates when interventions are accepted.[15] Our research reinforces that the interventions by clinical pharmacists assist the multidisciplinary team in the optimization of antimicrobial therapy, promoting its rational use.

A total of 140 drug dose adjustments were made, the main ones being antimicrobials (38.6%), antiulcerous (20.7%), electrolyte solutions (6.4%), corticosteroids (5%), analgesics (4.2 %), opioids (4.2%) and others (20.7%). Considering that the antimicrobials were the pharmacological class with the highest number of interventions for dose adjustment, especially sub-therapeutic (29.2%), the impact of these interventions is of utmost importance to define better clinical outcomes in the treatment of infections, in addition to having a direct impact on the reduction of antimicrobial resistance by the microorganisms.

The evaluation of laboratory tests is routine in the daily care of critically-ill patients. Pharmacists must monitor patients in laboratory for adverse drug events (ADEs) that alter electrolytes, hematimetry or other laboratory values, suggesting treatment alternatives with the multidisciplinary team.[6] In addition to that, the pharmacist can recommend starting or discontinuing

replacement of electrolytes, nutrients, minerals, blood and liquid products, if appropriate.[5] During the research, 161 interventions (18.2%) were performed related to the prescription of electrolytes (potassium, magnesium, calcium, sodium and phosphorus), especially regarding initiation (73%), interruption (26.7%) and dose guidance (5.6%), in addition to dilution and infusion rate guidelines. Most electrolytes (potassium chloride, magnesium sulfate and potassium phosphate) are considered potentially dangerous medications (PDMs); these are more likely to cause significant harms to the patients due to failure in the use process.[16] The research shows the importance of the pharmacist in the management of PDMs, being reinforced by studies that demonstrate that the participation of pharmacists are fundamental in the safety and use of PDMs, since they are professionals able to identify and prevent risks related to concentration, physical-chemical compatibility, drug interactions, dose, pharmaceutical form, administration route and times,[17], in addition to the daily clinical assessment of the need to initiate, maintain or interrupt electrolyte replacement.[5]

The interventions performed with indication or interruption of drug therapy were related to laxatives (18%), prokinetics (17%), analgesics (12%), antiemetics (10%), antihypertensives (9%), vitamins (9%) and corticosteroids (6%). 50 interruptions of therapeutic regimens were performed for a longer duration of treatment, mainly with antimicrobials (74%), corticosteroids (12%), albumin (7%) and dexmedetomidine (5%), ensuring rational use, cost reduction and less consumption of medications, especially antimicrobials. These data reinforce that health institutions must use clinical pharmacists as a vital component in a process improvement strategy and in promoting an ideal pharmacotherapy.[18]

In twenty-two patients, 32 serious drug interactions were identified, of which 59.3% were related to the risk of QT prolongation. The main conduct related to this interaction was the intensification of cardiological monitoring, in addition to assessing the risk-benefit of maintaining the related medications. However, four patients evolved with arrhythmia and had medication withdrawals that prolonged the QT interval (domperidone and haloperidol). Two patients had omeprazole replaced by ranitidine due to drug interaction with tacrolimus, evidenced by increased serum tacrolimus levels and risk of toxicity in transplanted patients. The other drug interactions identified resulted in an increased risk of nephrotoxicity, serotonin syndrome, myopathy, rhabdomyolysis and paralytic ileus. The rate of potential drug interactions identified in the sample was 14.1%, similar to that found (18%) in other studies.[19] The main therapeutic classes involved with potential drug interactions were antimicrobials (37.9%), prokinetics (31%), antidepressants (17.2%), sedatives (10.3%) and antiepileptics (6.8%). In another study, sedatives, antithrombotic, antifungal or antibiotic agents (macrolides, fluoroquinolones and cotrimoxazole) are responsible for 75% of the main drug interactions found in intensive care, and the identification of these interactions in intensive care practice is a complex task.[19] Considering the large number of drug interactions in intensive care, due to polypharmacy, intensive care pharmacists reduce the prevalence of drug interactions, providing the intensivists, according to specific situations of each patient, only relevant information on potential drug interactions.[20,21,22]

Drug incompatibilities are physical-chemical reactions that occur *in vitro* between two or more drugs, when the solutions are combined in the same syringe, equipment or vial.[11] The physical reactions can cause visible changes, such as precipitation, color change, consistency, opalescence or gas production.[23] A total of 129 drug incompatibilities were identified in the prescriptions of 33 patients, representing 21.2% of the population. The main classes of related medications were diuretics, anticonvulsants, antimicrobials, corticosteroids and electrolyte solutions. The interventions carried out to manage drug incompatibilities were guidance on the scheduling of injectable medications, washing of access and interruption of infusions, when possible, with the Nursing team, in addition to adjusting the infusion time of these medications.

Medication reconciliation in intensive care is among the interventions that reduce medication errors.[24] Bell *et al*. states that discharge from the ICU is a time when long-term treatment goals must be met and the usual medications must be restarted or reconsidered since, due to the critical condition of the patients at admission, medications for continuous use can be suspended temporarily.[25] Focus on post-ICU care is needed to reduce inappropriate drug discontinuation and unintended continuation of medications prescribed in the ICU after a serious illness.[26] Thirty interventions were conducted in relation to drug reconciliation, especially regarding inclusion (30%) and suspension of antihypertensive drugs (23.3%), suspension of oral hypoglycemic agents (16.6%) and suspension of anxiolytics, antidepressants and antipsychotics (30%) due to the lower level of consciousness.

32 interventions were performed regarding the prophylaxis of venous thromboembolism (VTE), especially regarding the request for initiation (65.6%) and suspension (34.3%) of pharmacological prophylaxis. The 8th Cosensus of the American College of Chest Physicians (ACCP) on prevention of VTE points out that the vast majority of hospitalized patients have at least one risk factor for the development of VTE, and nearly 40% have three or more, and points out that thromboprophylaxis is the initial strategy to improve the safety of hospitalized patients.[27] Farhat *et al.* highlights the need for the evaluation of high-risk clinical and moderate-risk surgical patients, since only 54% and 4% of these patients, respectively, received appropriate chemoprophylaxis, with the need to improve patient safety in relation to VTE in the first few hours of hospitalization.[28] Our results reinforce that the clinical pharmacist has the technical capacity to assess risk factors to suggest the initiation or suspension of pharmacological therapy for thromboprophylaxis, providing safety to the patients, especially considering that heparins are classified as PDMs.

23 interventions related to food were conducted, of which six (26%) were requests for a suspension in the diet to administer medications, due to the interaction of the enteral diet with medications (phenytoin and levothyroxine). The other interventions were the inclusion of a hypertonic glucose solution in fasting patients (21.7%) and inclusion of intravenous vitamin supplementation in patients on parenteral nutrition (52.2%).

In view of the data found and considering the importance of the multidisciplinary team in the care of critically-ill patients, the clinical pharmacist has the technical capacity to assist intensive care physicians in the safe prescription of medications, providing essential information such as reconstitution, dilution, infusion time, dose, dosage, administration route, drug interactions and incompatibilities, in addition to clinical follow-up of patients, especially acting in the management of antimicrobials, PDMs and optimization of pharmacotherapy. The application of the FASTHUG-MAIDENS tool was effective in increasing the number of pharmaceutical interventions in intensive care, providing greater safety in care for critically-ill patients. A recent systematic

review by Lee *et al*. on the role of the pharmacist in intensive care showed a significant reduction in mortality, length of stay in the ICU and the number of preventable and non-preventable events, highlighting the importance of pharmaceutical care in improving the clinical outcomes in critically-ill patients.[29]

Among the limitations of the work is the study design, which makes it impossible to establish the causality between the medication errors found and possible clinical outcomes, in addition to the failure to measure the possible clinical outcomes resulting from the pharmaceutical interventions, requiring the association of this study with others for obtaining more robust results on the application of the FASTHUG-MAIDENS mnemonic by intensive care pharmacists.

Conclusion

The increase in the number of pharmaceutical interventions performed, compared to the total interventions conducted prior to the research, demonstrates the effectiveness of the application of the FASTHUG-MAIDENS mnemonic by intensive care pharmacists in the optimization of pharmacotherapy for critically-ill patients.

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Conflicts of interest statement

The authors declare that there are no conflicts of interest in relation to this article.

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