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RESEARCH ARTICLE

Integrating a pharmacist into an anaesthesiology and critical care department: Is this worthwhile?

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Abstract

Background Operating rooms and Intensive Care Units are places where an optimal management of drugs and medical devices is required. *Objective* To evaluate the impact of a dedicated pharmacist in an academic Anaesthesiology and Critical Care Department. *Setting* This study was conducted in the Anaesthesiology and Critical Care Department of Grenoble University Hospital. *Method* Between November 2013 and June 2017, the drug-related problems occurring in three Intensive Care Units and their corrections by a full-time clinical pharmacist were analyzed using a structured order review instrument. Pharmaceutical costs in the Anaesthesiology and Critical Care Department were analyzed over a 7 year period (2010–2016), during which automated dispensing systems and recurrent meetings to review indications of medications and medical devices were implemented in the department. *Main outcome measure* Analysis of two issues: correcting drug-related problems and containing pharmaceutical costs. *Results* A total of 324 drug-related problems were identified. The most frequent problem concerned anti-infective agents (45%), and this was mainly due to the over-dosage of drugs (30%). Dosage adjustments were the most frequent interventions performed by the pharmacist (43%). Over the 7 year period, pharmaceutical costs decreased by 9% (€365,469), while the care activity of the department increased by 55% (+ 12,022 surgical procedures and + 1424 admissions in the ICU). *Conclusion* Integrating a pharmacist into the Anaesthesiology and Critical Care Department was associated with interventions to correct drug-related problems and containing pharmaceutical costs. Pharmacists should play a central role in such medical environments, to optimize the use of drugs and medical devices.

Keywords Drug-related problems · France · Health care costs · Patient safety · Pharmacists · Quality improvement

Impacts on practice

- Integrating pharmacists in anaesthesiology and intensive care is associated with the correction of drug-related problems and improved quality of care, and also with cost reductions.
- European hospital administrators should consider hiring pharmacists specifically for Intensive Care and Anaesthesiology Departments.

Introduction

Operating rooms (ORs) and intensive care units (ICUs) are both places that require an optimal management of drugs and medical devices. In the ICU, critically ill patients are at high risk of developing drug-related problems (DRPs), e.g., toxic drug–drug interactions and adverse drug events [1]. In both the OR and the ICU, a large variety of drugs and medical devices, such as infusion sets, catheters, endotracheal tubes, are used, and this can impact pharmaceutical costs. In this context, herein we discuss the role of an integrated pharmacist in an Anaesthesiology and Critical Care Department.

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The Joint Task Force of the Society of Critical Care Medicine and the American College of Clinical Pharmacy recommends that each ICU employs a dedicated pharmacist [2]. This practitioner should have the training and/or experience to provide pharmaceutical care for critically ill patients, including reviewing prescriptions, ensuring appropriate administration of drugs and participating in the development of protocols and research projects [3, 4]. It was first shown in 1999 that having a dedicated pharmacist in the ICU team reduced preventable adverse drug events caused by prescribing errors [5]. These findings have since been confirmed, and in addition integrating a pharmacist into the ICU team has also been shown to have an indirect impact on morbidity and mortality rates [6–10]. Moreover, in North America, involving pharmacists in the care of critically ill patients is associated with improved economic outcomes [9, 10]. However, in Europe it remains to be determined if ward-based pharmacists are financially viable [8, 11, 12].

Although it is recommended that a pharmacist is integrated into the OR team, there is limited data available concerning their impact on cost savings and the optimization of drug distribution. The benefits of employing a dedicated pharmacist have been demonstrated in pharmacy supply-chain management and in a patient-controlled analgesia dosing service [13–15].

The aim of our study was to assess the impact of employing a dedicated pharmacist in an academic Anaesthesiology and Critical Care Department, through the analysis of two issues: correcting DRPs and containing pharmaceutical costs.

Ethical approval

In France, this type of study does not require an ethical approval.

Methods

This study was conducted in the Anaesthesiology and Critical Care Department of the University Hospital of Grenoble Alpes (France). The department cares for 4000 critically ill patients annually, it has 3 ICUs (52 beds) and 38,000 procedures are performed annually in 64 ORs and interventional suites that require the presence of an anaesthesiologist. A full-time senior clinical pharmacist was fully integrated into the department in November 2013. The pharmacist implemented automated dispensing systems (ADS) in the ICUs in 2011–2012. Therefore, analysis of DRPs was performed after this period, i.e. 2013–2017. A DRP was defined as "an event or circumstance involving drug therapy that actually or potentially interferes with the desired health outcome" [16].

The temporal evolution of costs was analyzed over a longer period (2010–2016), to appreciate the impact the pharmacist had on pharmaceutical costs. In addition, a pharmacy resident worked in one of the ICUs under the supervision of the senior pharmacist.

Interventions made by the pharmacist

The pharmacist and the pharmacy resident reviewed medication orders every weekday to ensure the appropriate selection of drugs, doses, routes and frequencies; and checked for drug–drug interactions. The pharmacist accessed patient profiles through computerized physician order entry (CPOE) software (Centricity® Electronic Medical Records, General Electric Healthcare, Barrington, USA). Treatment optimization was orally presented during rounds with the ICU team. The pharmacist also consulted with patients prior to the pre-operative anaesthesia consultation, in order to perform medication reconciliation and obtain accurate and complete information on the patient's medication. Medication reconciliation helped the anaesthesiologist to plan potential drug discontinuation and choose the optimal anaesthetic drug.

The pharmacist also optimized therapeutic management and safety through other interdisciplinary collaborative actions (Table 1): implementing drug dispensing systems, managing and optimizing drug preparation and administration through the update of CPOE (pre-defined medication protocols with precise recommendations on the type and volume of solvent, administration rates and routes, incompatibilities), implementing medication reconciliation using an electronic file displaying information on medications, addressing environmental issues with regard to the use of halogenated agents and waste management, evaluating the exposure of OR staff to toxic products, and educating nurses and residents.

A steering committee consisting of the head of the anaesthesiology and critical care department, physicians in charge of care sectors, health executives, nurse representatives, the clinical pharmacist, a biomedical engineer and the administrative director met six times a year (three meetings for the ICU and three for the OR). During each meeting, they reviewed the evolution of pharmaceutical costs, the possible acquisition of new drugs and/or medical devices, and their inventory and order management. The pharmacist shared information on medications and medical devices, e.g. new products, product shortages, changes to pharmaceutical manufacturers, and health alerts.

Study analysis

The impact of integrating a pharmacist into our department was assessed through the retrospective analysis of two

Table 1 List of pharmacist-led activities in the critical care and anaesthesiology department

Step	Activities
Prescription (CPOE)	Protocols for drugs used daily in the ICU added to the CPOE
	Protocols for the continuous infusion of beta-lactams added to the CPOE
	Review of orders and optimization of the medication process (drug–drug interactions, dose adaptation for renal insufficiency or dialysis, drug monitoring…)—detailed in Table 2 and Fig. 1
Dispensing systems	Automated drug dispensing systems implemented in all ICUs and the emergency OR
	Kanban systems for medications and devices implemented in all ORs (anaesthesia)
Administration	Management of physicochemical incompatibilities using several tools: e-learning, CPOE, dedicated software to organize IV drugs on manifolds without PCI
	Drug labelling (colour codes, mandatory items such as name and dose of product, time of preparation…)
	Recommendations to supplement parenteral nutrition
	Drug preparation methods added to the CPOE: oral route (crushing of tablets and alternative solutions) and parenteral route (solvent choice, volumes, durations, rates)
Medication reconciliation	History of medications taken at anaesthesia consultation, with the help of a new tool: an electronic file on the patient's medications: study in progress (750 patients)
	Medication reconciliation with the help of the electronic medication file
Risk management	High-risk register in anaesthesiology
Education	Pharmacology courses on sedation/analgesia for ICU nurses: anti-infective and immunosuppressant drugs; catecholamines and emergency treatments; anticoagulants and coagulation factors
	Pharmacology of IV anaesthetics for certified registered nurse anaesthetists
Supervision	Pharmacy technicians, pharmacy students in the ICU and Anaesthesiology
	Supervisor of student nurse anaesthetists
Sustainable development and chemical hazards	Work on reducing pollution: reduction of the gas flow rate used to administer halogenated agents and waste sorting
	Evaluation of the exposure of OR staff to halogenated agents

CPOE computerized physician order entry, *ICU* intensive care unit, *OR* operating room, *PCI* physicochemical incompatibilities

issues: correcting DRPs in the ICUs and containing pharmaceutical costs in the department.

From November 2013 to June 2017, determination of the DRPs in the three ICUs by the pharmacist was performed using a structured order review instrument [17]. Non-adherence to guidelines or contraindications, untreated indications, suboptimal dosage, over-dosage, drug use without indication, drug–drug interactions, adverse reaction to a drug, improper administration, failure to receive a drug or drug monitoring were all identified as DRPs. A pharmacist intervention is a recommendation initiated by the pharmacist in response to a DRP occurring at any phase of the medication process, i.e. adding a medication, stopping a medication, suggesting an alternative therapy, modifying the administration route, performing therapeutic monitoring, optimizing the administration technique or suggesting a dose adjustment. This recommendation is accepted or not by the physician in charge of the patient.

Pharmaceutical costs concerned medications and sterile medical devices used in the department, i.e., the 3 ICUs and 64 ORs and interventional suites. The first step taken to control pharmaceutical costs was the creation of working groups, coordinated by the pharmacist, to implement protocols in the department. Since 2011 ADS (Omnicell©, Mountain View, USA) have been implemented in all ICUs in the department. Kanban systems for medications and devices were chosen for our ORs, this is a visual system to control stock with a two-bin system for each product; when the first bin is empty, a team member orders the product with the help of a bar-code; meanwhile, nurses can obtain the product from the second bin. The evolution of pharmaceutical costs and cost savings over the study period from 2010 to 2016 was evaluated in parallel to the medical care activity, i.e. the number of ICU admissions and the number of procedures requiring an anaesthesiologist. Medications such as coagulation factors and antifungal drugs, which are reimbursed by French health insurance, were excluded from the analysis.

Results

DRPs in the ICU

A total of 5398 patient prescriptions (one order per patient, multiple medications in each order) were reviewed between November 2013 and June 2017. Drug-related problems were reported for 186 patients, with a mean age of 58 years (12–93 years old). We identified 324 DRPs during the study period, associated with 439 medications, which is on average 2.5 DRPs per week (Table 2). A DRP could be associated

Table 2 Characteristics of drug-related problems (DRPs) (n = 324)

Drug-related problems (n = 324)	n	%	Examples
1. Non-adherence to guidelines or contraindication	27	8	
1.1 Non-adherence to formulary	12		Prescription of 20 mg nicardipine which is not available in the hospital: change to 10 mg amlodipine
1.2 Non-adherence to scientific guidelines	12		Patient treated with voriconazole for suspected Aspergillus infection. Sample positive for Candida albicans: change treatment to caspofungin
1.3 Contraindication	3		Mastocytosis and morphine: stop morphine
2. Untreated indication	23	7	
2.1 No treatment for real medical indication	16		Pulmonary transplant patient with a mismatch for CMV without prophylactic valganciclovir: add valganciclovir
2.2 Drug omission	4		Patient treated with Depakote before hospitalization: add Depakote
2.3 No prophylaxis or premedication	1		Co-trimoxazole in a transplanted patient without folinate: add folinate
2.4 Omission of associated medication	2		Parenteral nutrition without vitamins and oligoelements after surgical intervention: add vitamins and oligoelements
3. Subtherapeutic dosage	38	12	
3.1 Low therapeutic dose	38		Sulfadoxine/pyrimethamine 1 tablet a day for prevention of opportunist infections in a pulmonary transplant patient: increase the dose to 2 tablets a day
3.2 Duration too short	0		/
4. Overdosage	98	30	
4.1 Supratherapeutic dose	92		Trough level of vancomycin 40.8 mg/l: reduce dose
4.2 Same medication prescribed twice	6		Simultaneous oral and IV metronidazole: stop IV
5. Drug use without indication	20	6	
5.1 No valid indication	10		Oseltamivir in a patient whose symptoms had developed long before the recommended 48 h time frame: stop
5.2 Duration too long, without risk of overdose	5		Levofloxacin for more than 1 week with no positive results from bacteriology: stop
5.3 Pharmacological redundancy	5		Simultaneous sodium heparin and enoxaparin: stop heparin
6. Drug-drug interactions	25	8	
6.1 To take into account	1		Levothyroxine and rifampicin: assess TSH levels after 2 weeks
6.2 Precaution	10		Valproic acid and topiramate: risk of hyperammonaemia in a patient with a cerebral haemorrhage
6.3 Unadvised	7		Escitalopram and linezolid (risk of serotoninergic syndrome): stop escitalopram during antibiotic therapy
6.4 Contraindicated	7		Citalopram and erythromycin (risk of torsades de pointes): stop erythromycin
6.5 Unpublished (outside RCP)	0		/
7. Adverse drug reaction	8	2	Convulsions with cefoxitin and nefopam
8. Improper administration	57	18	
8.1 Alternative route (more efficient/less costly)	8		Linezolid oral route better than IV, patient can swallow tablets
8.2 Not adequate	27		Antiretrovirals (Truvada®, Norvir®) administered to a patient with a feeding tube: Truvada® in 10 ml water and Norvir® drinkable suspension
8.3 Wrong form	9		Tacrolimus long acting tablet not suitable for administration through feeding tube: prefer immediate release tacrolimus twice a day
8.4 Incomplete order	0		/
8.5 Wrong scheduling	13		Posaconazole tablets twice daily: once daily
9. Failure to receive drug	4	1	
9.1 Physicochemical incompatibility	4		Magnesium and calcium inside parenteral nutrition bag
9.2 Adherence problem	0		/
10. Drug monitoring	22	7	Clozapine without blood count
Type of pharmacist intervention (n = 324)	n	%	Examples
1- Add a medication	23	7	Proton pump inhibitor (PPI) not prescribed for history of gastric ulcer: add prophylactic dose of PPI

Table 2 (continued)

Type of pharmacist intervention (n = 324)	n	%	Examples
2- Stop a medication	35	11	Loperamide in infectious diarrhoea
3- Alternative therapy	66	20	Continuous infusion of argatroban in a patient with heparin allergy: fondaparinux
4- Alternative route of administration	7	2	Levetiracetam drinkable suspension for a burns patient who cannot swallow tablets
5- Therapeutic monitoring	23	7	Amiodarone and Rovamycine (risk of torsades de pointes): ECG monitoring
6- Optimization of administration technique	32	10	Oral Levothyroxin in a patient with haemorrhage from a duodenal ulcer: IV route
7- Dose adjustment	138	43	Reduce dose of fluconazole (800 mg to 400 mg daily) in a patient undergoing dialysis

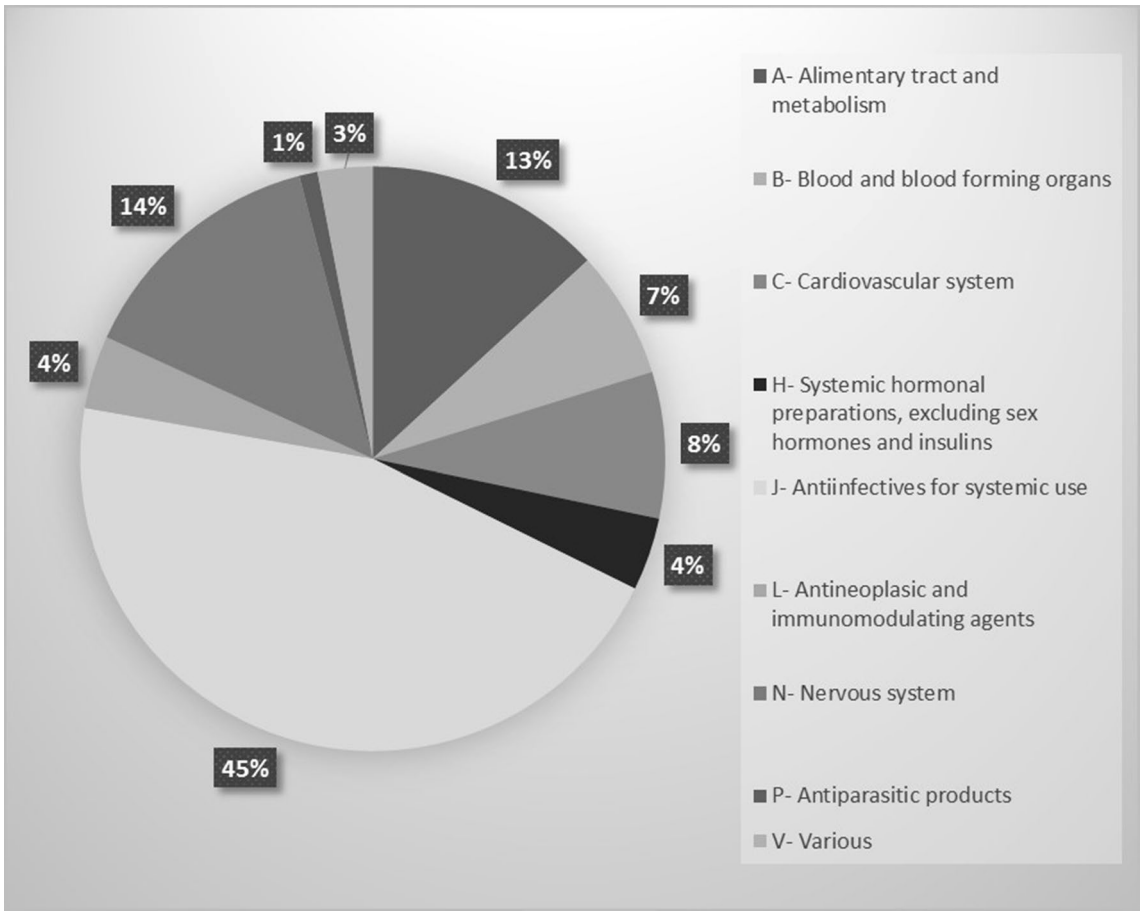


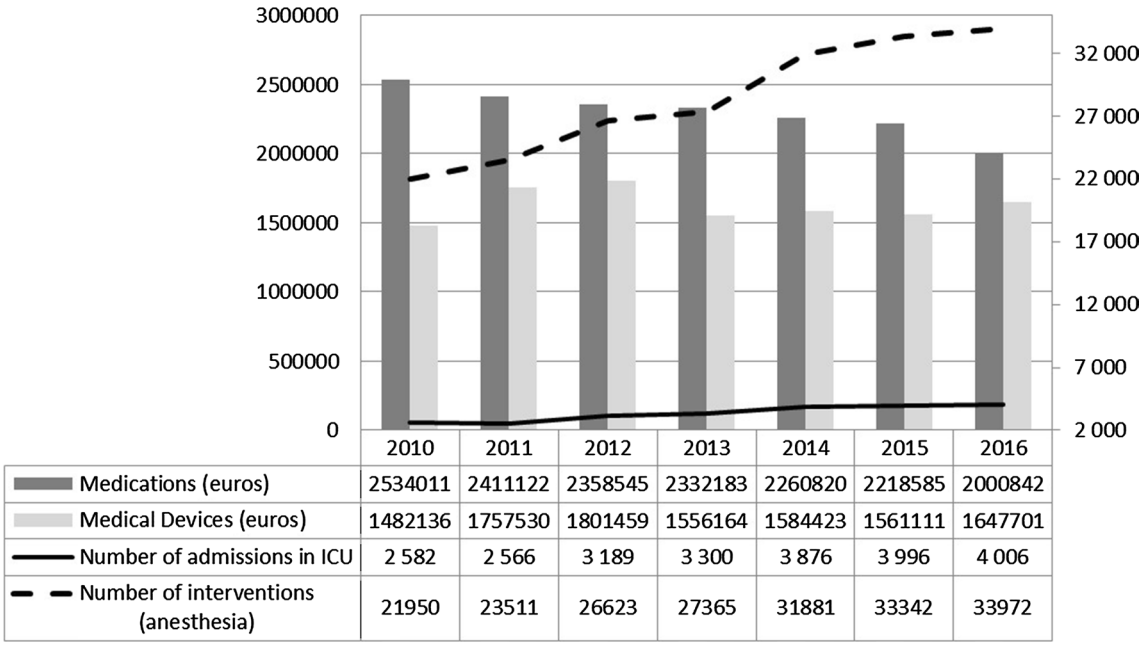
Fig. 1 Drug classes associated with pharmacist interventions according to the anatomical therapeutic chemical classification system (n = 439 medications)

with more than one drug, e.g. drug–drug interactions. In 301 cases (93%), the physician in charge agreed to implement the pharmacist's recommendations.

The class of drugs most frequently associated with DRPs was the anti-infective agents (n = 199; 45%) (Fig. 1): caspofungin (n = 20), piperacillin (n = 18), fluconazole (n = 16), ciprofloxacin (n = 16), imipenem (n = 12), vancomycin (n = 11), amoxicillin (n = 10) and ceftazidime (n = 9). Sedatives accounted for 14% of the DRPs (n = 63). Other drugs involved included pantoprazole (n = 18) and tacrolimus (n = 9).

Pharmaceutical costs

Between 2010 and 2016, the overall care activity gradually increased, with more anaesthetic interventions: 21,950 in



	2010	2011	2012	2013	2014	2015	2016
Medications (euros)	2534011	2411122	2358545	2332183	2260820	2218585	2000842
Medical Devices (euros)	1482136	1757530	1801459	1556164	1584423	1561111	1647701
Number of admissions in ICU	2 582	2 566	3 189	3 300	3 876	3 996	4 006
Number of interventions (anesthesia)	21950	23511	26623	27365	31881	33342	33972

Fig. 2 Evolution of activity and costs from 2010 to 2016

2010 versus 33,972 in 2016 (+55%); and more admissions to the ICUs: 2582 in 2010 versus 4006 in 2016 (+55%). Meanwhile, over the study period the overall cost of medications and medical devices decreased by 9%, which is a saving of €365,469 (Fig. 2). The largest saving was due to the optimization of anaesthetic agents, including reducing the number of pre-filled propofol syringes used and reducing the fresh gas flow rate used to administer halogenated agents. Other factors may have also reduced costs, such as a decrease in drug prices over this period. However, the cost of medical devices increased during this period, due to an increase in the number of dialysis sessions and the use of monitoring devices, according to international medical recommendations.

Discussion

Our work shows that there are three benefits associated with integrating a pharmacist into an Anaesthesiology and Critical Care Department: optimization of the medication process, financial savings as a result of optimizing the use of medications and medical devices, and the formation of a multidisciplinary partnership to share information.

We found that in the ICU the class of drugs most frequently associated with DRPs was the anti-infective agents (45%), whereas in medical wards most DRPs are related to psychotropic drugs (25.9%), antithrombotic drugs (15.9%), digestive and metabolic drugs (15.5%), and cardiovascular drugs (15.0%) [18]. This finding emphasizes the need to educate ICU staff in antimicrobial stewardship. Many drug–drug interactions that occur in the ICU [19] can be managed with the help of a pharmacist [20]. In the ICU, pharmacists monitor high-risk patients for DRPs, i.e. transplant patients, patients who need renal replacement therapy and patients with severe multi-organ failure [21]. A recent study determined that the time taken to review an individual prescription was on average 22.5 min [22].

The pharmacist and pharmacy resident were well accepted by the physicians and nurses. This was evidenced by the high level of acceptance of the pharmacist's interventions (93%), which was higher than the national acceptance rate (73%) [18]. The value of having a pharmacist on the ward and their participation in medical rounds is well documented [5]. Effective presence of the pharmacist in the ICU is essential for her/him to be trusted by nurses and physicians, advise the optimal therapy and make relevant interventions [23]. The pharmacist must also be specifically trained and have a good knowledge of the therapeutic problems encountered in an ICU.

Besides observing the daily interventions made by the pharmacist, we used a project-based approach. An important update was made to the management of prescriptions and the preparation and administration stages of the medication process in our ICUs. Standard prescriptions adjusted to specific doses and concentrations, and information on how to prepare and administer drugs

(solvent, volume, physicochemical incompatibilities) were displayed in the CPOE. As part of the update a variety of actions were taken to optimize drug administration, addressing the problem of physicochemical incompatibilities, which is of daily concern in the ICU [24]. To ensure that drugs were dispensed securely, we chose to implement an ADS in our ICUs and the emergency OR, which have been shown to be more profitable and safer than classic dispensing systems [25, 26].

Looking to further optimize the medication process, pharmacist-led medication reconciliation was implemented at both the pre-operative anaesthesia consultation and afterwards in the ICU. Medication reconciliation is an important step in the medication process. Before anaesthesia, it is essential to know which drugs are being taken by the patient in the pre-operative period, and to plan whether or not they are to be suspended [27]. In the ICU, patients may be at risk of medication omissions or unintended discontinuation of chronic treatments [28]. Due to the recent recommendations regarding the continuous infusion of beta-lactams in critically ill patients [29], we performed an additional update on anti-infective drugs.

The pharmacist also educated ICU staff, by providing pharmacology courses and passing on good practices in medication safety to ICU nurses, registered nurse anaesthetists and residents. As members of the ICU team, pharmacists also contribute towards quality improvement initiatives, scholarly and research activities, and the education and training of interdisciplinary personnel [30].

With the rising attention paid to a sustainable environment and resources, sustainable anaesthesia has emerged as a major concern within the OR. Several projects were conducted in our OR, including reducing pollution from halogenated agents and reducing waste; we also investigated the exposure of our OR staff to halogenated agents and explored ways to reduce it. A national working group was established to share all the sustainable initiatives set up in our OR.

Although activity increased over time, we managed to reduce costs. We were even able to introduce some drugs newly available on the market, such as dexmedetomidine and the local anaesthetics (hyperbaric prilocaine and chloroprocaine). Formularies for medications and medical devices were discussed, implemented and further managed through the described dispensing systems. We analysed the quantities of products necessary for the usual activity, to avoid both over-supply and lack of supply. In part, the reduction in cost was also due to price negotiations and using generic medications. A pharmacist working alone would not have succeeded. This achievement was the result of the cooperation of nurses and physicians, who realized the importance of waste reduction and the optimal use of medications and medical devices. The manager of the department also played a critical role.

Our retrospective and descriptive study has several limits. The value of the clinical pharmacist could have been further substantiated by conducting a survey of team members. We did not compare the number of DRPs before and after the integration of a pharmacist into the department. Moreover, we did not assess how the interventions the pharmacist made to prescriptions impacted costs. A recent French study showed that pharmacist-led interventions in critical care were associated with a decrease in the length of stay in the ICU and the hospital, and a decrease in drug costs in the ICU [11].

Conclusion

The integration of a pharmacist within our Anaesthesiology and Critical Care Department resulted in a fruitful collaboration. Pharmacists act as an interface between physicians and nurses, thereby closing the loop between actors in the medication process. Our study should motivate hospital administrators to employ pharmacists in their ORs and ICUs, thus enhancing the quality and safety of patient care, while optimizing costs. Pharmacists with an interest in the ICU and anaesthesiology should come together to organize a national network, and participate in a European network.

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