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The Wastage and Economic Effects of Anaesthetic Drugs and Consumables in the Operating Room

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Abstract

Objective: Anaesthesia is a branch in which new anaesthetic drugs, devices, instruments and new treatment methods have been developed. Because of these innovations, health expenditures have escalated. Anaesthetic drugs and consumables constitute the majority of these expenses. Some waste of used drugs and consumables in the operating room is unavoidable. However, excessive drug wastage can be controlled. One of the ways to reduce the financial burden of this wastage is to know the loss cost. This study aimed to discuss the effect of the wastage of drugs and consumables.

Methods: This prospective observational study was conducted in a hospital operating room over a six-week period. At the end of each operation and at the end of each operation day, the amount of wasted and consumables was recorded. The total wastage of the drugs and consumables was calculated by multiplying unit prices.

Results: Data of 363 cases were collected during the study period. The total loss cost calculated during the study period was 2545.77 TL. The highest total loss cost was rocuronium (29.95%) and propofol (27.99%). The least loss was neostigmine (0.06%). The consumption rate of consumables was lower than that of drugs.

Conclusion: A significant amount of drug wastage was recorded during the study period. This can be reduced by simple means. These applications vary from physician behavioural change to the preparation of standard doses of single-dose preparations. Cost training programmes at regular intervals can also be used as a cost-reduction strategy.

Keywords: Anaesthetic consumable waste, anaesthetic drug wastage, cost effect

Introduction

Anaesthesia is a branch in which new anaesthetic drugs, devices, instruments and new treatment methods have been developed. Using current approaches is essential to keep pace with information technology and pharmaceutical advances, and improve the quality of healthcare. However, these innovations contribute to the increase of continuous medical expenses in terms of hospital expenses (1). Because of increasing health expenditure, cost-reduction strategies have become very important in developing countries. The main concern in the field of anaesthesia is the wastage of drugs and consumables. Possible changes in the individual response of patients, unused drugs and opened ampoules and vials because of sterility concerns make some amount of drug wastage unavoidable in anaesthesia (2). However, it still constitutes a common target in terms of the reduction of operating costs and cost-reduction approaches (3). This financial burden can be reduced by reducing the wastage of drugs and consumables without compromising the quality of patient care.

Just as the drugs and consumables supplied in each country differ, the drugs and consumables used for different hospitals with different institutional characteristics may also be different (4). Therefore, each institution should follow its own cost analysis in a period when the financial resources of today are rapidly decreasing.

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This prospective observational study aimed to determine the wastage of anaesthetic drugs and consumables used in the operating room, to analyse the economic effects and to discuss the precautions that could be taken.

Methods

This study was conducted over six consecutive weeks between 1 July 2018 and 15 October 2018 in a university hospital operating room. We received approval of the local ethics committee of Kırıkkale University Faculty of Medicine at June 2018 (Ref. No. 2018.06.10) and written informed consent from the participants. The study included data from patients aged over 18 years who were American Society of Anesthesiologists (ASA) status I-II-III and undergoing general anaesthesia for obstetrics and gynaecology surgery, orthopaedic surgery, thoracic and cardiovascular surgery, general surgery, otorhinolaryngology surgery, ophthalmic surgery, neurosurgery, plastic and reconstructive surgery and urological surgery over the defined six-week period. Patients who underwent surgery under regional or local anaesthesia during this period were not included in the study. In our clinic, there are a certain number of drugs and consumables that are kept in each operating room. Only opioid drugs are kept in a locked cupboard and are dispensed by assistant physicians. The relevant anaesthesiologist determines drugs and consumables prepared in each operating room each day.

In this study, an anaesthesiologist who was blinded to the study and following the operation gave the drug preparation instructions for use in patients. An anaesthetist, other than the anaesthetist who performed the anaesthesia of the surgery, recorded the amounts of drugs and consumables that were not used preoperatively, perioperatively and in the early postoperative period except for inhalation agents at the end of the operation, with the help of the anaesthesia technician. At the same time, the amount of drugs and materials to be disposed off in the operating rooms at the end of each operation day was also recorded. To ensure that the study procedure does not affect the anaesthetic practices, the anaesthetist team was not generally informed about the study. These drugs and consumables comprised drugs left unused in the injectors, broken but unused ampoules, unused consumables and drugs that remained in the trash because of sterility (remaining after use). Unused drugs and materials in waste containers were also recorded using appropriate safety measures. However, care was taken to minimise exposure to hazardous wastes. Inhalation agents remaining in the vaporisers were not included in the study because they were used in the next surgery, and no leakage in the perioperative period was detected. Cost estimation of wasted drug amounts was done.

Statistical analysis

The sample size was calculated based on the study time as in previous studies (2, 5). Descriptive statistics were made for demographic data using the SPSS program for Windows Version 20.0 statistical package (IBM SPSS Corp.; Armonk, NY, USA) and presented as number and median (interquartile range) according to the Kolmogorov-Smirnov test. Data entry was provided using the Microsoft Office 2010 Excel program. The results were tabulated by making calculations. The amount of drug waste was multiplied by the price of the drug per unit (milligram price) during the study. The cost of the total drug waste in the study was divided by the number of patients using the same drug, and an estimate of the cost of the lost drug per case was made. In addition, according to the total wasted drug cost during the study, a certain percentage of drug-related waste cost was estimated. Likewise, unused materials were multiplied by unit prices (price per piece), and percentage estimates are given for total cost and wasted costs.

Calculations were made as follows (5):

1. Cost of wasted drug = amount of wasted drug × unit price of the drug.
2. Wasted drug price per patient = total wasted drug price / number of patients using the drug.
3. Percentage of drugs wasted as cost = wasted drug price / total wasted drug price.
4. Daily loss of drug cost = total wasted drug cost / total number of working days.
5. Wasted consumable cost = wasted consumable quantity × consumable unit price.
6. Wasted consumable price per patient = total cost of wasted consumables / number of patients using the consumable.
7. Percentage of consumables wasted as cost = cost of wasted consumables / total cost of wasted consumables.
8. Cost of daily lost consumable = total wasted consumable cost / total number of working days.

Results

A total of 363 patients who underwent general anaesthesia were included in the study. All patients' data were collected for six weeks. The demographic characteristics of the patients are shown in Table 1. Fentanyl, rocuronium, propofol or thiopental were prepared daily for each case according to the results of the observations made during the study. Also, it was observed that ephedrine and atropine were prepared for emergencies in every room. In addition, it was observed that lidocaine was prepared in most cases routinely. Table 2 shows the total amounts and daily average amounts of wasted drugs during the study period. In the study, the cost of wasted drugs and consumables was calculated by multiplying by unit prices (milligram price for drugs and price per piece for consum-

Table 1. Demographic characteristics of the patients

	O&G	O&T	T&CV	G	ENT	OPH	NEU	P&R	URO
Number of patients	15	85	9	123	64	14	18	5	30
Sex									
M	0	38	7	56	42	5	7	1	23
F	15	47	2	67	22	9	11	4	7
Age (year) median (min-max) (34-78)	39 (18-46)	40.5 (18-76)	56 (18-68)	49 (16-76)	40 (19-65)	67 (45-70)	59 (56-70)	40 (24-67)	56.5
Anaesthesia duration median (min-max) (68-150)	78 (60-120)	105 (45-210)	119 (55-140)	96 (50-310)	116.5 (65-209)	88 (67-120)	98.5 (78-128)	98 (87-105)	118.5
Surgery duration median (min-max) (60-140)	70 (50-110)	96 (35-200)	110 (45-130)	88 (40-300)	110 (55-200)	80 (60-110)	90 (70-120)	90 (80-99)	110
ASA, n									
I	9	29	2	18	12	0	4	2	8
II	6	14	0	32	22	4	8	3	10
III	0	42	7	73	30	10	6	0	12

O&G: obstetrics and gynaecology surgery; O&T: orthopaedics and traumatology surgery; T&CV: thoracic and cardiovascular surgery; G: general surgery; ENT: ear, nose and throat surgery; OPH: ophthalmic surgery; NEU: neurosurgery; P&R: plastic and reconstructive surgery; URO: urological surgery; ASA: American Society of Anesthesiologists; m: male; f: female; n: number of patients; min: minute; min: minimum; max: maximum

Table 2. Amount of unused and wasted drug during the research (amount of waste drug) after the cases were over

Drug	Total amount of waste (mg)	Daily average amount of waste (mg)	Number of cases in which drug was used
Propofol	4110	137	137
Thiopental	15,040	501.33	238
Fentanyl	6280	209.33	230
Rocuronium	3430	114.33	363
Midazolam	231.5	7.71	320
Lidocaine	3260	108.66	150
Tramadol	3835	127.83	260
Ephedrine	455	15.16	8
Atropine	3.3	0.11	360
Neostigmine	0.5	0.01	360
Paracetamol	5600	186.66	52
Ranitidine	165	5.5	144
Metoclopramide	0	0	130
Dexamethasone	72	2.4	168
Methylprednisolone	1440	48	16
Sugammadex	0	0	0
Remifentanil	7660	255.33	111
Dexketoprofen	0	0	114
Ondansetron	0	0	243
Morphine	0	0	50
Nitroglycerin	0	0	12

mg: milligram

ables) and shown in Table 3 and Table 4. The total loss cost calculated during the study period was 2545.77 TL (1304.55 TL: loss cost of total wasted drugs after the cases were over; 364.39 TL: loss cost of total wasted consumables after the cases were over; 876.83 TL: loss cost of total wasted drugs at the end of the workday).

The average daily loss cost was calculated as 84.86 TL. The highest total loss cost was because of rocuronium (29.95%) and propofol (27.99%). The least loss was with neostigmine (0.06%) and ephedrine (0.21%). Wastage of consumables was less than that of drugs. Although the cost loss was low in consumables, the greatest loss cost was because of spiral intubation tubes (25.93%). Losses were also relatively high with 5 mL (16.35%) and 10 mL (25.87%) injectors and electrocardiogram (ECG) electrodes (9.75%), respectively. Serum sets (1.36%) and oral airway kits (2.05%) generated the lowest loss cost.

The drugs causing end-of-day cost loss were thiopental, propofol, lidocaine, ephedrine, rocuronium, nitroglycerin, atropine, remifentanil and paracetamol (Table 5). The total cost of loss was 876.83 TL for end-of-day cost loss. Thiopental (24.6%), lidocaine (20.6%) and rocuronium (11.8%) were the highest end-of-day losses. Paracetamol (0.6%) and remifentanil (1.6%) were the most cost-effective drugs. No end-of-day cost loss was found because of consumables.

Table 3. Cost analysis of drug wastage after the cases were over during the research period

Drug	Total Cost of loss Amount (TL)	Average Cost of Daily loss (TL)	Loss cost per case in which drug was used (TL)	Total loss percentage (%)	Unit Price (mg price) of the drug (TL)
Propofol	365.37	12.17	2.67	27.99	0.09
Thiopental	102.27	3.41	0.43	7.84	0.01
Fentanyl	73.47	2.44	0.32	5.63	0.01
Rocuronium	390.67	13.02	1.08	29.95	0.11
Midazolam	72.69	2.42	0.23	5.57	0.31
Lidocaine	45.64	1.52	0.30	3.49	0.01
Tramadol	53.69	1.78	0.21	4.12	0.01
Ephedrine	2.73	0.09	0.34	0.21	0.001
Atropine	5.54	0.18	0.01	0.42	1.68
Neostigmine	0.77	0.02	0.00	0.06	1.54
Paracetamol	15.06	0.50	0.29	1.16	0.003
Ranitidine	25.57	0.85	0.18	1.96	0.15
Metoclopramide	0	0	0	0	0.07
Dexamethasone	33.12	1.10	0.19	2.54	0.46
Methyl-prednisolone	79.66	2.65	4.98	6.11	0.05
Sugammadex	0	0	0	0	0.57
Remifentanil	38.30	1.28	0.34	2.94	0.005
Dexketoprofen	0	0	0	0	0.04
Ondansetron	0	0	0	0	2.58
Morphine	0	0	0	0	0.09
Nitroglycerin	0	0	0	0	0.48
Total	1304.55				

TL: Turkish Lira; unit price: milligram price

Discussion

The estimated total cost loss was 2545.77 TL (because of total wastage after the cases were over and at the end of the workday). In total, the drug that caused the most loss was rocuronium (493.75 TL), followed by propofol (454.27 TL) and thiopental (317.49 TL).

When considered for an operation, anaesthesia-related drugs constitute low cost for each patient. However, a large number of anaesthesia for many patients will increase the total cost. Neuromuscular blocking drugs constitute approximately one-third of the cost of hospital anaesthetics drugs (6). The muscle relaxant used changes in different countries and institutions, as well as according to the case changes. Rocuronium is frequently used in our hospital. In this study, rocuronium (29.95%) caused the most cost loss. In another study, vecuronium (35.21%) caused the most financial loss (2). This loss can be reduced by appropriate use of neuromuscular blockers, assessment of the degree of blockage and loading of only the required amount.

Although the amount of thiopental (15,040 mg) loss was the highest, the effect of this amount on total loss cost was low when compared with rocuronium because of its cheaper unit price. Conversely, the loss amount of rocuronium (3430 mg) was lower than that of thiopental, but the cost loss was higher because of the higher unit price.

The cost of propofol-induced loss accounted for approximately 27.99%. In our hospital, because of the difficulties encountered with the purchase of propofol, it was not used in many cases. When it is considered that propofol can be kept for up to 6 h after the ampoule is broken and because of high unit price, a high percentage of loss may be expected. However, this loss cost is thought to be reduced by approximately 20% by decreasing the wastage of drugs as suggested by Gillerman and Browning (7). Drugs used in routine practice are drawn before the patient comes to the operation room and discarded at the end of the operation or day when not used for a patient (with the concern of sterility). The cost of lost drugs would decrease if drugs were prepared according to the type of the anaesthesia required after a rapid evaluation when the patient comes to the operating room.

The estimated percentage cost loss with thiopental sodium was 7.84%; the total loss cost was 102.27 TL. Two 20-mL injectors

Table 4. Analysis of cost of wastage of consumables during the research period

Consumable	Number of cases in which the consumable used	Number of unused consumable	Total loss cost (TL)	Average cost of daily loss (TL)	Loss cost per case in which the consumable was used (TL)	Total loss (%)	Unit price (pcs price) of consumable (TL)
0.9% isotonic solution	365	0	0	0	0	0	7.06
Ringer lactate	167	0	0	0	0	0	8.91
Gelofusine	30	0	0	0	0	0	15.5
Intubation tube	320	12	13.44	0.45	0.04	3.69	1.12
Spiral intubation tube	43	9	94.50	3.15	2.20	25.93	10.5
Intracath	363	18	23.40	0.78	0.06	6.42	0.30
Aspiration tube	363	68	14.96	0.49	0.44	4.11	0.22
Airway	363	22	7.48	0.25	0.02	2.05	0.34
Serum set	361	4	4.96	0.16	0.01	1.36	1.24
Injector 5 mL	363	115	59.57	1.99	0.16	16.35	0.52
Injector 10 mL	362	182	94.27	3.14	0.26	25.87	0.52
Injector 20 mL	360	15	7.77	0.26	0.21	2.13	0.52
Injector 50 mL	86	0	0	0	0		1.2
ECG electrode	363	111	35.52	1.18	0.09	9.75	0.32
Nasogastric tube	56	4	8.52	0.28	0.15	2.34	2.13
Pressure adapter	48	0	0	0	0	0	30.2
Total			364.39				

TL: Turkish Lira; unit price: milligram price

Table 5. At the end of the workday cost analysis of the drugs and consumables

	Total amount (mg)	Daily average amount (mg)	Total cost (TL)	Daily average cost (TL)	Total waste percentage
Thiopental	31,650	1055	215.22	7.17	24.6
Propofol	1000	333.33	88.9	29.63	10.1
Atropine	63	2.1	105.84	3.52	12.1
Ephedrine	3080	102.6	18.48	0.61	2.1
Lidocaine	12,880	429.3	180.32	6.01	20.6
Methylprednisolone	875	31.25	48.41	1.61	5.5
Rocuronium	905	31.20	103.08	3.43	11.8
Nitroglycerin	200	7.4	96.8	3.22	11.0
Remifentanil	2880	102.8	14.4	0.48	1.6
Paracetamol	2000	74.07	5.38	0.17	0.6
Total			876.83		

mg: milligram; TL: Turkish Lira

are prepared during the preparation of the drug because 1-g thiopental vials are used. If part of the second injector is used, the remaining drug in the syringe goes into waste after the case is over. When it is not used, it is kept for subsequent cases but discarded at the end of the workday. Previously, the cost effect of thiopental was lower than the total loss because of its relative inexpensiveness (8). However, increasing drug prices and high amounts of loss caused the cost loss to be considerable. There is information about the cheap nature of thiopental sodium and its easy availability in hospital supply (1). Therefore, the resulting thiopental wastage suggested that the anaesthetic team did not appreciate the need for precaution with this drug, which could explain the unexpected increased waste. Drawing drugs in smaller volumes to injectors, sharing drugs with different operating rooms and raising awareness of new prices of drugs will reduce this cost loss.

Atropine and ephedrine accounted for 12% and 2.1% of wastage of at the end of the workday total cost loss in this study. In previous studies, significant wastage was reported for atropine and ephedrine (2, 9). In each operating room, ephedrine 50 mg and atropine 1 mg were routinely prepared as emergency drugs. Because of fact that only one person from the anaesthesia team stays near the patient during the operation, it can be life-saving if urgent drugs are predrawn into syringes and available near the anaesthetic equipment. However, the cause of wastage of atropine and ephedrine in this study was because of prepared and discarded drug in injectors that were not used during the cases. When the cost required to prepare single-dose atropine and ephedrine in injectors was calculated, it was observed that the costs of preparing these drugs were not taken into consideration because of the amount and cost of wasted drugs (9). Also, only one ampoule of atropine next to anaesthesia workstation would be safe against intraoperative bradycardia. In addition, adequate fluid management and the use of anaesthetic drugs by titration would help reduce the need for ephedrine.

Lidocaine is frequently used to eliminate the intubation stress response and to reduce propofol injection pain (10). Therefore, we noticed that lidocaine was also drawn in routine practice, such as in emergency medicine. It is obvious that drawing of this drug into a syringe only in appropriate and necessary cases would reduce the cost of waste at the end of the day.

Although there are routine rules for opioids, the wastage cost of these drugs was considerable (5.63%) because of the use of 10 mL of fentanyl ampoule withdrawal into only one injector. Midazolam is routinely administered as premedication as soon as the patients come to the operation room. It was also noticed that the loss of midazolam was because of the drugs remaining in the injectors because of this routine procedure. These problems can be solved by taking the drug into 2.5 mL injectors according to the appropriate dose range according to the weight of the patients.

In previous studies, 100% cost loss was reported related to adrenaline because of the routine preparation of this drug (1). However, in our clinical practice, we do not routinely withdraw adrenaline. On the other hand, the higher cost of unit prices of some drugs such as methylprednisolone (6.11%; total loss cost percentage after the cases were over) affected the total cost loss. Conversely, although the amount of wastage of remifentanil (2.94%), tramadol (4.12%) and paracetamol (1.16%) was more than with other drugs, the unit price cost was relatively low, so the loss cost was slightly lower.

As in previous studies, although wastage of drugs was significantly higher in this study, wastage of consumables (total loss cost of consumables was 364.39 TL) was lesser (3). Spiral endotracheal tubes caused the highest cost loss in the consumables (25.93%) because of the high unit price. Although the unit price was still low for 5 mL, 10 mL injectors and ECG electrodes, it caused cost loss because of lack of diligence when using (16.35%, 25.87% and 9.75% cost loss for these consumables, respectively).

Gillerman and Browning (7) stated that drug costs could be limited by reducing drug waste. At this point, efforts to increase cost awareness will reduce the wastage of drugs (11). It may be thought that changing the behaviour of the anaesthesia team would be temporary. However, if an effort is made in this context, if it is concentrated, long-lasting behavioural changes can be acquired after a period of time. For this, periodic price awareness training meetings can be held. Drug prices can be made into lists and hung in operating rooms. The practical participation of each team member in the operating room to effect changes can be beneficial and constructive.

It is suggested that the use of syringes prepared commercially or by pharmacy departments will decrease waste and potential drug errors, and that emergency drugs will have a long shelf-life and effectiveness (12).

Mini-jet drugs in sterile injectors can be prepared and used instead of atropine bulbs. Thiopental is prepared as a commercial preparation in injectors, and its shelf-life can be extended and preserved with sterility (12). Ephedrines can also be prepared as prefilled sterile injectors (12). When ephedrines are prepared, lower amounts can be shared for each case in different low-volume injectors on the morning of each surgery day instead of a 10 mL syringe for one bulb. However, this application was not used for some drugs such as propofol; this application is not used for drugs that are taken and should be discarded when not used, such as propofol.

Only patients undergoing general anaesthesia were included in this study. Larger studies can be undertaken to include regional anaesthesia. Secondly, the effect of wasted drugs and consumables on used drugs and consumables may be investigated in subsequent larger studies.

Conclusion

A considerable amount of drug wastage was observed during the study period. This can be reduced by simple means without compromising patient health/safety. Thus, environmental pollution is reduced. These applications can vary from physician behavioural change to standard doses of single-dose drug preparations. Regular cost training programmes can also be used as a financial reduction strategy.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Kırıkkale University School of Medicine (June 2018; Ref. No. 2018.06.10).

Informed Consent: Written informed consent was obtained from participants who participated in this study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The author have no conflicts of interest to declare.

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