Cost identification analysis of general anesthesia

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Abstract

Background and Aims : Rising health costs are challenging anesthesiologists to search for cost-effective anesthetic techniques. We conducted a study to estimate variable cost per case and cost of drug wastage as percentage of total drug cost associated with different modalities of general anesthesia (GA).

Material and Methods: This prospective study was carried out after approval by institutional ethical committee in 258 adult patients aged 18–60 years of either sex, American Society of Anesthesiologists physical status I or II, with a surgical duration of 1–4 hours, posted for elective surgery under GA with endotracheal intubation. At the end of surgery, total utilization of each drug, anesthetic gases, and consumables were noted and remaining drug was regarded as wastage. Cost was recorded as per maximum retail price for that particular brand in the market at start of study and total cost was calculated. For purpose of analysis, cases were divided into low flow sevoflurane, high flow sevoflurane, high flow isoflurane, low flow isoflurane, and total intravenous anesthesia (TIVA).

Results: The mean variable cost was highest with TIVA (₹2713.82 ± 509.57) and lowest with low flow isoflurane (₹1981.62 ± 335.03; $P < 0.001$). Drug wastage was 13.1% overall, with highest in low sevoflurane group and lowest in TIVA.

Conclusion: Low flow anesthesia with isoflurane is more cost-effective as compared to high flow techniques and TIVA even for short duration surgeries. Rational use of drugs and consumables and minimizing wastage can further reduce anesthesia costs.

Keywords: Low flow anesthesia, pharmacoeconomics, total intravenous anesthesia

Introduction

With the introduction of new and advanced techniques, the healthcare costs have also increased progressively. One of the major expenditures in a hospital has been attributed to anesthetic procedures.[1] It thus becomes challenging for the anesthesiologist to use newer techniques that help maintain the standards of patient safety, yet are cost-effective in routine use.

The market for surgery and anesthesia does not follow conventional supply/demand and cost/quality equilibrium laws. In economic terms, value-based anesthesia care[2] can be evaluated by cost identification (minimization) analysis which involves comparison of acquisition costs of various anesthesia techniques providing the desired outcome.[3]

Although studies have compared different anesthetic techniques (e.g., spinal vs general anesthesia)[4] for a particular surgery with respect to their cost efficacy, patient safety, and side effects, or two different general anesthetic techniques [high flow and low flow inhalational anesthesia with one agent[5] or low flow anesthesia with total intravenous anesthesia {TIVA}],[6-8] a comprehensive analysis of cost identification for general anesthesia is lacking.

Another method of minimizing costs is to reduce drug wastage. Studies illustrate that using drugs judiciously will eventually

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Access this article online	
Quick Response Code:	Website: www.joacp.org
	DOI: 10.4103/joacp.JOACP_77_19

How to cite this article: Malhotra R, Kumar N, Jain A. Cost identification analysis of general anesthesia. J Anaesthesiol Clin Pharmacol 2020;36:219-26.

Received: 21-Mar-2019 **Revised:** 21-May-2019 **Accepted:** 20-Jun-2019
Published: 15-Jun-2020

reduce costs[9] but fail to elucidate the techniques associated with less wastage.

Therefore, we designed a study to ascertain the variable costs associated with delivery of anesthesia, with a primary objective to estimate the variable anesthetic costs with different modalities of general anesthesia viz TIVA, high flow sevoflurane, high flow isoflurane, low flow sevoflurane, and low flow isoflurane. The secondary objectives of our study were to identify the variable cost per case of general anesthesia, and to calculate the cost of drug wastage as percentage of total drug cost with different modalities of general anesthesia.

Material and Methods

This prospective cost analysis study was carried out after approval by the institutional ethical committee from November 2014 to March 2016 in adult patients aged 18–60 years of either sex, ASA I or II, and a surgical duration of 1–4 hours posted for elective surgery under general anesthesia with endotracheal intubation. Patients undergoing surgery under regional block, regional block supplemented with general anesthesia, and cases with any adverse intraoperative event were excluded. The trial was registered prospectively with Clinical Trial Registry of India (CTRI/2014/11/005209; www.ctri.nic.in).

The technique of anesthesia and the drugs used were decided by the consultant anesthesiologist. A note was made of all the consumables used and the drugs loaded for use. Drugs were assumed to be loaded in concentrations and quantity appropriate for the patient. All patients were managed according to standard protocols. The flow of oxygen and other gases was noted. Any change in their concentrations along with the duration of use was also recorded.

The cost of oxygen and nitrous oxide was calculated as the quantity of total gases used, multiplied by the cost of one liter of gas. Medical air is supplied as compressed air; hence, there are no variable costs involved and were not included in cost analysis. As the inhalational agents are supplied in liquid formulations but used as vapors, the amount of liquid used was calculated by the Dion's[10] formula corrected for ambient temperature as described by Biro.[11,12] Both, fresh gas flow (FGF) and concentration are subject to multiple changes, which may happen independently of each other. The FGFs and concentrations for the time period they were constant were noted. This was again noted if either the flows or the concentrations were changed. Therefore, the time segment with constant FGF and concentrations were identified and the consumption values were extracted for each of these time segments, which in turn were summed up for the concluding amount of consumed agent at the end of the case.

At the end of surgery, total utilization of each drug was noted and any drug remaining was regarded as wastage and taken into account. Fresh syringes and drugs were used for each patient so as to avoid cross infection. Use of more than one syringe for a particular drug and needles used in excess of syringes were counted as wastage. The cost of consumables, drugs, inhalational agents, oxygen and nitrous oxide were recorded as per the maximum retail price for that particular brand in the market at the start of the study and unit price calculated [Annexure I].

For the purpose of analysis high flow anesthesia was defined as total FGF >2 L/min and low flow anesthesia as total FGF ≤2 L/min during the maintenance phase with a targeted MAC of 0.8-1.2. TIVA implied that nitrous oxide and volatile anesthetic agents were not used during the entire anesthetic duration. Soda lime canister was expected to last 8 h and was changed daily. Same brand of soda lime was used for all cases. The cost of soda lime was calculated based on the duration of anesthesia. Based on the institutional practice, the cases were divided into five groups:

High flow sevoflurane (HS): FGF >2 L min^{-1} and sevoflurane used throughout

Low flow sevoflurane (LS): FGF <2 L min^{-1} and sevoflurane used in maintenance

High flow isoflurane (HI): FGF >2 L min^{-1} and isoflurane used throughout

Low flow isoflurane (LI): FGF <2 L min^{-1} and isoflurane used in maintenance, and

Total intravenous anesthesia (TIVA): Anesthesia maintained with oxygen, air, and propofol infusion (since target control infusion pumps are not available in our institute, propofol was calculated and administered on the basis of per Kg body weight. Hemodynamic parameters and surrogate signs were used to monitor depth of anesthesia as Bi Spectral Index was not available).

Cost identification analysis was done as follows:

Total variable cost = Cost of consumables + cost of intravenous induction and maintenance drugs used + cost of inhalational agents + cost of O_2 + cost of N_2O + cost of other intravenous drugs used + cost of drugs left unused.

Total cost per case and total cost of wastage of drugs as a percentage of total cost of drugs loaded were also calculated and compared between groups to arrive at the cheapest modality of anesthesia per patient per hour.

We could not find a similar comprehensive study in literature to calculate the sample size.

Based on approximately 400 adult general anesthetics administered in our department from January to July 2014, we expected to recruit at least 250 patients according to our inclusion criteria.

The data were compiled, tabulated, and statistically analyzed using SPSS version 23.0. Quantitative analysis of mean cost per case (± SD) between different modalities was done by Kruskal–Wallis test. Qualitative analysis of percentage of total wastage of drugs was analyzed using Kruskal–Wallis/Mann–Whitney U test. A P value of <0.05 was accepted as significant.

Results

A total of 269 cases were recruited for the study. Four patients refused consent, duration of surgery was found to be more than 4 hours in three cases and in four cases multiple inhalational agents were used. Data from 258 cases were therefore tabulated and analyzed.

The patients did not differ between groups with respect to age, sex, duration of surgery and duration of anesthesia. The type of surgeries is described in Table 1.

Total cost of general anesthesia was ₹5,99,862.90 for 258 cases and mean cost for study population was ₹2325.05 ± 523.87, the difference in cost was statistically significant between groups. The mean cost was highest in TIVA group followed by high flow sevoflurane group. The mean cost in high flow groups was higher than that of low flow groups [Table 1].

The mean wastage was ₹131.67 ± 101.84. The mean wastage cost was higher in low flow sevoflurane group; however, this difference was statistically not significant among groups [Table 2]. The mean cost of drugs wasted was 13.1% of the total cost of drugs issued for the patient, which was significantly different among groups ($P < 0.01$). The percentage drug wastage was least in the TIVA (9.0%) group as compared to other groups [Table 1]. The major component of wastage was muscle relaxant accounting for 38–71% of total wastage costs. Propofol in TIVA group accounted for 43% of total wastage [Table 2].

The cost of anesthesia was further categorized and analyzed as per the phase of anesthesia viz premedication, induction, maintenance, reversal, and consumables.

The mean cost of premedication was ₹70.32 ± 20.94 which was significantly different between groups. The cost of premedication was much higher in LI, LS, and TIVA groups when compared to the high flow groups [Table 3].

The mean cost of induction was ₹377.84 ± 107.45. Induction cost was least in TIVA group as compared to groups where inhalational agent was used during induction; the difference in induction cost was statistically significant between groups (Table 3).

The mean cost of maintenance was ₹757.74 ± 462.25. Cost of maintenance in high flow sevoflurane was almost equivalent to TIVA. However, it was higher than other groups and this difference was statistically significant between groups [Table 4].

The mean cost of oxygen used during reversal was significantly different among groups. However, cost of neostigmine and glycopyrrolate was not different between groups [Table 4].

The mean cost of consumables was ₹1042.39 ± 145.21 ($15.35/≤11.41) and was highest in TIVA. Difference in cost was statistically significant among groups [Table 4].

Discussion

Providing an efficient, safe, and quality healthcare has been the focus in this era of modernization and advanced technologies. One of the most important limiting factors in development of newer technologies and advancements has been their cost of utilization at the patient level. In order to avail efficient and safe treatment, the patient is indebted to pay more. The cost of healthcare to a patient is mainly attributed to the demand of the patient, availability of resources, facility of healthcare, and also to the paying ability of the payer.[13]

The cost of anesthesia in healthcare setup is mainly divided into fixed and variable commodities. The fixed equipments include the gas pipelines, operating tables, anesthesia machines, and various others which are one time investments and barely have an impact on the day-to-day expenditure on each surgery. The variables which include the consumables, anesthetic drugs, and gases mainly have an impact on the total cost borne by the patient/institution.

Cost containment and cost-effective use of resources has become a priority within healthcare. This can be achieved by

Table 1: Patient characteristics and cost of anesthesia

	Total (*n*=258)	LS (*n*=51)	HS (*n*=56)	HI (*n*=52)	LI (*n*=52)	TIVA (*n*=47)	*P*
Age (years)	35.9±10.7	35.4±9.2	38.2±11.6	35.7±10.9	37.6±11.5	32.2±9.1	
Sex							
F	224	46	42	44	46	46	
M	34	5	14	8	6	01	
Duration of anesthesia (min)	95.9±36.4	87.2±28.5	92.4±29.0	91.8±32.1	109.1±48.3	99.3±38.5	
Total cost/patient	2325.05±523.87 ($34.25/£25.46)	2050.51±291.32	2631.30±556.12	2255.50±422.22	1981.62±335.03	2713.82±509.57	**<0.01**
Drug wastage	13.1%	17.6%	17.0%	12.4%	13.0%	9.0%	**<0.01**
Surgery	Laparoscopic cholecystectomy (*n*=164)	34	35	40	35	20	
	Diagnostic laparo-hysteroscopy (*n*=48)	9	9	3	7	20	
	Laparoscopic cystectomy (*n*=19)	2	4	1	5	7	
	Laparoscopic hernioplasty (*n*=17)	5	5	5	2	-	
	Breast mass excision (*n*=3)	1	1	1	-	-	
	Total laparoscopic hysterectomy (*n*=4)	-	-	1	3	-	
	Hemithyroidectomy (*n*=3)	-	2	1	-	-	

	LS vs HS	LS vs HI	LS vs LI	LS vs TIVA	HS vs HI	HS vs LI	HS vs TIVA	HI vs LI	HI vs TIVA	LI vs TIVA
Total cost/patient	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 2: Wastage

Wastage Cost	Total (*n*=258)	LS (*n*=51)	HS (*n*=56)	HI (*n*=52)	LI (*n*=52)	TIVA (*n*=47)	*P*
Consumables	21.21±61.31	30.84±79.60	17.41±61.74	38.17±78.96	15.82±40.25	2.44±3.37	**<0.01**
Premedication	18.69±12.73	20.71±11.69	17.82±13.41	17.43±15.60	20.46±14.62	16.93±4.46	**0.03**
Muscle Relaxant	75.52±74.10	97.50±74.53	99.92±96.77	58.65±64.08	62.40±59.60	55.73±52.67	**<0.01**
Induction Agent	2.91±10.62	2.87±8.12	5.24±14.81	3.67±11.80	2.30±10.61	0.0±0.0	**<0.01**
Others	2.49±6.25	4.98±7.86	0.557±1.87	1.418±5.40	2.33±6.45	3.44±7.39	**<0.01**
Propofol	10.97±36.56	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	60.23±66.59	**<0.01**
Total	131.67±101.84 ($1.93/£1.44)	156.92±117.92 ($2.31/£1.71)	140.97±116.18 ($2.07/£1.54)	119.35±107.28 ($1.75/£1.30)	103.34±64.92 ($1.52/£1.13)	138.14±85.56 ($2.03/£1.51)	0.09

Wastage Cost	LS vs HS	LS vs HI	LS vs LI	LS vs TIVA	HS vs HI	HS vs LI	HS vs TIVA	HI vs LI	HI vs TIVA	LI vs TIVA
Consumables	0.87	0.87	0.95	**<0.01**	0.94	0.75	**<0.01**	0.89	**0.01**	**<0.01**
Premedication	0.07	0.07	0.29	**<0.01**	0.89	0.47	0.4	0.46	0.25	0.13
Muscle relaxant	0.69	**<0.01**	**0.01**	**<0.01**	**0.02**	0.05	**0.02**	0.58	0.91	0.67
Induction agent	0.89	0.58	0.26	**<0.01**	0.52	0.22	**<0.01**	0.56	**<0.01**	**<0.01`**
Others	**<0.01**	**<0.01**	**0.01**	0.11	0.47	0.16	**0.04**	0.49	0.22	0.49
Propofol	1	1	1	**<0.01**	1	1	**<0.01**	1	**<0.01**	**<0.01**
Total	0.3	**0.04**	**0.01**	0.68	0.33	0.29	0.54	0.78	0.15	**0.03**

modifying the variable cost, which may be determined by the technique of anesthesia.

Cost identification studies can be performed only when we assume that the technique of anesthesia does not affect the patient outcome and any of the techniques would have been equally safe and efficacious. Ours was a real-time cost calculation and none of the variables were controlled.

The total anesthetic cost (irrespective of duration) was highest for TIVA and this can be attributed to high cost of propofol (₹0.95 mg^{-1}) compared to groups where inhalational agents (isoflurane: ₹11.27 ml^{-1}; sevoflurane: ₹29.38 ml^{-1} of liquid) were used. The cost was lowest in LI group primarily due to reduced consumption ((MAC_{iso} = 1.2; MAC_{sevo} = 2) and low per unit cost of isoflurane. Despite this, the mean cost of LS group was less than that of HI

Table 3: Cost of premedication and induction

	Total (*n*=258)	LS (*n*=51)	HS (*n*=56)	HI (*n*=52)	LI (*n*=52)	TIVA (*n*=47)	*P*
Fentanyl	58.87±16.64	53.44±17.86	53.62±17.41	51.28±15.78	57.50±18.04	47.98±12.12	0.15
Midazolam	17.53±12.21	20.39±10.80	13.46±13.10	12.50±13.11	17±12.49	25.44±3.79	**<0.01**
Total cost	70.32±20.94 ($1.03/£0.77)	73.83±21.69 ($1.08/£0.80)	67.08±22.66 ($0.98/£0.73)	63.38±22.21 ($0.93/£0.69)	74.50±21.69 ($1.09/£0.81)	73.43±12.01 ($1.08/£0.80)	**<0.01**
Induction agent	47.94±42.73	45.66±44.33	50.77±51.50	42.08±38.28	38.65±42.40	63.77±29.42	**<0.01**
Muscle relaxant	267.92±86.67	288.27±67.70	251.99±121.49	268.41±84.07	266.16±79.68	266.21±60.81	0.91
Oxygen	0.429±0.243	0.415±0.25	0.499±0.281	0.471±0.25	0.400±0.213	0.345±0.160	**<0.01**
Nitrous oxide	22.94±15.90	33.54±11.14	25.81±12.61	20.05±9.45	33.07±13.11	0.0±0.0	**<0.01**
Inhalational agent	47.22±42.38	69.68±29.11	69.65±52.41	21.28±36.31	26.95±10.97	0.0±0.0	**<0.01**
Total cost	377.84±107.45 ($5.56/£4.13)	437.58±100.76 ($6.44/£4.79)	398.73±137.39 ($5.87/£4.36)	352.31±91.43 ($5.19/£3.85)	365.25±88.97 ($5.38/£4.00)	330.33±71.72 ($4.86/£3.61)	**<0.01**

Bold value are mean with P<0.05

	LS vs HS	LS vs HI	LS vs LI	LS vs TIVA	HS vs HI	HS vs LI	HS vs TIVA	HI vs LI	HI vs TIVA	LI vs TIVA
Midazolam	**<0.01**	**<0.01**	0.14	**<0.01**	0.7	0.15	**<0.01**	0.08	**<0.01**	**<0.01**
Total cost	0.08	**0.01**	0.92	0.74	0.39	0.08	**0.02**	**0.01**	**<0.01**	0.85
Induction agent	0.41	0.59	0.39	**<0.01**	0.73	0.09	**<0.01**	0.15	**<0.01**	**<0.01**
Oxygen	0.06	0.14	0.83	0.12	0.66	**0.02**	**<0.01**	0.06	**<0.01**	0.13
Nitrous oxide	**<0.01**	**<0.01**	0.94	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
Inhalational agent	0.29	**<001**	**<0.01**	-	**<0.01**	**<0.01**	-	**<0.01**	-	-
Total cost	0.25	**<0.01**	**<0.01**	**<0.01**	**0.04**	0.11	**<0.01**	0.51	0.06	**<0.01**

and HS group which emphasizes the fact that low flows reduce costs.[14-16]

Provided flows are constant, nonsoluble agents, such as desflurane and sevoflurane, are costlier than isoflurane.[17-21] This difference is due to sevoflurane being 2.5 times costlier than isoflurane. Boldt *et al.* found the anesthesia costs similar irrespective of isoflurane or sevoflurane since the cost of acquisition for both the agents was comparable.[6]

TIVA, on the contrary, has been universally found to be the costliest technique, comparable only to sevoflurane when used at high flows.[6,22-25]

Breaking down the total cost of anesthesia, we found that the cost of premedication was largely determined by midazolam with highest consumption in TIVA group and the groups with low flow anesthesia techniques as compared to high flow groups.

The induction cost was largely determined by the induction agent used, i.e., thiopentone or propofol in the inhalational group and the cost of inhalational agent as compared to TIVA group where only propofol was used. The carrier gases used in induction contributed to reduction in cost in TIVA group as nitrous oxide was not used.

Paradoxically, the cost of induction was highest in LS group as compared to HS group. Being a relatively insoluble agent, MAC of sevoflurane is easily attained using high flows. While high flows allow an early equilibrium and subsequent less dialed concentration, the opposite holds true for low flow anesthesia. An initial high flow and high concentration are required to "charge" the circuit and saturate the soda lime so that when the flows are reduced, MAC does not decrease. Similarly, flows need to be increased during reversal phase to facilitate the outflow of the anesthetic gases. Whichever technique is used, the total cost of anesthesia thus hinges on the maintenance phase. Therefore, use of low fresh gas flow reduces the cost by almost 50% as a direct consequence of reduction of flows. The cost of soda lime used for low flow technique is mitigated by reduction in the cost of nitrous oxide. With TIVA, higher unit cost of propofol as compared to inhalational agents is the major contributor to increased costs.

The cost of muscle relaxant used was not significantly different among groups. This was because their use is independent of anesthesia technique and depends on patient and duration of surgery.

The difference in cost of oxygen consumption during reversal phase may be attributed to the duration of oxygen used. The cost of neostigmine and glycopyrrolate was not significantly different.

The consumables constitute 45% of total cost. The cost of consumables was highest in TIVA group attributed to use of extension tubing, three-way, and 50 ml syringes. While procuring consumables at a lower price may compromise

Table 4: Cost of maintenance, reversal, and consumables

	Total (n=258)	LS (n=51)	HS (n=56)	HI (n=52)	LI (n=52)	TIVA (n=47)	P
Muscle relaxant	178.07±121.69	171.73±100.47	208.07±139.11	186.48±139.72	184.22±126.36	133.11±77.19	0.16
O_2	1.88±1.45	0.914±0.36	3.04±1.42	3.20±1.49	1.13±0.49	0.867±0.573	**<0.01**
N_2O	187.97±187.13	83.917±37.08	353.50±178.71	369.20±155.51	100.43±41.33	0.0±0.0	**<0.01**
Maintenance agent							
Inhalational agent	387.24±375.54	148.11±76.36	511.44±319.83	137.02±83.36	62.34±40.09	0.0±0.0	**<0.01**
Propofol		0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	860.56±403.32	
Opioid used	12.04±22.89	11.20±24.96	4.88±14.43	4.04±12.50	12.41±23.68	29.94±27.26	**<0.01**
Antiemetic	15.36±9.26	21.85±7.69	17.96±5.73	16.67±4.16	18.75±6.38	0.0±0.0	**<0.01**
Analgesic	11.78±1.09	11.52±1.90	12±0.0	11.53±1.29	11.92±0.55	11.91±0.58	**0.03**
Soda lime	13.20±13.38	19.98±6.52	0.0±0.0	0.0±0.0	24.99±11.07	22.76±8.81	**0.03**
Total cost	757.74±462.25 ($11.16/£8.30)	470.57±201.14 ($6.93/£5.15)	1110.9±532.37 ($16.36/£12.16)	728.15±316.09 ($10.72/£7.97)	416.21±192.69 ($6.13/£4.55)	1059.14±435.95 ($15.60/£11.60)	**<0.01**
Neostigmine	25.59±4.12	25.60±4.64	26.72±4.27	25.19±3.70	25.19±4.15	25.07±3.62	0.19
Glycopyrrolate	50.33±11.09	52±13.24	53.22±10.58	49.29±10.34	48.26±10.77	48.47±9.60	0.08
O_2	0.840±0.44	0.884±0.50	0.932±0.45	0.881±0.33	0.867±0.43	0.609±0.38	<0.01
Gloves	14.33±3.99	15.52±4.88	14.92±3.73	13.75±3.69	14.06±3.98	13.22±3.17	**0.04**
IV cannula	224.07±73.20	228.24±81.7	216.70±67.44	242.88±96.71	221.25±62.08	210.64±43.67	0.58
Tegaderm	46.04±6.80	45±0.0	45±0.0	47.59±10.59	46.73±8.73	45.95±6.56	0.22
IV set	76.45±10.36	75±0.0	75±0.0	79.32±17.65	77.88±14.56	75±0.0	0.09
Electrodes	31.83±2.05	31.91±2.94	32.25±2.72	31.70±1.45	31.50±0.0	31.72±1.53	0.21
IV fluid	221.58±86.31	210.74±79.53	201.62±68.74	227.08±97.60	248.84±114.76	220.90±49.32	**<0.01**
Extension tubing	27.71±48.82	4.31±21.56	9.82±31.65	8.46±29.59	12.69±35.48	112.34±16.04	**<0.01**
Three way	11.84±25.14	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	65.00±0.0.	**<0.01**
Syringes	108.20±14.24	102.22±11.59	102.18±12.43	108.47±10.63	111.01±10.96	118.49±18.50	**<0.01**
Needles	22.08±3.22	22.17±2.40	22.17±2.72	23.65±2.27	23.88±2.58	18.12±2.65	**<0.01**
Suction catheter	42.67±3.78	43±0.0	41.46±8.05	43±0.0	43±0.0	43±0.0	0.12
Endotracheal tube	185.00±0.0	185±0.0	185±0.0	185±0.0	185±0.0	185±0.0	1
Ryle's tube	30.17±21.19	28.23±21.97	25.71±22.47	25.09±22.56	35.48±18.55	37.34±17.09	**<0.01**
Total cost	1042.39±145.21 ($15.35/£11.41)	991.35±113.03 ($14.60/£10.85)	973.72±96.54 ($14.34/10.66)	1036.02±175.67 ($15.26/£11.34)	1051.34±147.71 ($15.48/£11.51)	1176.75±84.69 ($17.33/£12.89)	**<0.01**

Bold value are mean with P<0.05

	LS vs HS	LS vs HI	LS vs LI	LS vs TIVA	HS vs HI	HS vsLI	HS vs TIVA	HI vs LI	HI vs TIVA	LI vs TIVA
Oxygen	**<0.01**	**<0.01**	**<0.01**	0.05	0.48	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
Nitrous Oxide	**<0.01**	**<0.01**	**0.01**	**<0.01**	0.3	**<0.01**	**<0.01**	**<0.01`**	**<0.01**	**<0.01**
Maintenance agent	**<0.01**	0.18	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.01**
Opioid	0.14	0.09	0.57	**<0.01**	0.83	**0.03**	**<0.01**	**0.02**	**<0.01**	**<0.01**
Antiemetic	**<0.01**	**<0.01**	**0.03**	**<0.01**	0.18	0.49	**<0.01**	0.05	**<0.01**	**<0.01**
Analgesic	**0.03**	0.55	0.16	0.19	**<0.01**	0.29	0.28	0.05	0.07	0.94
Total Cost	**<0.01**	**<0.01**	**0.02**	**<0.01**	**<0.01**	**<0.01**	0.65	**<0.01**	**<0.01**	**<0.01**
O2	0.33	0.58	0.98	**<0.01**	0.63	0.27	**<0.01**	0.49	**<0.01**	**<0.01**
IV Fluid	0.65	0.32	**<0.01**	**0.03**	0.13	**<0.01**	**<0.01**	0.07	0.32	0.33
Extension Tubing	0.29	0.42	0.15	**<0.01**	0.82	0.66	<0.01	0.51	**<0.01**	**<0.01**
Three Way	1	1	1	**<0.01**	1	1	**<0.01**	1	**<0.01**	**<0.01**
Syringes	0.74	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.21	0.06	0.45
Needles	0.99	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.72	**<0.01**	**<0.01**
Ryle's Tube	0.56	0.47	0.07	**0.03**	0.89	0.01	**<0.01**	**0.01**	**<0.01**	0.6
Total Cost	0.59	0.12	**<0.01**	**<0.01**	**0.04**	**<0.01**	**<0.01**	0.06	**<0.01**	**<0.01**

on their quality, in a system of healthcare as present in our country, a central administrative policy to decrease the price of consumables can drastically cut the anesthesia costs.

Limiting wastage of drugs and other items can also lead to significant decreases in the cost of anesthesia. Approximately, ₹131.67 of the total cost of anesthesia comprised of items not utilized (5.7%).

The most commonly wasted were drugs (87%), of which muscle relaxants contributed 58% of total wastage. This signifies a greater scope of utilization by reducing the wastage of muscle relaxants. Instead of full vial, withdrawing drug as required would have decreased wastage. Also, the formulations available may not be commensurate with the prescribed dosages. The case in point refers to midazolam which is supplied in our hospital as 5 mg/mL ampoule, while premedication dose for an adult patient is 1–2 mg. Similarly, bulk vial of propofol i.e., 50 mL vial is much cheaper than five 10 mL vials which were used for maintenance phase in the TIVA group.

We find our results in concurrence with Lustig *et al.*[26] who reported muscle relaxants (72%) and propofol (13%) as major components of wastage. The findings of our study were in contrast to the findings of Chaudhary *et al.*[9] The major component of wastage was induction agent (56.27% of the total wastage), while muscle relaxant contributed to 17.8% of total cost of wastage in their study.

Although only 16% of wastage was attributable to consumables- mainly intravenous cannula and syringes, this can be easily corrected by proper education and rational use. The most common reason for wastage of cannula was a pre-existing narrow bore cannula already secured in the wards which was changed in the operating room. Rationale use of syringes implies that only a single syringe is used for a particular drug.

Since this is a cost identification study, the cost of fixed elements such as personnel and machine costs was not included. Actual cost of a technique can be evaluated only if benefits are also considered. For example, a technique may be cheap but if it is associated with significant postoperative pain or nausea vomiting and necessitates a greater stay in the postoperative care unit, the combined cost may actually be higher. This anomaly can only be corrected by performing cost-effectiveness or a cost benefit analysis which was not the aim of our study. The other limitation includes a single center study. This was mitigated by taking into account the anesthetic practices of different consultants.

Conclusion

To conclude, use of low flow anesthesia with isoflurane significantly decreases the cost of anesthesia as compared to use of high flow techniques or TIVA even for short duration surgeries. Substituting high flow sevoflurane and high flow isoflurane with low flow isoflurane would result in savings of ₹650 and ₹274 per case, respectively. While this difference may not be much in the total patient care cost, it amounts to roughly a reduction of 12–28% of mean cost of anesthesia. A further reduction in wastage would increase the savings by at least 5%.

Financial support and sponsorship

Institutional.

Conflicts of interest

There are no conflicts of interest.

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Annexure I

Agent	Package	Unit	Cost per unit (₹)
Fentanyl	100 μg/ampoule	1 μg	0.42
Midazolam	5 mg/ampoule	1 mg	5.2
Thiopentone	1 gm/vial	1 mg	0.049
Propofol	100 mg/vial	1 mg	0.95
Rocuronium	50 mg/vial	1 mg	7.82
Scoline	500 mg/vial	1 mg	0.126
Ondansetron	4 mg/ampoule	1 mg	3.87
Diclofenac	75 mg/ampoule	1 mg	0.16
Soda lime	5 kg/canister	1 kg	110
Neostigmine	500 μg/ampoule	1 mg	8.48
Glycopyrrolate	0.2 mg/ampoule	0.1 mg	8.9
Isoflurane	100 ml/bottle	1 ml	11.27
Sevoflurane	250 ml/bottle	1 ml	29.38
Oxygen		1 L	0.0212
Nitrous oxide		1 L	1.3
Gloves	50 pair/pack	1 pair	5.5
18G cannula	Per pack	1 pc	195
20G cannula	Per pack	1 pc	210
Tegaderm	Per pack	1 pc	45
Infusion set	Per pack	1 pc	75
Extension tubing	Per pack	1 pc	110
Three way stopcock	Per pack	1 pc	65
10 ml syringe	Per pack	1 pc	15.5
5 ml syringe	Per pack	1 pc	12
2 ml syringe	Per pack	1 pc	9.5
50 ml syringe	Per pack	1 pc	27
ET tube	Per pack	1 pc	185
Suction catheter	Per pack	1 pc	43
Ryle's tube	Per pack	1 pc	45
RL	Per pack	1 bottle	55.82