

# Cost of Anesthetic Supplies and Staffing for Operative Anesthesia is \$8.62 per Minute

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**Objectives:** The purpose of this study is to characterize the cost per minute for anesthesia care in the operating room based on currently published literature.

**Design:** Systematic literature review.

**Main outcome measurement:** cost per minute (\$/min)

**Results:** Google Scholar and PubMed search produced 824 articles regarding “anesthesia cost per minute” of which 18 had novel estimates for anesthesia cost per minute. The mean cost of anesthesia staffing was  $\$5.51 \pm \$3.71$ , anesthetics  $\$3.11 \pm \$4.08$  for a combined cost per minute for OR anesthesia care of \$8.62.

**Conclusion:**

Published estimates of anesthesia costs are rare and largely of low quality. The best estimate based on the literature is \$8.62 per minute, however, there is significant room for improving this estimate.

**Level of Evidence:** IV; Systematic Review of level IV or higher evidence

**Keywords:** Business, management, human resources, cost, value, efficiency.

(*J Ortho Business 2023; Volume 3, Issue:3, Pages 17-20*)

## INTRODUCTION

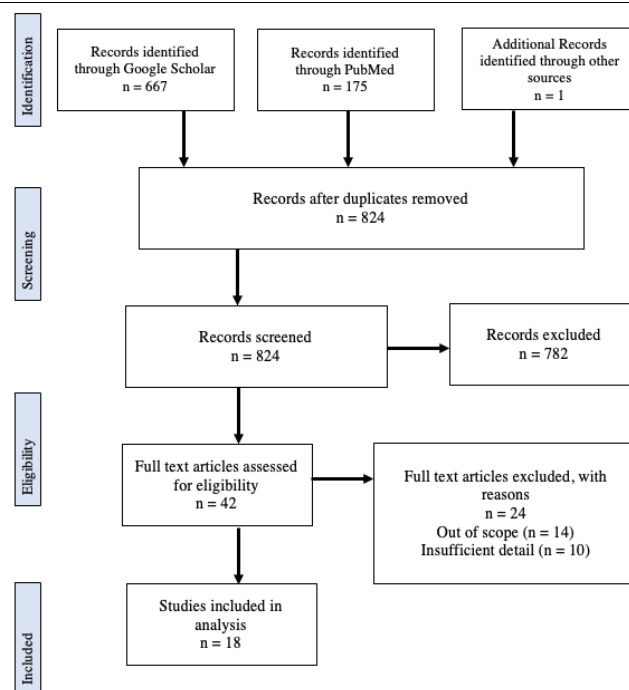
With advancements in medical technology, increased prevalence of same-day elective surgical procedures, and rising healthcare expenditure, cost-effectiveness for patients and healthcare organizations is paramount<sup>1-4</sup>. Previous studies have analyzed the costs of running an operating room<sup>5</sup>; however, the costs of performing and administering anesthesia were not clearly defined. The purpose of this study is to review available literature estimating the cost per minute of anesthesia in the operating room, including various anesthetic agents and the cost of personnel.

## METHODS

A literature search was performed using Google Scholar through Publish or Perish and PubMed. The search keywords used for Google Scholar and PubMed were “anesthesia cost per minute”. Results from 1995 through 2023 were obtained. One additional source was obtained outside of Google Scholar and PubMed literature search in a review of citations from included articles.

After duplicates were removed, all results were independently reviewed by two authors. First, the titles were screened for eligibility. Then, abstracts of selected articles were reviewed and articles potentially containing estimates regarding anesthesia cost per minute were included. Full texts were then screened to determine what was included and not included in the anesthesia cost. The PRISM Diagram is shown in Figure 1.

Figure 1: PRISM Diagram



For most sources, a single number was used to calculate the average anesthesia cost per minute. For one source that only reported a range for multiple anesthetic agents, a range of values was calculated for average anesthesia cost per minute. The fiscal year was used for estimating the cost when available in a few sources and the publication year was used when not. All costs given in Euros were converted to USD. All costs were adjusted for inflation to 2022 USD.

## RESULTS

After duplicates were removed, 824 articles were generated from the literature search. After screening the titles, 782 articles were discarded. Out of the 42 articles remaining, 14 articles were excluded for being out of scope. 10 articles were excluded for insufficient detail. For example, anesthesia cost may have been provided without the length of anesthesia time so anesthesia cost per minute could not be calculated. 18 studies were finally included in the analysis.

Out of the 18 studies, 7 studies only contained information about the anesthetic agent cost per minute. The mean cost of all anesthetic agents adjusted to 2022 dollars from all seven studies was \$3.11 per minute of anesthesia (SD \$4.08)<sup>6-12</sup> (Table 1). The mean cost of propofol was \$5.33 per minute (SD: \$5.69)<sup>6,7,12</sup>. The mean cost of all inhaled anesthetics (sevoflurane, desflurane, isoflurane) was \$1.08 per minute (SD: \$1.51)<sup>6,7,9-11</sup>.

11 out of 18 studies contained information regarding overall cost of anesthesia for various procedures, cost of anesthesiologist personnel, cost of anesthesia nurse personnel, or cost of post-anesthesia care (Table 2). Out of the 11 articles included, 2 articles were specific to orthopaedic procedures, which were ACL reconstruction and carpal tunnel release. The mean overall cost of anesthesia staffing adjusted to 2022 dollars was \$5.51 with a standard deviation of \$3.71<sup>13-23</sup>.

The combination of anesthetic and staffing yields an estimated cost per minute for anesthesia of \$8.62 per minute.

## DISCUSSION

The purpose of this study was to determine the inflation-adjusted cost of one minute of anesthesia time based on the reported data available within the current literature.

From the eighteen articles that met inclusion criteria, it was determined that the mean cost of all anesthetic agents was \$3.11 per minute of anesthesia (SD \$4.08)<sup>6-12</sup> and the mean overall cost of anesthesia was \$5.51 (SD \$3.71)<sup>13-23</sup>. The combination of anesthetic and staffing yields an estimated cost per minute for anesthesia of \$8.62 per minute. For anesthetic agents, propofol was the most expensive at \$5.33 per minute with the highest standard deviation at \$5.69<sup>6,7,12</sup>, compared to inhaled agents at \$1.08 per minute<sup>6,7,9-11</sup>. Out of the seven studies concerning anesthetic agents per minute, three of the studies were specific to laparoscopic surgery which had higher costs per minute<sup>7,8,12</sup>. This can be attributed to the fact that laparoscopic patients typically have higher BMI and thus have higher anesthesia requirements<sup>24</sup>. The remaining eleven studies looking at overall costs of anesthesia was largely composed of personnel costs. When comparing costs among the varying types of operative procedures, most of them require the same anesthesia burden. However, it was determined that the cost of anesthesia for emergent surgery for colonic cancer was more expensive at \$15.57 per minute for emergent surgery versus \$9.73 per minute for elective surgery<sup>17</sup>. Only two studies were specific to orthopaedic procedures (ACL reconstruction and carpal tunnel release), with the cost of personnel being more expensive at \$5.29 per minute for a carpal tunnel release<sup>19</sup> versus \$4.90 for an ACL reconstruction<sup>18</sup>.

It is difficult to quantify and compare anesthesia costs due to the high variability of accounting methods and transparency of indirect costs. The lack of a standard most likely contributes to the standard deviations that were greater than the mean. However, in more recent articles including the two articles specific to orthopaedic procedures, there is a trend towards using Time-Driven Activity-Based Costing (TDABC) as a bottom-up costing methodology that calculates the costs of resources consumed as a patient moves along the care process<sup>19</sup>. By utilizing a time map approach and thus requiring a high visibility into each contributing component to the orthopaedic care process, cost analysis can more accurately identify redundancies and improve workflow and

Table 1: Cost per minute based on anesthesia type

Author	Year	\$/min	\$/min inf adj	Included
Bockskai et. al	2018	\$0.22	\$0.26	Propofol in ear-nose-throat surgery
		\$0.20	\$0.24	Sevoflurane in ear-nose-throat surgery
Braun et. al	2005	\$2.68	\$4.07	Desflurane in laparoscopic prostatectomy
		\$2.79	\$4.23	Propofol in laparoscopic prostatectomy
Fodale et. al	2005	\$1.32	\$2.02	Fentanyl in laparoscopic cholecystectomy
		\$1.09	\$1.67	Remifentanyl in laparoscopic cholecystectomy
Golembiewski et. al	2010	\$0.56	\$0.77	Desflurane
		\$0.79	\$1.08	Sevoflurane
Ponsonnard et. al	FY2011-2012	\$0.12-	\$0.16-	Halogenated agents (sevoflurane, isoflurane, desflurane)
		\$0.14	\$0.18	
Singh et. al	2013	\$0.16	\$0.20	Sevoflurane in pediatric short procedures
Wagner et. al	1995	\$5.77	\$11.49	Propofol in laparoscopic gynecologic surgery
		\$5.59	\$11.13	Thiopental in laparoscopic gynecologic surgery
Overall	Average	\$1.78	\$3.11	
	SD	+/- 2.04	+/- 4.08	
Propofol	Average	\$2.93	\$5.33	
	SD	+/- 2.77	+/- 5.69	
Inhaled anesthetics	Average	\$0.75	\$1.08	Sevoflurane, desflurane, isoflurane
	SD	+/- 0.98	+/-1.51	

Table 2 Cost per minute based on anesthesia staff

Author	Year	\$/min	\$/min infl adj	Included
Allen et. al	2016	\$10.00	\$12.41	One unit of anesthesia
Borendal et. al	2011	\$2.27	\$2.98	Personnel in abdominal hysterectomy Time in post-anesthesia care Anesthesia in the OR
		\$1.34	\$1.76	
		\$0.93	\$1.22	
Childers et. al	2018	\$3.42	\$4.29	Anesthesia in laparoscopic appendectomy
Demirel et. al	2014	\$1.10	\$1.39	Anesthesia in open appendectomy
		\$1.12	\$1.41	Anesthesia for elective surgery for colonic cancer
Janson et. al	2004	\$3.02	\$4.83	Anesthesia for emergent surgery for colonic cancer
		\$9.73	\$15.57	
Koolmees et. al	2021	\$3.96	\$4.90	Anesthesiologist personnel for ACL reconstruction
Martin et. al	2018	\$4.40	\$5.29	Attending and CRNA for carpal tunnel release
		\$3.17	\$3.81	Attending and resident for aortic valve replacement
		\$3.61	\$4.65	Anesthesia and time in post-anesthesia care
Raft et. al	FY2012	\$3.61	\$4.65	
Schuster et. al	2004	\$3.34	\$5.23	Anesthesiologist personnel cost
		\$1.31	\$2.05	Anesthesia nurse personnel cost
		\$0.88	\$1.38	Material and pharmaceutical costs
		\$0.65	\$1.02	Overhead costs
		\$0.49	\$0.77	Anesthesiologist personnel cost
Shippert et. al	2005	\$4.00	\$6.24	Personnel cost in pediatric appendectomy
Yu. Al	2016	\$3.62	\$4.48	
Average		\$4.05	\$5.51	
SD		+/- 2.55	+/- 3.75	

cost efficiency of all participating teams, to include anesthesia, radiology, pathology, and implants.

Another weakness of this study is its limited applicability to orthopaedic procedures. The articles included in this study mainly addressed the costs associated with personnel, inhaled agents, and propofol. With the greater prevalence of same-day elective orthopaedic surgeries, many anesthesiologists are utilizing regional blocks with Monitored Anesthesia Care (MAC) or Laryngeal Mask Airways (LMA) which require a lower general anesthesia burden than Endotracheal Intubation (ETT). Thus, in regard to orthopaedic procedures, the mean cost of anesthesia determined in this study is potentially inflated, given the lengthier time of stay and complications associated with extubation. Further research is warranted to not only elucidate a reproducible standard for how costs are measured and accounted for, but also a more accurate reflection of anesthesia use in orthopaedic procedures.

## CONCLUSION

In conclusion, the cost of anesthesia during surgical procedures is poorly reported in the literature and can vary considerably based upon methods and pharmaceuticals used. Further efforts are needed to better quantify and delineate the steps and costs associated with anesthesia care in order to identify areas of redundancy and improve workflow and efficiency.

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