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# Price analysis of medicines used in general anesthesia before and after the SARS-CoV-2 pandemic: a retrospective observational study

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## Abstract

**Objectives:** with the emergence of the pandemic in early 2020, there was an increase in the prices of medicines used in hospital anesthetic procedures. The main objective of this study was to assess the variations in prices of anesthetics used in general anesthesia procedures between the periods prior to and after the beginning of the SARS-CoV-2 pandemic. **Methods:** we investigated 105 anesthetic records of exploratory laparotomies or laparoscopic procedures performed in a private hospital in southern Brazil and analyzed the prices of medicines used in two general anesthesia techniques: total intravenous anesthesia (TIVA) and balanced anesthesia with anesthetic gases. We obtained the price of anesthetic procedures from records issued in the final trimesters of 2019, 2020, and 2021 (33, 43, and 29, respectively). **Results:** a statistically significant difference in prices was seen between periods for both techniques. The price of TIVA in 2019 was R\$ 229.30/hour, in 2020 it was R\$ 472.13/hour, and in 2021 it was R\$ 247.38/hour. For balanced anesthesia, this price was R\$ 66.32/hour in 2019, R\$ 109.97/hour in 2020, and R\$ 90.30/hour in 2021. In a post hoc analysis, significant differences were observed in the hourly prices of TIVA between 2019–2020 ( $p=0.01$ ) and 2020–2021 ( $p=0.04$ ); for balanced anesthesia, this was seen only in the 2019–2020 period ( $p=0.02$ ). **Conclusion:** this study demonstrated significant increases in the mean prices of general anesthesia administered via intravenous (up to 36.36%) or inhalation (up to 89.47%) routes for exploratory laparotomies performed before and after the beginning of the SARS-CoV-2 pandemic in a private hospital in southern Brazil. However, no statistical difference in the hourly prices was observed between 2019 and 2021 for both anesthetic techniques.

**Keywords:** anesthesia, general; anesthetics; drug prices; inflation, economic; laparotomy

## Análise de preços de medicamentos utilizados em anestesia geral nos períodos pré e pós-pandemia de SARS-CoV-2: estudo observacional retrospectivo

## Resumo

**Objetivos:** com o advento da pandemia no início de 2020, houve um aumento dos preços dos medicamentos utilizados em procedimentos anestésicos hospitalares. O objetivo principal deste estudo foi avaliar as variações de preços dos anestésicos utilizados em procedimentos de anestesia geral entre os períodos anterior e após o início da pandemia de SARS-CoV-2. **Métodos:** foram investigados 105 relatórios anestésicos de laparotomias exploradoras ou procedimentos laparoscópicos realizados em um hospital privado no sul do Brasil e foram analisados os preços dos medicamentos utilizados em duas técnicas de anestesia geral: anestesia venosa total (AVT) e anestesia balanceada com gases anestésicos. Obteve-se o preço dos procedimentos anestésicos dos relatórios anestésicos emitidos nos últimos trimestres de 2019, 2020 e 2021 (33, 43 e 29, respectivamente). **Resultados:** observou-se diferença estatisticamente significativa nos preços entre os períodos para ambas as técnicas. O preço da AVT em 2019 foi de R\$ 229,30/hora, em 2020 foi de R\$ 472,13/hora e em 2021 foi de R\$ 247,38/hora. Para anestesia balanceada, esse preço foi de R\$ 66,32/hora em 2019, R\$ 109,97/hora em 2020 e R\$ 90,30/hora em 2021. Em uma análise *post hoc*, foram observadas diferenças significativas nos preços por hora da AVT entre 2019–2020 ( $p=0,01$ ) e 2020–2021 ( $p=0,04$ ); para a anestesia balanceada, isso foi observado apenas no período de 2019–2020 ( $p=0,02$ ). **Conclusão:** este estudo demonstrou aumentos significativos nos preços médios da anestesia geral administrada por via intravenosa (até 36,36%) ou inalatória (até 89,47%) para laparotomias exploradoras realizadas antes e após o início da pandemia de SARS-CoV-2 em um hospital privado no sul do Brasil. Entretanto, não foi observada diferença estatística nos preços por hora entre 2019 e 2021 para ambas as técnicas anestésicas.

**Palavras-chave:** anestesia geral; anestésicos; preços de medicamentos; inflação; laparotomia



## Introduction

General anesthesia can be performed using basically two techniques: total intravenous anesthesia (TIVA) and inhalation anesthesia, also known as balanced anesthesia. Both techniques fully meet the anesthetic requirements of surgeries such as video-assisted laparoscopic cholecystectomy, abdominal herniorrhaphy, laparotomy, thoracic surgery, and oral and maxillofacial surgery. Considering that different anesthetics are used in these two techniques, there are differences in medicine prices, anesthesia recovery time, incidence of postoperative nausea and vomiting (PONV), postoperative need for rescue analgesia, and patient satisfaction. Malhotra et al.<sup>1</sup> demonstrated, in a study performed in India, that TIVA has higher prices when compared to balanced anesthesia and less medicine waste, but postoperative outcomes were not considered. Although intravenous anesthetics are more expensive, they significantly decrease the incidence of PONV, the length of stay in the recovery room, and time to recovery of full cognitive function<sup>2-5</sup>.

Anesthesia procedures represent significant prices within the surgical environment of hospitals. Anesthetic medicines comprise around 10%–13% of a hospital pharmacy budget<sup>6</sup>. With the SARS-CoV-2 pandemic, there was a substantial increase in the prices of hospital medicines in Brazil<sup>7</sup>. This may be explained by the increase in cases of patients infected by SARS-CoV-2 and the consequently increased demand for anesthetics (sedatives, hypnotics, opioids) by intensive care unit (ICU) beds. In addition, domestic shortages, the effect of exchange rates, and the price of production supplies also contribute to this issue<sup>8</sup>. A financial impact is thus seen on hospital budgets related to surgical procedures, which in the private sector are funded by health care providers and in the public sector, by the Unified Health System (SUS).

The main objective of this work was to verify if there was a significant difference in prices of the main medicines used for general anesthesia before and after the beginning of the SARS-CoV-2 pandemic in a private hospital in southern Brazil. A secondary objective assessed if there is a difference between the prices of anesthetic medicines for TIVA and inhalation anesthesia currently. Our main hypothesis is that, since the beginning of the pandemic, there were significant increases in prices of medicines used for general anesthesia, above the annual inflation rate, both for TIVA and inhalation anesthesia. This study is justified by the fact that these data may be useful for understanding the economic impact caused by the SARS-CoV-2 pandemic on the price of medicines used for general anesthesia, particularly in some private hospitals in southern Brazil.

## Methods

The study design was of a retrospective observational price analysis. Data regarding medicine prices were obtained from a single private hospital in southern Brazil. For standardizing data and comparing prices, we selected anesthetic records of general anesthesia performed in open laparotomy or video-assisted laparoscopic surgery. These types of surgeries were chosen because they allow the use of TIVA or inhalation anesthesia without changes to their advantages or disadvantages. The anesthetic procedures were performed by a private anesthesiology unit the author takes part in and the choice of technique was made by the professional responsible for each case. We included anesthetic records from October, November, and December 2019, 2020,

and 2021. The last trimester of 2019 corresponds to the period before the beginning of the pandemic and represents a time with no influence of the global crisis generated by the disease in the pharmaceutical industry market. The trimesters occurring in 2020 and 2021 correspond to periods after the beginning of the pandemic and represent times when the sudden increase in demand for medicines had already happened, driven by hospitals with patients in ICU beds. The exclusion criteria used in this study comprehend cases where general anesthesia was associated with regional anesthesia or neuraxial anesthesia (spinal or peridural anesthesia).

The database was constructed with data obtained from anesthetic reports. The anesthetic regimens followed the protocols of the anesthesiology unit and did not change over the study years. The composition of the TIVA regimen included propofol 1% prefilled syringe (PFS) 50mL, rocuronium 10mg/mL 5mL, remifentanyl 2mg, morphine 10mg/mL 1mL, and lidocaine 1% without vasoconstrictor 20mL. The composition of the inhalation anesthetic regimen included propofol 20mL, sevoflurane (mL), rocuronium 10mg/mL 5mL, fentanyl 50mcg/mL (2mL, 5mL, or 10mL), and lidocaine 1% 20mL. Some medicines such as succinylcholine 100mg, midazolam 1mg/mL 5mL, and dexmedetomidine 200mcg/mL 2mL were available for both techniques and used at the discretion of the anesthesiologist in each case. A spreadsheet was constructed with the price of each vial or ampoule paid by the hospital pharmacy. In the case of sevoflurane (an inhalation anesthetic), where the vial has a 250 mL volume and can be used in more than one general anesthesia procedure, we calculated the price corresponding to the mean fraction used for inhalation anesthesia (example: if the mean consumption per procedure was 50 mL, we considered the price of 20% of the vial). This way, when adding up the prices of each medicine used in the anesthetic procedures, we obtained the total price individually. The prices of consumables such as syringes, needles, venous catheters, infusion pump administration sets, microporous tape, vascular access dressings, orotracheal tubes, breathing circuit filters, bispectral index (BIS) electrodes, other adjuvant medicines, vasopressors, and other commonly used materials in both techniques were not evaluated; medical air and oxygen were also not included. Considering that surgical procedures can have variable durations and anesthetic consumption is directly proportional to time, we calculated the price per hour of anesthesia.

With the aim of identifying the individual difference in prices for each general anesthesia technique throughout time, we firstly compared the values in Brazilian Reals for 2019, 2020, and 2021. Then, the mean and hourly prices of the TIVA and inhalation anesthesia techniques were compared regarding the final trimester of 2021. Hourly prices were calculated as the sum of the prices paid for the anesthetics in each anesthesia technique divided by the procedure time in hours (e.g., a total of R\$ 150.00 spent on a 2-hour anesthesia = R\$ 75.00/hour). Moreover, variations in the prices of each anesthetic were demonstrated between 2019 and 2021. For these analyses, the mean inflation rate was obtained for Brazil between the studied periods (using the accumulated annual inflation rate at the end of 2020 and 2021) through the Extended National Consumer Price Index (IPCA, data from the Brazilian Institute for Geography and Statistics, IBGE), thus verifying whether there was a real increase in medicine prices. The methodology used for price analysis was based on various studies on this theme published in medical journals<sup>1-6</sup>. Leftover medicines or the earnings of health care professionals involved in the surgical procedures were not considered.



The sampling procedure was determined by the anesthetic records available at the unit for the chosen periods, as long as all inclusion criteria had been met. Data regarding prices were presented in Brazilian Reals (R\$) and represent values paid by a private hospital in southern Brazil during the three last months of 2019, 2020, and 2021.

Data were typed into Microsoft Excel and exported to SPSS v. 20.0 for statistical analysis. Categorical variables were described as frequencies and percentages. The symmetry of quantitative variables was verified by a Kolmogorov-Smirnov test. Quantitative variables with normal distribution were described as means and standard deviations and compared between different years using analysis of variance (ANOVA) followed by a post hoc Tukey test. The comparison between techniques was performed using a Student's t-test for independent samples. A significance level of 5% ( $p < 0.05$ ) was considered for the comparisons.

The study was conducted in accordance with the provisions of the Declaration of Helsinki and approved by the Institutional Review Board (IRB #5.550.950).

## Results

The flowchart for the selection of anesthetic records is available as supplementary material (Supplementary material 1). Briefly, a total of 111 anesthetic records of exploratory laparotomies performed in all three periods were identified. Only six records (two from each year) did not fulfill inclusion criteria due to incomplete data, use of sedation instead of general anesthesia, or concomitant use of neuraxial anesthesia, bringing the total number of included records in this study to 105.

Out of 105 valid records, 33 were from 2019, 43 from 2020, and 29 from 2021. TIVA was used in 40 cases, whereas inhalation anesthesia was used in 65 cases. Table 1 shows demographic

data, type of anesthesia, type of surgery, and duration of the procedures.

**Table 1.** Demographic data, type and duration of surgical procedures.

	TIVA	Inhalation	Total
Total number of patients	40	65	105
Age (years), mean (SD)	59.27 (21.17)	71.41 (14.10)	-
Male, n (%)	11 (27.5%)	21 (32.3%)	32
Elective, n (%)	29 (72.5%)	25 (38.5%)	54
Urgent, n (%)	11 (27.5%)	40 (61.5%)	51
Open surgery, n (%)	17 (42.5%)	42 (64.6%)	59
Video-assisted laparoscopic surgery, n (%)	23 (57.5%)	23 (35.4%)	46
Surgery duration (min), mean (SD)	95.8 (50.6)	88.08 (41.5)	91.05 (45.11)

TIVA, total intravenous anesthesia

There was no statistical difference in surgery duration when comparing the studied periods (mean duration in 2019 = 91.2 min; mean in 2020 = 91 min; mean in 2021 = 90.8 min;  $p = 0.99$ ). A significant difference was observed in the mean price of TIVA ( $p = 0.02$ ) between 2019, 2020, and 2021, as well as for inhalation anesthesia ( $p = 0.009$ ). The same happened for the hourly price of anesthesia in both techniques (TIVA  $p = 0.006$ ; inhalation anesthesia  $p = 0.029$ ). The highest values (in Reals) were found for 2020 considering both techniques, as described in Table 2. Table 3 shows percentage variations found between years and the annual inflation rate through the IPCA.

**Table 2.** Price analysis for each anesthetic technique and year.

	Procedures	Mean price	Variation (compared to 2019)	Hourly price	Variation (compared to 2019)
TIVA	40				
2019	14	R\$ 380.17		R\$ 229.30	
2020	17	R\$ 522.23	37.36%	R\$ 472.13	105.90%
2021	9	R\$ 366.64	-3.55%	R\$ 247.38	7.88%
Inhalation	65				
2019	19	R\$ 80.86		R\$ 66.32	
2020	26	R\$ 153.43	89.47%	R\$ 109.97	65.81%
2021	20	R\$ 122.81	51.87%	R\$ 90.40	36.30%

TIVA, total intravenous anesthesia

**Table 3.** Analysis of price variations (compared to 2019).

	Variation mean price	Variation hourly price	Annual inflation rate (IPCA)	Accumulated inflation rate 2020+2021 (IPCA)
TIVA				
2020	37.36%	105.90%	4.52%	
2021	-3.55%	7.88%	10.06%	15.03%
Inhalation				
2020	89.47%	65.81%	4.52%	
2021	51.87%	36.30%	10.06%	15.03%

TIVA, total intravenous anesthesia



A post hoc analysis of hourly prices demonstrated that the highest variations were found between 2019 and 2020. For TIVA, price differences were observed between 2019–2020 and 2020–2021. For inhalation anesthesia, a significant difference was observed only between 2019 and 2020. These data are better presented in Table 4.

Considering only the last year analyzed by the study (2021), the mean price was R\$ 366.64 for procedures with TIVA (n=9) and R\$ 122.81 for procedures with inhalation anesthesia (n=20).

Table 5 shows the unit price paid by the hospital for each medicine and yearly price variations between 2019 and 2021.

**Table 4.** Post hoc analysis.

Hourly price of TIVA	
2019-2020	p=0.010 <sup>1</sup>
2019-2021	p=0.979
2020-2021	p=0.042 <sup>1</sup>
Hourly price of inhalation anesthesia	
2019-2020	p=0.022 <sup>1</sup>
2019-2021	p=0.337
2020-2021	p=0.433

<sup>1</sup>Statistically significant (Tukey test). TIVA, total intravenous anesthesia

**Table 5.** Prices of anesthetics per year and yearly price variations.

Anesthetic	Unit price 2019	Unit price 2020	Unit price 2021	Variation 2019-2020	Variation 2020-2021	Variation 2019-2021
Sedatives/ hypnotics						
Sevoflurane 250mL	R\$ 299.00	R\$ 310.04	R\$ 341.00	3.69%	9.98%	14.04%
Propofol 10mg/ml 20mL	R\$ 7.50	R\$ 31.69	R\$ 23.50	322.53%	-25.84%	213.33%
Propofol PFS 50mL	R\$ 124.52	R\$ 124.52	R\$ 138.58	0.00%	11.29%	11.29%
Midazolam 1mg/mL 5mL	R\$ 1.36	R\$ 16.95	R\$ 6.30	1146.32%	-63.83%	363.23%
Neuromuscular blocking agents						
Rocuronium 10mg/mL 5mL	R\$ 10.83	R\$ 25.69	R\$ 18.00	137.21%	-29.94%	66.20%
Succinylcholine 100mg	R\$ 7.50	R\$ 19.50	R\$ 19.00	160.00%	-2.56%	153.33%
Opioids						
Fentanyl 2mL	R\$ 1.22	R\$ 7.43	R\$ 1.28	509.01%	-82.77%	1.04%
Fentanyl 5mL	R\$ 1.90	R\$ 5.80	R\$ 5.80	205.26%	0.00%	205.26%
Fentanyl 10mL	R\$ 3.80	R\$ 5.40	R\$ 8.40	42.10%	55.55%	121.05%
Remifentanil 2mg	R\$ 27.00	R\$ 140	R\$ 31.16	418.51%	-77.74%	15.40%
Morphine 10mg/mL 1mL	R\$ 2.55	R\$ 3.85	R\$ 3.33	50.98%	-13.50%	30.58%
Other anesthetics						
Lidocaine 1% 20mL	R\$ 6.70	R\$ 6.50	R\$ 6.81	-2.98%	4.76%	1.64%
Dexmedetomidine 200mcg/mL 2mL	R\$ 32.00	R\$ 27.00	R\$ 12.27	-15.62%	-54.55%	-61.65%

PFS, prefilled syringe

## Discussion

With the data found in this study, it is possible to ascertain those anesthetics used for general anesthesia had a sharp readjustment in prices, especially between the end of 2019 and the end of 2020. Both techniques (TIVA and inhalation anesthesia) suffered significant impacts on prices. The largest readjustments in the first year of the pandemic (2020) happened for midazolam (1146%), fentanyl 2 mL (509%), remifentanil (418%), and propofol 20 mL vial (322%), which are considered indispensable to general anesthesia and are also used for maintaining sedation in patients in mechanical ventilation beds at ICUs. These and other medicines contributed to an increase of up to 37.36% in the mean price of TIVA and 89.47% in the mean price of inhalation anesthesia during this period. When considering hourly prices, the increase was even higher for TIVA, reaching a 105.9% variation.

The analysis of data referring to the second year of the pandemic (2021) demonstrated that prices decreased in comparison to the previous year but have still not returned to pre-pandemic values. However, when considering the accumulated inflation rate in Brazil between the beginning of 2020 and the end of 2021 (IPCA = 15.03%), no differences in hourly prices were observed in neither of the techniques. In other words, anesthetics became individually more expensive during the pandemic, but in the studied sample there was no significant impact to the final price of general anesthesia procedures.

The results obtained here are in accordance with the trend of reports published by FIPE/Bionexo, who use the Medicine Price Index for Hospitals (IPM-H) as the main parameter and analyzes medicines classified into therapeutic categories. The accumulated index for 2020 had a 15.57% overall increase. The group of medicines aimed at the nervous system (anesthetics, analgesics, and hypnotics) had a 52.55% increase, and those aimed at the musculoskeletal system had a 36.46% increase<sup>8</sup>. These price readjustments can be justified by a marked increase in the consumption of hypnotics and analgesics in the ICU environment, especially considering patients with COVID-19 who required mechanical ventilation, often of long duration (> 21 days). This led to a scarcity of anesthetics in the domestic market and distributors had to resort to importations for meeting hospital demands. Souza et al.<sup>9</sup>, evaluated the price of pharmacotherapy for patients in mechanical ventilation beds at a COVID-19 ICU in a general hospital of Rio de Janeiro and found expressive price increases for midazolam (+375.5%), rocuronium (+64%), norepinephrine (+1664.7%), and enoxaparin (+1062.2%) throughout 2020. The author also described that the group comprising neuromuscular blocking agents, sedatives, and anesthetics corresponded to 53.64% of the total price of medicines used in this ICU. This way, similarly to what happened with operating rooms, the study showed that the ICU environment also suffered from scarcity and higher prices of its main medicines, whether they are anesthetics or of other classes.



A Brazilian study published in 2021 discussed the vulnerability of national pharmaceutical industries in the context of the pandemic and identified as the main factors for its insufficient production: 1) uncoupling of public policies and industrial policies; 2) dependence on imported active pharmaceutical ingredients (API), since Brazil produces only 10% of the required amount; 3) depreciation of the Brazilian Real relative to the US dollar, increasing the prices of importing ingredients and medicines. These factors, among other aspects and in association with a sudden increase in the demand for anesthetics at hospitals, shortages in national pharmaceutical distributors, and the unpreparedness of public and private entities in face of a situation without precedent in the modern world, contributed to a greater or lesser extent to the variations in prices of medicines in the first two years of the pandemic<sup>10</sup>.

When comparing techniques as of today, TIVA presents much higher mean and hourly prices than inhalation anesthesia. However, this study collected only prices of medicines that were employed in anesthetic procedures and did not evaluate postoperative outcomes such as PONV, pain, patient satisfaction, and length of stay in the recovery room bed; therefore, a cost analysis could not be performed, although previous studies have demonstrated superior results with TIVA<sup>2-4</sup>. Moreover, we did not adjust for anesthetic consumption according to factors inherent to each patient such as age, sex, weight, comorbidities, and disease severity due to the difficulty in performing this kind of analysis; this represents a limitation of the study.

We highlight that the values paid for anesthetic medicines were informed by the operating room pharmacy of a single private hospital in southern Brazil. These do not necessarily reflect prices from other regions of the country or those paid by large public hospitals.

## Conclusion

The SARS-CoV-2 pandemic has affected the economy between 2020 and 2021, hitting primarily the health care sector and leading to readjustments to the prices of hospital supplies. With the main objective of assessing differences in the prices of medicines used in general anesthesia, we demonstrated significant increases in the mean prices of general anesthesia administered via intravenous (up to 36.36%) or inhalation (up to 89.47%) routes for exploratory laparotomies performed before and after the beginning of the pandemic in a private hospital in southern Brazil. However, in a post hoc analysis, no differences were observed in the hourly prices of both anesthetic techniques between 2019 and 2021, especially considering the accumulated inflation in this period. As a secondary objective, we demonstrated that the mean price of TIVA was around three times higher than that of inhalation anesthesia in 2021.

Future studies may be able to clarify whether the beginning of the pandemic and the national and global economic crisis we are going through had consequences to the hospital price of other medicines and supplies used in operating rooms and ICUs.

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## Collaborators

Project conception or analysis and interpretation of data: TFS, MSS, and AB

Article writing or critical review relevant to the intellectual content: TFS and AB

All the authors have read and approved the final version to be published and take responsibility for all information in the paper, ensuring the accuracy and integrity of any part of it.

## Conflict of interests statement

The authors declare that there are no conflicts of interest regarding this article.

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