



Cohort Study

Type, management, and associated factors of failed spinal anesthesia in cesarean section. Prospective cohort study

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ARTICLE INFO

Keywords:

Failed spinal anesthesia
 Cesarean section
 Spinal anesthesia

ABSTRACT

Background: Spinal anesthesia is an anesthesia technique suitable for cesarean section to avoid respiratory complications. However, the management of spinal anesthesia is very important because spinal anesthesia may fail and the patient may be exposed to pain and discomfort.

Objective: To assess the type, management, and related factors of failure of spinal anesthesia at cesarean section.

Methods: Multicenter prospective cohort study was conducted at a public hospital in Addis Ababa on 794 mothers who met the criteria for cesarean section under spinal anesthesia. Data collection methods were adopted, including chart reviews and observations of spinal anesthesia procedures. The data collected was entered in Epi info version 7 and analyzed in SPSS version 20. Independent variables with dependent variables were analyzed using logistic regression. A p-value of 0.05 for & it; was considered a statistically significant test cutoff.

Result: Of 121 failed spinal anesthesia 35 were complete and 86 were partial failed spinal anesthesia from those complete failed spinal anesthesia were managed by repeating spinal and converting to general anesthesia and partial failed spinal anesthesia were managed by the supplementary drug. Experience of the anesthetist <1 (AOR = 4.12, 95% CI, 2.47–6.90), patient position (AOR = 14.43, 95% CI, 2.65–78.61), number of attempts >1 (AOR = 9.26, 95% CI, 5.69–15.01), bloody CSF (AOR = 6.37, 95% CI, 2.90–13.96), BMI ≥30 kg/m² (AOR = 2.03, 95% CI, 1.12–3.68) and dose of bupivacaine <10 mg (AOR = 2.72, 95% CI, 1.33–5.53) were found to be statistically significant associated with failed spinal anesthesia.

Conclusion and recommendation: Experience of anesthetists (<1 year), obesity, bupivacaine dose <10 mg, bloody appearance of CSF, number of attempts > 1 were associated factors for failed spinal anesthesia in cesarean section. Our failed spinal management is not the same among hospitals and does not follow recommended failed spinal management. Up-skilling of anesthesia professionals should be considered on identified associated factors of failed spinal anesthesia and management of failed spinal anesthesia should be based on the recommended guidelines.

1. Introduction

With the rate of cesarean section increasing worldwide, spinal anesthesia is the anesthetic of choice for the procedure. Spinal anesthesia is performed by injecting a local anesthetic into the cerebrospinal fluid [1,2]. Failure of spinal anesthesia may be partial or complete. Complete failure is defined as the absence of sensory or motor blockade, and partial failure is defined as insufficient level, quality, or duration of drug action for that particular surgery [3,4]. If you are using

bupivacaine; if anesthesia and pain relief is not achieved within 10 min after heavy bupivacaine administration or within 25 min after successful intrathecal isobaric bupivacaine administration, it is considered a spinal anesthesia failure and also inability to access the subarachnoid space during lumbar puncture was considered as a spinal failure [5]. To prevent pain during cesarean section, anesthesia up to T5 is required [6].

Block height estimates may vary depending on the relationship between the evaluator's experience and the patient's perception, as well as the estimated block height by touch, prick, or chill [7]. Achieving spinal

Abbreviations: AOR, Adjusted odd ratio; ASA, American society of anesthesiology; BMI, Body mass index; Bsc, Bachelor degree in anesthesia; cs, cesarean section; CSF, cerebro spinal fluid; GA, General anesthesia; Msc, Masters degree in anesthesia; OR, Operation room; SA, Spinal anesthesia; SPSS, statistical package for social science.

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<https://doi.org/10.1016/j.amsu.2022.103616>

Received 7 March 2022; Received in revised form 9 April 2022; Accepted 9 April 2022

Available online 22 April 2022

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anesthesia depends on the experience of the anesthesiologist. Many studies consider obesity as an independent predictor of FSA, but others disagree. Many other factors were also considered, such as blood present in the cerebrospinal fluid, emergency cesarean section, multiple trials, bupivacaine dose, duration of surgery, prior anesthesia, spinal needle type and size, and bupivacaine baricity. This is due to the heavy pressure of unsuccessful spinal anesthesia [7–11].

According to a report of 92 maternal deaths in South Africa between 2008 and 2010, 73 (79%) of patients died from spinal anesthesia, of these, 10 were associated with complications from general anesthesia performed when spinal anesthesia was insufficient for surgery. Lack of clinical experience and inadequate access are the leading causes of maternal mortality. This is because there are few options to approach failure (1). Successful spinal anesthesia may be partial or complete and may require the use of various adjuvants or conversion to general anesthesia, which may have medical and legal implications. The most common cause of gynecological anesthesia lawsuits is discomfort during cesarean section with spinal anesthesia (2). Many studies have linked spinal block failure with other factors in developed countries. Data on the management and co-factors of spinal anesthesia failure in our country are limited. Therefore, the purpose of this study is to evaluate the types and management of spinal anesthesia failure and the co-factors of spinal anesthesia failure.

2. Methods

2.1. Study area and design

A multicenter prospective cohort study was conducted at Addis Ababa city public hospital, Ethiopia from December 2018 - to May 2019. Addis Ababa is the capital city of Ethiopia with a population of 3,475,952 according to the 2007 population census. The city has 40 hospitals (12 public and 28 private), 29 health centers, 122 health stations, 37 health posts, and 382 private medium clinics [17]. In each hospital, on average, there are two or more operating rooms to provide surgical services for emergency as well as elective procedures. This study is registered in the research registry at www.researchregistry.com with Research Registry UIN: [researchregistry7634](https://www.researchregistry.com/record/researchregistry7634), [research Registry.pdf](#). And the methodology is reported according to SROSS guidelines 2021 [25,26].

3. Source and study population

3.1. Source of population

All mothers who underwent elective and emergency cesarean section at Addis Ababa public hospitals.

3.2. Study population

Mothers who underwent elective and emergency cesarean section under spinal anesthesia fulfilled the inclusive criteria at Addis Ababa public hospitals during the study period.

3.3. Inclusion

All ASA I and ASA II mothers who underwent elective or emergency cesarean section under spinal anesthesia were included in the study.

3.4. Exclusive criteria

Mothers who had combined spinal-epidural (CSE) for labor analgesia and mothers who developed intraoperative high or total spinal anesthesia.

4. Variables

4.1. Dependent variable

Failed Spinal Anesthesia (yes or no).

4.2. Independent variable

- Socio-demographic characteristics: Age, weight, height, and BMI
- Obstetric related factor: Gestational age, classification of cesarean section.
- Anesthesia-related factors: Previous anesthesia history, ASA status, anesthetist experience, patient position, spinal needle type and size of spinal needle, lumbar puncture approach and numbers of attempts, the appearance of CSF, dose, and baricity of bupivacaine, adjuvant drug, and level of lumbar puncture.
- Surgical related factors: Duration of surgery and blood loss

4.3. Operational definition

- Complete failed spinal anesthesia: No somatosensory block at all.
- Partial failed spinal anesthesia: There is a partial block but needs supplemental analgesia to complete the surgery.
- Experience having <1 year consider all undergraduate students and graduates having less than or equal to one year.
- Experience having >1 year considers all postgraduate students and professionals who have been providing clinical service for > 1 year.

5. Sample size and sampling techniques

5.1. Sample size calculation

Using a single population proportion formula with the proportion of failed spinal anesthesia [9.1%], 95% confidence level and margin of error $\alpha = 5\%$. We found a sample size of = 794.

5.2. Sampling technique

Five public hospitals were randomly selected out of twelve by a lottery method and then the sample size was proportionally allocated over the selected hospitals. We observed 1225 mothers from logbooks who got operated on for cesarean delivery during the past three and half months at selected Addis Ababa public hospitals. The study unit was determined from 1225 mothers estimated to undergo emergency and elective cesarean section under spinal anesthesia in five public hospitals during the study period, 794 participants were recruited with the probability of about 65% considering the consecutive emergency or elective cesarean section. All 794 participants were selected by systemic random sampling. The first parturient was selected randomly and used as exclusion criteria, then data collection was made on 2 mothers for every 3 mothers who underwent emergency and elective cesarean section until the required sample size is reached (Fig. 1).

5.3. Data collection procedures

Data were collected through patient interviews, medical card reviewing, and observing spinal anesthesia procedures. We collect data on five major areas. The first data were about participants' demographic information (age, weight, height, and BMI); the second – Obstetric related data (indication for Caesarean section, classification of surgery (elective or emergency), gestational age, and the number of previous Caesarean sections were recorded); thirdly – anesthetic related data (the previous history of anesthesia, ASA status, position in which the spinal was performed, intervertebral space used, type and dose of bupivacaine injected, sensory block height determined by loss of cold sensation ion, motor grading, need for intravenous supplemental analgesia (e.g.

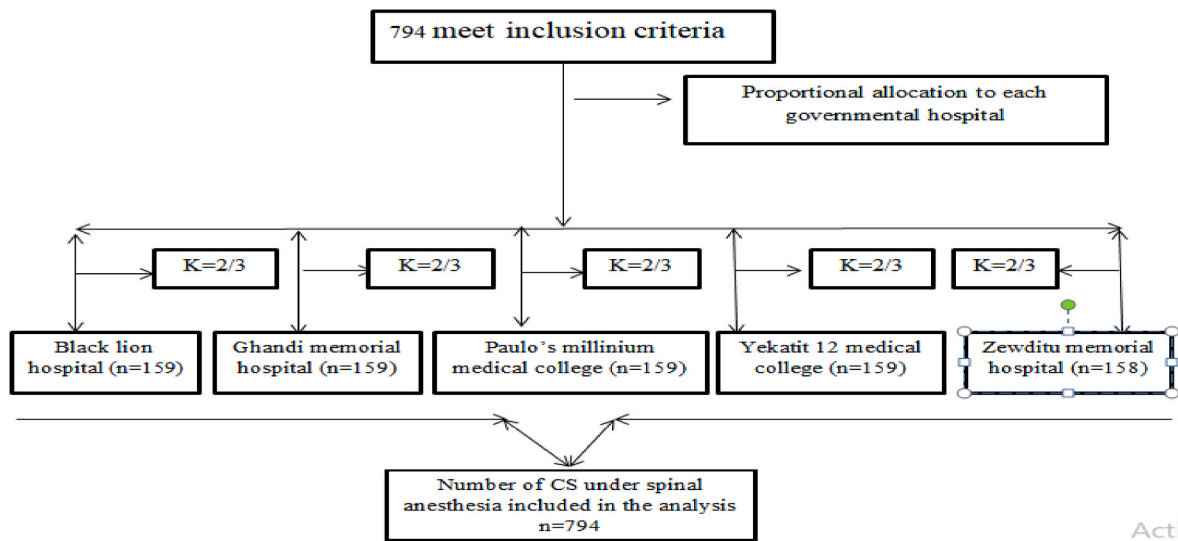


Fig. 1. Proportional allocation and enrollment chart for parturient underwent elective and emergency cesarean section.

ketamine, fentanyl, and pethidine), need for conversion to general anesthesia or repeating spinal anesthesia and the status of the anesthetists and experience who performed the spinal block); and fourthly – surgical related data (Duration of surgery, blood loss, and status of the surgeon).

5.4. Data quality control

To ensure data reliability and validity, questionnaires were pre-tested at 5% of the sample size before actual data collection. Learning orientation regarding the purpose and relevance of the study was provided by the principal observer. All elements of the survey tool and the entire data collection process were left to the data collectors and supervisors. Regular monitoring and follow-up were performed during data collection. Each questionnaire was reviewed daily by the supervisor and then double-checked for completeness and consistency by the study director. Incomplete data was not entered in the database prepared by Epi Info. Data cleansing and cross-validation of missing data were performed before analysis in Excel and SPSS.

5.5. Data analysis and interpretation

Data were coded and entered into Epi info version 7 and exported to SPSS version 20. Data was analyzed using SPSS version 20 windows and all independent variables with dependent variables were analyzed using binary logistic regression. Odds ratios, 95% confidence intervals, and p-values were calculated to identify relevant factors and determine the degree of association. For multivariate logistic regression analysis, variables with a p-value less than 0.2 in bivariate logistic analysis, a p-value < 0.05 was considered statistically significant.

6. Result

The data were obtained from a total of 794 participants with a mean age of 28.39 ± 5.873 and BMI 24.56 ± 3.22. Of the total participants, 225 (28.3%) were emergency and 569 (71.7%) were elective cesarean section (Table 1).

6.1. Anesthetic-related characteristics of 794 mothers underwent emergency and elective cesarean section

About 84.5% of the participants were classified as ASA-I and only 33.8% of the participants had had previous experience with spinal

Table 1

Socio-demographic, obstetric, and surgical characteristics of mothers who underwent emergency and elective cesarean section.

Variables	Categories'	Frequency	Percent
Age	15–24	244	30.7
	25–34	410	51.6
	35–44	140	17.6
BMI	<18.5	59	0.6
	18.5–24.9	489	61.6
	25–34.9	218	27.5
	35–39.9	56	7.1
	≥40	3	0.4
Classification	Emergency	225	28.3
	Elective	569	71.7
Duration of sur	<45 min	67	8.4
	45–60 min	19	2.4
	>60 min	72	9.1
Blood loss	0.5–1litter	72	9.1
	>1 litter	722	90.9

anesthesia. Almost all (98.9%) spinal anesthesia was performed in a sitting position and 58.7% of it was performed by an anesthetist who had more than a year of experience. Only 10% of participants received <10 mg while the rest received 10–15 mg of bupivacaine. The dermatome block level was optimally achieved by 67.3% of the participants. The majority (60.3%) of participants' spinal anesthesia injection was succeeded in the first attempt though it has been repeated two times in 19.4%, three times in 9.7%, and more in 10.6% parturients (Table 2).

6.2. Type, management and associated factors of failed spinal anesthesia

Of 121 failed spinal anesthesia in this study, 35 completely failed spinal anesthesia, and 86 partially failed spinal anesthesia. Of 35 completely failed spinal anesthesia. 6 were managed by way of repeating spinal anesthesia and the remaining 29 were converted into general anesthesia. Partial failed spinal anesthesia in this study was managed by ketamine 24, fentanyl 17, pethidine 26, and morphine 11. (see Figs. 2 and 3)

In this study we found a statistically significant association between failed spinal anesthesia with; BMI ≥30kg/m2 (AOR = 2.03,95%CI, 1.12–3.68), less experienced anesthetist (<1year) (AOR = 4.60, 95% CI, 2.80–7.56), lateral patient position during injection (AOR = 14.43, 95% CI, 2.65–78.61), number of attempts (AOR; 9.26, 95% CI; 5.69–15.01), the bloody appearance of CSF (AOR = 6.37, 95%CI, 2.90–13.96),

Table 2
Anesthetic related characteristic of 794 mothers underwent emergency and elective cesarean section.

Variables		Frequency	(%)
History of SA	Yes	268	33.8
	No	526	76.2
ASA status	ASA I	679	84.5
	ASAI	115	14.5
Experience of anesthetist	<1year	328	41.3
	≥1year	466	58.7
Patient position	Sitting	785	98.9
	Lateral	9	1.1
Baricity bupivacaine	Isobaric	748	94.2
	Hyperbaric	46	5.8
Dose of bupivacaine	<10 mg	84	10.6
	≥10 mg	710	89.4
Appearance of CSF	Clear	751	94.6
	Bloody	43	5.4
Spinal needle	≥24 gauge	175	22
	<23 gauge	619	78
Adjuvant	Yes	121	15.2
	No	673	84.8
Intervertebral space of injection	L2-L3	7	0.9
	L3-L4	758	95.5
	L4-L5	29	3.7

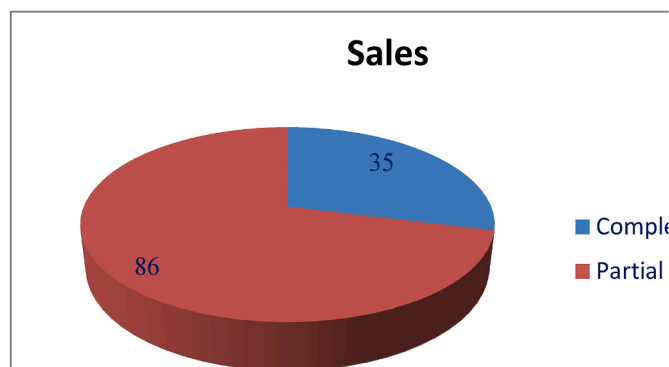


Fig. 2. Type of failed spinal anesthesia in this study.

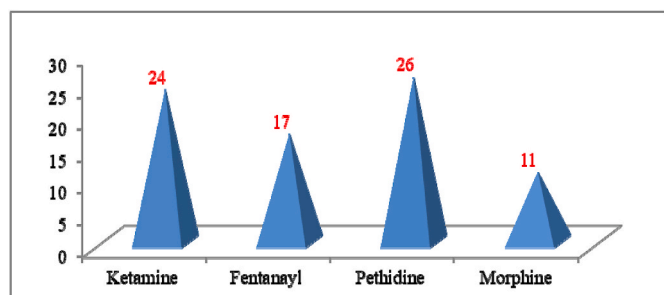


Fig. 3. Management of partial failed spinal anesthesia in our study.

utilization of anesthetics without adjuvants (AOR = 2.72, 95% CI, 1.33–5.53) and dose of bupivacaine (AOR = 2.37; 95%CI, 1.20–4.68); during cesarean section (Table 3).

7. Discussion

Complete anesthesia without any discomfort was supposed to be achieved after spinal anesthesia for specific surgical procedures. Spinal anesthesia is called failure when anesthetic drugs fail to work completely to the required level after being successfully injected into the subarachnoid spaces and or facing difficulty accessing subarachnoid

space [5,7]. In our study, 80% of completely failed spinal anesthesia was converted into general anesthesia and the remaining was managed by repeated spinal anesthesia. The Royal College of Anesthetists recommended, in possession of best practice, that the change rate from spinal anesthesia to GA should be <1% for elective CS and <3% for non-elective CS. In this study, the conversion rate is high and which increases the morbidity and mortality of both mother and baby [2]. The partial failed spinal anesthesia was managed by the supplementary drug. There is no failed spinal management algorithm in each hospital. Hence, follow different management modalities. Thus, in our study, management of failed spinal anesthesia was inconsistent with guidelines developed by the NHS foundation trust [1].

On multivariable logistic regression analysis, we found mothers who had not taken adjuvant were greater than 2 times more likely to require intraoperative analgesia. A possible justification could be that adjuvant potentiates local anesthetic and decreases the intraoperative requirement for analgesia [7,10,12]. This study showed years' experience of anesthetists (<1year) was significantly associated with the occurrence of failed spinal anesthesia. Possible justification could be explained as a technical error like loss of injectory, misplace injection, solution selection error, inappropriate dose selection, incorrect positioning, and inappropriate needle insertion due to spinal anesthesia becoming the unilateral or inadequate sensory height of spinal anesthesia [13,19].

We found mothers whose BMI ≥30kg/m² were at higher odds of resulting in failed spinal anesthesia (FSA), This finding was consistent with the study result of A. Alabi et al. [14]. But it is inconsistent with the study of Rekew [5]. The possible reason could be due to anatomical challenges of accessing the intervertebral space and the skills of anesthetists performing spinal anesthesia [21] the obscured landmark in mothers whose BMI ≥30kg/m² makes the identification of the landmark for spinal anesthesia difficult to locate and it also affects the distribution of local anesthetic [15,23]. However, some studies did not report any difficulty in performing spinal anesthesia in obese pregnant women [14].

The bloody CSF appearance was associated with failed spinal anesthesia; which is consistent with Alabi A et al. study [18]. This might be due to incorrect placement of the spinal needle in the subarachnoid space; the appearance of clear CSF in the needle hub is an essential pre-requisite for spinal anesthesia although it did not guarantee success [20,22].

More than a one-time attempt of spinal needle insertion was found to be associated with failed spinal anesthesia; which was consistent with the study by Rukewe, multiple punctures were associated with failed spinal anesthesia. However; intervertebral space placement was not found a significant association for failed spinal anesthesia unlike that of Rukewe, where L4-L5 intervertebral space was associated with failed spinal anesthesia [5]. The speed of onset, quality, and duration of spinal anesthesia is determined by the dose of the local anesthetic [24]. In this study, the result demonstrated mothers who were taken (<10 mg of bupivacaine), were associated with failed spinal anesthesia compared with mothers who were taken (≥10 mg of bupivacaine) which was inconsistent with the study done by Rukewe [5,16].

8. Conclusion and recommendation

Experience of anesthetists (<1 year), obesity, bupivacaine dose <10 mg, bloody appearance of CSF, number of attempts > 1 were associated factors for failed spinal anesthesia in cesarean section. Our failed spinal management is not the same among hospitals and does not follow recommended failed spinal management. Up-skilling of anesthesia professionals should be considered on identified associated factors of failed spinal anesthesia and management of failed spinal anesthesia should be based on the recommended guidelines.

Table 3
Factors associated with failed spinal anesthesia in cesarean section.

Variables	Failed-spinal anesthesia		COR (95%CI)	AOR (95%CI)	P-value	
	Yes n (%)	No n (%)				
BMI (kg/m ²)	<30	92 (11.6%)	579 (73%)	1	1	0.02
	≥30	29 (3.7%)	94 (11.8%)	1.94 (1.21–3.11)	2.03 (1.12–3.68)	
SA history	No	90 (11.3%)	436 (55%)	1	1	0.224
	Yes	31 (3.9%)	237 (29.8%)	0.65 (0.41–0.98)	0.72 (0.42–1.22)	
Experience of anesthetist	≥1 year	35 (4.4%)	431 (54.2%)	1	1	<0.0001
	<1 year	86 (10.8%)	242 (30.5%)	4.38 (2.87–6.68)	4.60 (2.80–7.56)	
Patient position	Setting	115 (14.5%)	670 (84.4%)	1	1	0.002
	Lateral	6 (0.76%)	3 (0.38%)	11.65 (2.87–47.25)	14.43 (2.65–78.61)	
Appearance of CSF	Clear	99 (12.5%)	652 (82.1%)	1	1	0.001
	Bloody	22 (2.8%)	21 (2.6%)	6.90 (3.69–13.00)	6.37 (2.90–13.96)	
Numbers of attempt	1	50 (6.3%)	583 (73.4%)	1	1	<0.0001
	≥1	71 (8.9%)	90 (11.3%)	9.20 (6.02–14.06)	9.26 (5.69–15.06)	
Baricity of bupivacaine	Isobaric	110 (13.9%)	638 (80.4%)	1	1	0.66
	Hyperbaric	11 (1.4%)	35 (4.4%)	1.81 (1.11–3.70)	0.967 (0.40–2.32)	
Dose of bupivacaine in mg	≥10	102 (12.8%)	608 (76.6%)	1	1	0.013
	<10	19 (2.4%)	65 (8.2%)	1.74 (1.00–3.03)	2.37 (1.20–4.68)	
Adjuvant	Yes	17 (2.14%)	160 (20%)	1	1	0.006
	No	104 (13%)	513 (64.6%)	1.91 (1.11–3.28)	2.72 (1.33–5.53)	

Where: 1 = reference group COR = crude odd ratio AOR = adjusted odd ratio CI = confidence interval n = number % = percent.

Ethical approval

Ethical approval was secured from Addis Ababa University institutional review board.

Sources of funding

Fully funded through Addis Ababa University. the study sponsors have no role in the collection, analysis and interpretation of data; in the writing of the manuscript; and in the decision to submit the manuscript for publication. Meeting No. 105/2018, protocol number: 21/18 Anes, Assigned No. 21/2018

Author contribution

ZB and HJ contribute equally in Conceptualization, Validation, Data Cu rationand Writing - Original Draft, Writing - Review & Editing.

Research registration number

1. Name of the registry: [Researchregistry.com](https://www.researchregistry.com).
2. Unique Identifying number or registration ID: 7634.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): [Research Registry.pdf](https://www.researchregistry.com/record/7634).

Guarantor

Zenebe Bekele.

Data statement

The data in this review is not sensitive in nature and is accessible in the public domain. The data is therefore available and not of a confidential nature.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Declaration of competing interest

None.

Abbreviations and acronyms

ASA	American Society of Anesthesiologists
BMI	Body Mass Index
BSC	Bachelor degree in anesthesia
CS	Cesarean section
CSF	Cerebrospinal fluid
ETB	Ethiopian Birr
GA	General Anesthesia
MSC	Master degree in anesthesia
OR	Operation Room
SA	Spinal Anesthesia
SPSS	Statistical Package for Social Sciences

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2022.103616>.

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