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FACTORS OF FAILED SPINAL ANESTHESIA IN DIFFERENT SURGICAL PROCEDURES AT TERTIARY CARE HOSPITALS DISTRICT MARDAN, PAKISTAN

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ABSTRACT

Background: *Failed Spinal Anesthesia (FSA) is a significant clinical concern that occurs unexpectedly, exposes patients to an unpleasant ordeal of pain, and requires the conversion of spinal anesthesia to general anesthesia. This transition increases the risks associated with airway manipulation and the inherent complications of general anesthesia. The unpredictability of FSA poses challenges for anesthetists, impacting patient safety and surgical outcomes. This study aimed to identify and analyze factors contributing to failed spinal anesthesia in different surgeries, providing insights to improve success rates and enhance perioperative care.*

Methods: *This comparative cross-sectional study included 275 patients through a convenient sampling technique. The participants were scheduled for different surgeries under spinal anesthesia at Mardan Medical Complex, Mardan, Pakistan, from September 2024 to November 2024. The Q-square statistical test was employed to evaluate the main dependent variable (outcome of spinal anesthesia, which was measured as failed or successful).*

Results: *The overall occurrence of failed spinal anesthesia was 3.6%. Failed spinal block was dependent mainly on the type of surgery, as the findings of this study indicated that failure events occurred in the majority of C-section cases (10.9%, n=6), followed by orthopedic surgeries (5.5%, n=3). Other major factors involved were; the urgency of the surgery, obese BMI, and patient position (as seen in most of the orthopedic cases with injections in the lateral position).*

Conclusion: *The findings of this study revealed that multiple factors, including patient position, type of surgery, high BMI, bloody appearance and absence of free flow CSF should be considered by anesthesia providers to minimize the risk of spinal block failure.*

Keywords: *Spinal anesthesia, Local anesthesia, Regional anesthesia, Cerebrospinal Fluids (CSF), Failed spinal anesthesia*

INTRODUCTION

Spinal anesthesia (SA) is a widely utilized regional block technique that induces short-term numbness of motor, sensory and sympathetic nerves, which is achieved by injecting local anesthetics into the subarachnoid

space (1)(2) . However, failure of a spinal block may occur when analgesia is insufficient for surgery, or when the subarachnoid space is not reached, Spinal Anesthesia (SA) failure may occur (3). The incidence rate of failed spinal anesthesia (FSA) previously reported is approximately 1% to 17%(4). Some studies define failure as the absence of adequate anesthesia or analgesia within 10 minutes of administering hyperbaric bupivacaine (5). Such failures subject patients to unpleasant experiences of pain and exposure to the possible risks associated with general anesthesia, which are avoidable(6)(7) (3).

Spinal anesthesia is the preferred choice for orthopedic, gynecological, urological, general surgeries and cesarean sections (8) because of its fast-acting nature, predictability, ability to reduce intermediate to high cardiac risk, reduces postoperative pneumonia and ability to control postoperative pain (1,3). It has advantages in minimizing intermediate to high cardiac risk, reducing post-operative pneumonia and providing effective postoperative pain control. Moreover, compared with general anesthetics, spinal anesthesia avoids the need for airway manipulation(10), minimizes intraoperative blood loss, and offers excellent maternal and neonatal outcomes than general anesthetic does (11). Compared with general anesthesia, it has a lower maternal mortality and morbidity rate (12)(13).

These advantages may be lost if failure of the spinal block occurs and if the patient requires general anesthesia or second spinal anesthesia. Such situations pose important clinical challenges, particularly in terms of timely decision making and patient safety (14) (15). Despite the high percentage of success in providing acceptable surgical anesthesia, failure of spinal anesthesia has been reported following the injection of local anesthetic (LA) into the cerebrospinal fluid (16) (6). However, many publications report two main classifications. First, discomfort or pain that arises during surgery and necessitates further analgesics is referred to as partial failure. Failure to produce sufficient sensory suppression, dictating general anesthesia, is referred to total failure (3).

Failed spinal anesthesia may have several disadvantages, including insufficient analgesia during surgery, and repeated spinal anesthesia procedures, which can cause local anesthesia toxicity, high spinal and total spinal, prolonged operating times, and conversion to general anesthesia. Other factors associated with failure of spinal block include; age, sex, American society of anesthesiologist score (ASA), height weight, BMI, dose of bupivacaine and duration of time from administration of spinal up to the end of surgery (7). In the case of orthopedic surgeries due to position influenced by pain and when spinal anesthesia is given in the lateral position for hip procedures under both conditions the chances of spinal block failure has been noted (15). Notably, most cases of spinal failure result from technical errors, which can be avoided(4). The objectives of this study were to identify and analyze factors contributing to failed spinal anesthesia in patients who underwent different surgical procedures under spinal anesthesia.

MATERIALS AND METHODS:

Study design, settings and duration:

This is a comparative cross-sectional study. We conducted this study in Mardan Medical Complex Mardan, Pakistan from September 2024 to November 15, 2024.

Population, sample size, technique and selection of study participants:

A nonrandomized simple convenient sampling method was used to collect data from all participants. Patients were included if they met the following characteristics irrespective of sex: age 18 years and older, ASA class-1 and class-2 physical status patients. Patients were selected from five departments including; all cesarean sections, orthopedic surgeries, urological surgeries, general surgeries, and gynecological procedures under spinal anesthesia. Patients who received combined spinal-epidural anesthesia, preoperative lower limb peripheral nerve block and patients on preoperative sedative medications were excluded from this study. The outcome of spinal anesthesia, categorized as failed or successful, was assessed using a pinprick test. The sample size of this study was calculated through a formula $\boldsymbol{n} = \left(\frac{Z\alpha}{2}\right)^2 p\,(1-p)/\varepsilon^2$ (1), which was 272.13. Since this study was conducted in five different operation theaters (OTs), the sample size was evenly distributed with 55 patients recruited from each OT, resulting in a total of 275 participants. The estimated proportion was 23% (1), margin of error was 5%, which was taken as 0.05 with a 95% CI.

Conduct of procedure:
A questionnaire developed by the authors, was utilized for gathering information from the study participants. Data collection was conducted following verbal informed consent through patient interviews, medical records and observation of the patient directly during the procedure. The primary dependent variable measured in this study was the outcome of the spinal anesthesia, categorized as failed or successful. The questionnaire utilized in this study consisted of targeted questions addressing the clinical and demographic characteristics regardless of gender including; age, weight, height and BMI. It also captured data of patient clinical history including; type of surgery, urgency of surgery, conversion of failed spinal to general anesthesia, and the use of adjuvant in case of event failure. Additionally, This study explored various clinical and anesthetic related factors including: physical status of the patient through American Society of Anesthesiologist classified patients (class-1 and class-2 only), name of local anesthetic used, brand name of local anesthetic, its dose and baracity, patient position at time of injection, spinal needle type, number of skin puncture attempts, characteristics of CSF and level of anesthesiologist experience. Further information's were obtained from patients regarding pain during injection and the use of intervertebral space for spinal injection. To confirm the arachnoid puncture and spinal anesthesia outcomes, the study employed conceptual tools including the pinprick test, to validate the loss of sensation in the lower limb.

Data analysis procedure:
Upon completion of data collection, the dataset was analyzed using statistical package for social sciences (SPSS version 22). Descriptive statistics were employed to summarize data, and the results were presented through tables and graphs for clarity. Chi-square test statistics was implemented for the identification of most significant association between spinal anesthesia outcomes and the independent categorical variables of this study. A p-value of < 0.05 was considered statistically significant.

Ethical considerations:
Ethical approval was obtained from the board of study and advance research committee of the Superior University Lahore. Additionally, permission for the data collection was granted by the ethical committee of Mardan Medical Complex, Mardan. Verbal informed consent was obtained from each participant during the preoperative period with the assurance of their wright to refuse participation. Confidentiality and privacy were assured by avoiding personal identifiers and locking the filled questionnaire forms.

RESULTS
A total of 275 patients undergoing different surgical procedures including; C-section, orthopedic, urological, gynecological and general surgeries were enrolled from the operating department of Mardan Medical Complex, a tertiary care hospital in Mardan, Pakistan. Of the total participants, we observed 3.6% failed spinal blocks, and all these events were promptly converted to general anesthesia. The majority of the procedures were elective surgeries accounting for 86.5% (n=238) while 13.5% (n=37) were emergency surgeries.

Sociodemographic characteristics of the participants:
Table-1 clearly shows that the mean age of the participants was 39 ±14.975 years, ranging from 18-76 years and the mean weight was 70.55 ±9.46 kg, ranging from 50-97 kg. The mean height of the participants was 1.67 ±0.07 meters, ranging from a minimum of 1.45 meters to a maximum 1.88 meters. The BMI distribution showed that almost half 46.2% (n=127) were in the normal weight range BMI 18.5–24.9, and a similar percentage 46.9% (n=129) had overweight BMI 25–29.9 category. Just 6.9% (n=19) of individuals had a BMI of 30 or more, which is considered obese. Among the total respondents, 78.2% (n=215) were ASA class-I, while 21.8% (n=60) fell into ASA class-II category.

Clinical factors:
All the patients had received hyperbaric bupivacaine (brand name bupicane SP) in doses ranging from 10mg to 15mg. The pinprick test was employed, post-spinal injection, to assess the pain sensation in the lower limb

of all participants. Sensation to pinprick test was observed in 3.6% (n=10) patients, indicating the spinal block failure was occurred in these cases. In this study, the quincke spinal needle was most frequently used 92.7% (n=255) by anesthesiologists, while the Whitacre needle was employed in 7.3% (n=20) of patients. Free-flowing cerebrospinal fluid was observed in 97.1% (n=267) of the cases confirming the correct placement of the needle.

The majority of the cases 94.2% (n=259), had clear non-bloody CSF, whereas 5.1% (n=14) patients had bloody appearance of their CSF. Regarding the experience of anesthesia providers, most of them (71.6%, n=197) had >3 years of experience, followed by those with 2-3 years of experience (18.5%, n=51) and 1-2 years of experience (9.8%, n=27). In terms of the injection site, the L3-L4 intervertebral space was most commonly used (90.9%, n=250) whereas the L4-L5 space was used in 9.1% (n=25) of events. A total of 1.5% (n=4) patients reported pain during incision. Adjuvants such as paracetamol, ketamine, nalbuphine and propofol were administered in 5.1% (n=14) of the patients for the management of pain and enhancement of patient comfort during the surgery.

Statistical correlation of Failed Spinal Anesthesia:

The table-2 below has shown illustration of P-values drawn from the chi square test statistics which was employed for correlational analysis. This study found that at p = 0.009 the cesarean sections had the highest spinal anesthesia failure rate (10.9%), followed by orthopedic procedures (5.5%) and general surgeries (1.8%). Patients in the lateral position for injection demonstrated a higher likelihood of failed spinal anesthesia (20.0%) compared to those in the sitting position (3.3%) at a p = 0.049. Mostly this study observed failed spinal anesthesia events in Emergency cases (16.2%, n=6, p = 0.001) highlighting the necessity of extra safety measures in emergency surgical settings to enhance spinal anesthesia outcomes. The spinal block failure rate was significantly greater (15.8%, p = 0.013) in patients with a BMI > 30 than for those with BMI ranges of 25–29.9 (3.1%) and18.5–24.9 (2.4%). A linear-by-linear association (p = 0.04) further supports the idea that a higher BMI is linked to a higher risk of spinal anesthetic failure.

Failure of the spinal block was assessed in multiple skin puncture attempts (p=0.005), with a single attempt we observed failure rate of 2.5%, with two attempts it increased to 11.1%, while with more than two attempts it was about 25.0%. Furthermore, our study observations showed that the absence of free-flowing CSF was significant at a p=0.001, with 50.0% failure rate. Likewise, bloody CSF nature was linked to a higher spinal failure rate (28.6%, p=0.00), while compared with non-bloody appearance of the CSF (1.5% failures)

Both the Fisher's Exact Test (p = 1.000) and the Pearson Chi-Square test (p = 0.367) indicate that the type of needle used has no discernible effect on whether spinal anesthesia is successful or not. Despite the fact that all anesthetic failures were caused by the Quincke needle (3.9%), the small sample size for Whitacre spinal needles suggest that this is more likely to be a result of the Whitacre needle's restricted use. According to the p-value from the Pearson Chi-Square (0.222), the selection of the intervertebral space has no marked effect on whether spinal anesthesia is successful or unsuccessful. The statistical study does not support a substantial association, suggesting that other factors may influence anesthetic outcomes, even though the failure rate is higher (8.0%) at the L4/L5 level. Likewise, the level of experience had not showed any statistical correlation (p=0.47).

These results reported that multiple factors are involved in failure of the spinal block including; urgency and type of surgery, sitting position of the patient, multiple skin puncture attempts, bloody nature of the CSF, absence of free-flowing CSF, and obese category of BMI.

Table-1: Frequencies and percentages of categorical and continuous

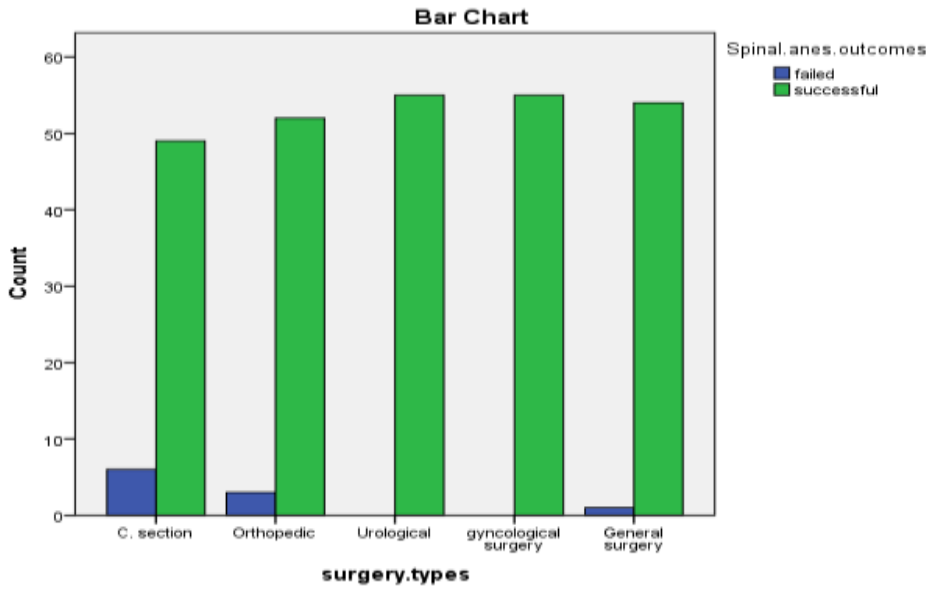
Variables	Categories	Frequency (total = 275)	Percentages
Outcome of spinal anesthesia	Failed	10	3.6%
	succesfull	265	96.4%
Name of local Anesthetic used	Bupicain SP (Bupivacaine)	275	100%
Baricity of local anesthetic	Hyperbaric	275	100%
Urgency of the surgery	Elective	238	86.5%

	Emergency	37	13.5%
Type of surgery	c-section	55	20.0%
	Orthopedic	55	20.0%
	Urological	55	20.0%
	Gynecological	55	20.0%
	General surgery	55	20.0%
Dose of local anesthetics used	13-15 mg	269	97.8%
	10-12 mg	6	2.2%
ASA class	ASA class-I	215	78.2%
	ASA class-II	60	21.8%
Conversion of spinal anesthesia to GA	Yes	10	3.6%
	No	265	96.4%
Use of adjuvants	Yes	14	5.1%
	No	261	94.9%
Name of adjuvants used	Paracetamol	7	2.5%
	ketamine	3	1.1%
	Nalbuphine	3	1.1%
	Nalbhupine and propofol combine	1	0.4%
Patient position at time of injection	Sitting position	270	98.2%
	Lateral decubitus	5	1.8%
Spinal needle type	Quincke	255	92.7%
	Whitacre	20	7.3%
Pain during incision	Yes	4	1.5%
	No	271	98.5%
Attempts of skin puncture for arachnoid injections	Once	244	88.7%
	Twice	27	9.8%
	More than twice	4	1.5%
Confirmation of arachnoid puncture	Presence of free flow CSF	267	97.1%
	Absence of free flow CSF	8	2.9%
Characteristics of the CSF	Bloody	14	5.1%
	Non-bloody	259	94.2%
	No csf seen	2	0.7%
Loss of sensation to pinprick test	Yes	265	96.4%
	No	10	3.6%
Intervertebral space used for injecting local	L3-L4	250	90.9%
	L4-L5	25	9.1%
Anesthesiologist experience who performed spinal injection (in years)	1y-2y	27	9.8%
	2y-3y	51	18.5%
	>3years	197	71.6%
Body Mass Index (BMI)	18.5-24.9	127	46.2%
	25-29.9	129	46.9%
	>30	19	6.9%
Continuous variables			
	Age (years)	**Weight (KG)**	**Height (meter)**
Mean	38.93	70.55	1.67
Standard deviation	14.99	9.46	0.06
Minimum	18	50	1.45
Maximum	76	97	1.88

Table-2: Comparison of outcome with other independent variables;

Categories	Variables	Spinal Anesthesia Outcomes		P-Values
		Failed	**Successful**	
Surgery-Type	C-section	6 (10.9)	49 (89.1%)	0.009
	orthopedic	3 (5.5%)	52 (94.5%)	
	urological	0 (0.0%)	55 (100.0%)	
	gynecological	0 (0.0%)	55 (100.0%)	
	General surgery	1 (1.8%)	54 (98.2%)	
Patient position	Sitting	9 (3.3%)	261 (96.7%)	0.049
	Lateral	1 (20%)	4 (80%)	
Spinal needle type	Quincke	10 (3.9%)	245 (96.1%)	0.367
	Whitacre	0 (0.0%)	20 (100.0%)	
Intervertebral space	L3-L4	8 (3.2%)	242 (96.8%)	0.222
	L4-L5	2 (8.0%)	23 (92.0%)	
Surgery urgency	Emergency	6 (16.2%)	31 (83.8%)	0.001
	Elective	4 (1.7%)	234 (98.3%)	
Dose of local anesthetics	10-12 mg	1 (16.7%)	5 (83.3%)	0.085
	13-15 mg	9 (3.3%)	260 (96.7%)	
BMI	18.5-24.9	3 (2.4%)	124 (97.6%)	0.013
	25.29.9	4 (3.1%)	125 (96.9%)	
	>30	3 (15.8%)	16 (84.2%)	
Skin Puncture attempts at vertebral column	Once	6 (2.5)%	238 (97.5%)	0.005
	Twice	3 (11.1%)	24 (88.9%)	
	> two times	1 (25.0%)	3 (75.0%)	
Confirmation of arachnoid puncture	Free-flow CSF	6 (2.2%)	261 (97.8%)	0.001
	Absence of free-flow CSF	4 (50.0%)	4 (50.0%)	
CSF characteristics	Bloody	4 (28.6%)	10 (71.4%)	0.001
	Non-bloody	4 (1.5%)	255 (98.5%)	
experience of the anesthesia provider	1y-2y	2 (7.4%)	25 (92.6%)	0.47
	2y-3y	1 (2.0%)	50 (98.0%)	
	>3years	7 (3.6%)	190 (96.4%)	

Figure-1: Comparative analysis of cases of failed spinal anesthesia during different surgeries



Discussion:

The purpose of this study was to determine different factors associated with spinal anesthesia failure, in a range of different surgical procedures under spinal anesthesia. This study revealed 3.6% overall spinal anesthesia failures, which is much lower than that reported in a similar study conducted in 2024 by Demilie et al (22.4% failure). This prominent discrepancy and the lowest failure rate may be influenced by our smaller cohort (275 versus 532), the fact that the majority of the techniques were performed by experienced anesthetists, inconsistencies in methodology and variations in patient characteristics. The current study focused only on total spinal anesthesia failure, which requires conversion to general anesthesia, whereas Demilies et al studied both complete and partial spinal anesthesia failure (1). Similarly, AASVANG et al; reported a 3.9% incidence of failed spinal anesthesia, which is in concordance with the findings of this study (7).

This study reported that the majority of spinal anesthesia failures were observed in participants who underwent C-sections and orthopedic procedures, accounting for 10.9% and 5.5% respectively. In case of early-one, the pregnant patients experience physiological and anatomical changes, which are consistently linked to higher spinal block failures. These findings are supported by similar study of Rashpal et al (17.4% failures in C-sections) (17). In contrast, the late-one is supported by demilie et al (reported 19.8% failures in orthopedic surgeries). This alignment was also influenced by similar factors contributing to the failure, such as surgery type and surgery urgency, patient positioning for injection (mostly lateral), and obesity. Another finding is that the failure rate was high in emergency cases, which was 16.2% (1). This finding was supported in the previous literature of Vadhanan et al; in 2020 through the possibility of technical errors in delivering spinal anesthesia, which further increases the likelihood of failures in emergency cases (18).

Another finding that stands out from the results reported is that in patients who were positioned laterally for spinal injection, the rate of failure was higher (20%) than that in those who were positioned in sittings for injection (3.3% failure events were recorded). Although findings suggest that the sitting position could benefit patients in terms of less chances of failure, the reliability of this finding is limited due to small sample size in the lateral positioned group. These findings somewhat surprising given the facts that M Al Malyan et al findings of patient position mostly lateral is associated with increased success (20), which emphasized that unilateral blocks may benefit more from lateral position. This possible divergence in findings could be the type of spinal block. While shaikh et al disagree with these findings and support the findings of this study, which emphasized that the sitting position reduces failure events by improving access to intervertebral areas and enabling precise needle placement (19).

This study revealed that 2.4% of patients within the normal weight BMI group experience failure events and that the overweight BMI group was associated with 3.1% failed cases, while patients with a BMI greater than 30, had increased chances of failure (15.8%, p=0.013). This finding is consistent with that of Yuksek et al and other previous literatures, which emphasize that obesity increases the risks of block failure by decreased intrathecal space and difficulty in palpating the possible landmarks (18) (3). Another important finding discovered in this study was association of skin puncture attempts with spinal anesthesia outcome (p=0.005). This study observed 2.5% failure events in a single vertebral skin puncture group, 11.1% in the group with two attempts, which was further increased to 25% in individuals with more than two skin punctures. These outcomes were consistent with those of Yuksek et al., that challenges are seen in the group with skin puncture attempts of more than three times (recorded 16.6% failed cases). Similarly, demilie et al., further support the idea that repeated puncture attempts for spinal injections could affect the rate of success (1).

Additionally, this study found that the most significant factor associated with increased failure rates was appearance of bloody CSF or absence of CSF flow, which was associated with a failure probability of 28.6% compared to 1.5% failures in individuals with non-bloody clear CSF. Through these findings, we encourage the confirmation of clear CSF flow in the stylet, to guarantee accurate needle insertion into the intrathecal space. These results support the idea of demilie (2024), who stresses that spinal anesthesia failure is caused mainly by a lack of CSF or its bloody appearance (1). One unanticipated result was the non-significance of the level of experience of the anesthesia provider, whereas demilie (2024) reported that the experience of anesthetists was strongly correlated with failed spinal blocks. This contradictory finding might be explained by the fact that the majority of anesthesia providers contributing in this study had more than three years of

experience, which reduced the probability of failed cases. Therefore, it is important to attain proper training programs prior performing human intervention for spinal anesthesia, as strongly recommended by NYSORA guidelines (2023) (21).

Limitations of this study:

This study has several limitations including, a small sample size, and availability of a single government tertiary care hospital in the district of Mardan which limits this study to only a single hospital. A large sample size and multiple districts should be considered in future research.

Conclusion:

The overall occurrence of failed spinal anesthesia can be attributed to several factors including, the type and urgency of surgery, the patient position during injection of spinal, body mass index, and absence of free-flow CSF in the needle while injecting local anesthetics, bloody characteristics of the cerebrospinal fluid, and the need for more than once skin puncture attempts. In regards to this study findings, the authors suggest that multiple factors should be considered and that proper protocols should be in practice in all cases of spinal anesthesia.

CONFLICT OF INTEREST: None declared

Author's contribution:

1. Author-1 wrote the main manuscript and contributed to the data analysis and data entry and computed tables and charts.
2. Author-2 encouraged author-1 and supervised the overall work until final review. He has discussed and approved the main objectives with author-1.
3. Author-3 (co-supervisor) has contributed in the final review of the manuscript, supervised closely the author-1 throughout this research.

Author-4 has contributed to the data collection, data entry and discussion of unforeseen clinical factors during spinal anesthesia procedure.

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