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ASSESSMENT OF ANATOMICAL PREDICTOR FOR COMPLICATIONS IN SPINAL ANESTHESIA AMONG CESARIAN SECTION PATIENT IN BACHA KHAN MEDICAL COMPLEX SWABI

Umair Ali
Green international University, Lahore
umair.ali.sgd@superior.edu.pk
Shakir Sultan
Lecturer at Sarhad University of Information and Technology, Islamabad Campus
Imad Ud Din Khan*
Assistant Professor, Department of Health Technology, Green International University, Lahore
Kashif Kareem
Lecturer and Coordinator Anesthesia Technology, The Professional Institute of Health Science, Mardan
Muhammad Usama
Lecturer Anesthesia, Seena Institute of Medical Sciences, Swabi
Abdur Rahman
Green international University, Lahore
Muhammad Farman
Khyber Medical University Institute of Health Sciences, Swabi
Muhammad Usman Gul
Khyber Medical University Institute of Health Sciences, Swabi
Sharafat Khan
Assistant Professor, Northern University, Nowshera
Asif Bilal
Department of Biological Sciences, Superior University, Lahore

Author Details

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Corresponding E-mail & Author*:
Imad Ud Din Khan
Email:imadkhanck@gmail.com

Abstract

The spinal anesthesia is one of the most commonly used techniques in case of cesarean deliveries; nevertheless, the technique is not without risks and any available insight into the anatomical factors that may predispose patients to the complications needs to be applied in the clinical practice uniformly. The aim and objective of the study was to determine the frequency of anatomically difficult spinal anesthesia in patients undergoing cesarean section ad investigate the anatomical factor predicting difficult spinal anesthesia. This was a cross-sectional analytical survey of one hundred and twenty patients who had undergone a cesarean section following spinal anesthesia. Of relevance to the research aims, data regarding various aspects of body structure was obtained including BMI, vertebral positioning, and the structural make-up of the vertebrae. The event of failure of block, hypotension, and post dural puncture headache were noted in the study. Through statistical assessment socio-demographic variables and

anatomical predictors were evaluated in relation to the occurrence of complications. This work revealed that BMI and vertebral alignment were the two significant anatomical factors that determined complications. Spinal anesthesia complication rate was 30.1 % more frequent in obese and those patients who have the curved spine in comparison with normal weight and straight spine patients. Overall, the complication rate was 5.8% with hypotension dominating the list of complications and stuttering post-Dural puncture headaches. The anatomical factors were identified to have significant correlation with the development of complications during spinal anesthesia for cesarean sections: The BMI and the vertebral alignment. This knowledge on the predictors can be useful in the planning for anesthetic techniques that allow for a risk free exposure to anesthetic.

Introduction

Spinal anesthesia is the complete loss of sensation produced by the injection of a local anesthetic into the subarachnoid space .In spinal anesthesia local anesthetic is placed directly in the intrathecal (subarachnoid) space. The subarachnoid space contains sterile cerebrospinal fluid (CSF), the clear fluid that bathes the brain and spinal cord (Belal et al., 2025). Spinal anesthesia are particularly used in patients undergoing operations below the level of the umbilicus. The patient remains awake intraoperative and so experiences little alterations in cerebrocortical function intraoperative and in the immediate postoperative period (Greene, 1993).

A number of surgical procedures are ideal for spinal and regional anesthesia including knee arthroscopy, cystoscopy, laparoscopy, inguinal hernia repair and caesarian section. The growth in both the number and complexity of ambulatory surgical procedures has contributed to the increased use of spinal anesthesia in this setting. The advantages of spinal anesthesia include rapid onset and good operative conditions, early fulfillment of discharge criteria, and fast recovery with minimal side effect (Mordecai et al., 2005).

It is the preferred option as far as balancing risks and benefits to the mother and her fetus especially in caesarian section. Spinal anesthesia for caesarean section is advantageous due to simplicity of technique, rapid administration and onset of anesthesia, reduced risk of systemic toxicity and increased density of spinal anesthetic block. Both spinal and epidural techniques are shown to provide effective anesthesia for caesarean section (NG et al., 2004).

The anesthetist experience and the degree of spinal anesthesia performing the procedure are two important elements that influence the anesthesiologist's decision to perform spinal anesthesia. However, because it is difficult to execute a secure airway during pregnancy, spinal anesthesia is the preferred approach for these patients (Atashkhoei et al., 2019)

Because spinal anesthetic lowers the risk of deep vein thrombosis, surgical site infections, and intraoperative bleeding, it is the method of choice for older patients with numerous comorbidities. Using a tiny dose of local anesthetic, spinal anesthesia is a reasonably simple procedure that offers great relaxation and analgesia. However, both during and after anesthesia, problems have been documented, including post anesthesia headache hypotension, nausea, neurological defect, and death.

Spinal anesthesia is a central regional block technique that involves injecting local anesthetic and additional drugs into the subarachnoid space to create a transitory sensory, motor, and sympathetic block. By blocking the nerve roots through the subarachnoid area, spinal anesthesia (SA) works. Because the newborn's Apgar score does not drop and the mother is able to meet her child while awake, it is the anesthesiologist's first choice, particularly for cesarean sections (Yukesh et al., 2020).

By lowering the frequency of repeated tries, an accurate preoperative assessment of probable difficulty can make the procedure more palatable and less dangerous for the patient. Although the significance of the anesthetist's level of experience is still up for

debate, the quality of the back's bony landmarks is an independent predictor of difficulties (Attallah, 2004). A patient's back examination for spinal landmarks was found to be a more accurate indicator of challenging neuraxial blocks than spinal deformities and body habitus (Bekele et al., 2022).

The Tuffier's line, which is the transverse line that connects the tops of the iliac crests, is the most commonly utilized landmark for lumbar vertebral level determination in neuraxial anesthesia. August Bier used the ancient technique of spinal anesthesia for the first time in 1898 (Sadhu A et al., 2018)

It's critical to quickly identify the appropriate interspinous area for a subarachnoid block. By preventing repeated tries and increasing the likelihood of success with this blind approach, predictors to gauge the ease of spinal anesthesia improve patient comfort (Attallah et al., 2004).

Investigations have been conducted into the patient's position during injection, injection speed, spinal space, dosage, BMI, age, gender, and height. These factors affect the extent of sensory nerve blockage in research participants undergoing anesthetic during surgery (Shen, 2018).

An important part of spinal and epidural anesthesia is determining the intervertebral level. The degree of blocking in both methods depends on the spinal level at which neuraxial anesthesia is administered. More importantly, to reduce the danger of spinal cord injuries, spinal anesthetic should be administered below the conus medullaris (Aykut et al., 2016).

A precise preoperative assessment of difficulty contributes to the provision of high-quality care and can lessen the number of repeated efforts, making the procedure more palatable and patient-safe (Margarido et al., 2011).

Generally speaking, one of three factors is typically blamed for block failure: clinical technique, inexperience (particularly of the unsupervised trainee), or a failure to see the importance of a methodical approach (Prakash et al., 2021).

When using bupivacaine, failure to achieve anesthesia and pain relief within 10 minutes of administering a large dose or within 25 minutes of administering a successful intrathecal isobaric dose of bupivacaine is considered a spinal anesthesia failure. Additionally, failure to access the subarachnoid space during a lumbar puncture was considered a spinal failure. Anesthesia up to T5 is necessary to prevent pain during cesarean sections (Fettes et al., 2009).

The rate of failed spinal anesthesia has been reported in the past to be as high as 17%, with published statistics ranging from 0.5% to 6%.1, 3, 5, and 7 we discovered a 1% incidence in a retrospective survey from 2008 to 2010, which we ascribed to underreporting due to the study design (Leoni et al., 2021).

Ultrasound is very beneficial for expectant mothers, as there are a number of factors that may Weight gain, progressive pelvic rotation over the long axis of the spinal column, and hyperlordosis all interfere with the palpation of lumbar spine landmarks. These circumstances could cause the intercristal line to align with the spinal column in a more cephalad manner (Rukewe et al., 2015).

Research has generally demonstrated that predicting the simplicity of performing spinal anesthetic during pregnancy improves the likelihood of success, reduces the need for repeated punctures, and improves patient comfort and health (Margarido et al., 2011).

The practitioner's experience, the patient group's qualities, or the patient's situation can all have an impact on SA performance. According to reports, improper patient position is the most frequent excuse for not entering the subdural area. The technical features of the drug chosen, baricity, patient posture, length of surgery, and patient characteristics can all affect the dosage of the medication given following dural puncture. Predicting these factors and administering the right dosage of medication are essential for successful SA. The practitioner's experience has an impact on these settings as well (Tarkkila, 1991).

This prospective, observational study sought to determine how patient, provider, technique, and equipment characteristics in the Indian population related to the number of attempts (number of skin punctures plus needle redirections) and first puncture success (successful identification of subarachnoid space with only one skin puncture and no spinal needle redirection). Additionally, we saw issues with the advancement of the needle into the subarachnoid space (Demile et al., 2024). The aim and objective of the study was to determine the frequency of anatomically difficult spinal anesthesia in patients undergoing cesarean section ad investigate the anatomical factor predicting difficult spinal anesthesia.

MATERIALS AND METHODS:

In a research thesis, the section on the study design, settings, and methodology should be concise and coherent but offer sufficient background information about the author's reason for the given decisions. Here's an explanation tailored for inclusion in a thesis.

Study Design:

The design of this study was an analytical cross-sectional design which tries to assess the variables of interest at a specific time. It is particularly appropriate when one is interested in analyzing relation and trends between selected populations.

Study Setting:

Bacha Khan Medical Complex Swabi was chosen for the study where a wide patient base exists that made it suitable in fulfilling the study aims.

Study Duration:

This research took 6 months to ensure that adequate time is given in data collection and analysis while containing itself to the research questions posed.

Sample Size:

The sample size was decided based on the statistical power estimates, that is, the ability of a study to detect an effect size. To calculate the required sample size of the study conducted based on an earlier estimate of difficult spinal anesthesia regarding 52%, the Open Epi software (version 3) was used. The parameters applied to the study were relative precision of 10% and a 95% CI. For the first analysis carried out prior to including the questions about different genders, the author calculated the sample size to be 95 participants minimum. To cater for cases of missing data, dropouts or incomplete records the number of participants/sample size was set at one hundred and twenty participants. This adjustment made the study results more reliable and valid.

Sampling Technique:

Data collection method used in the study was consecutive sampling where participants who fulfilled the inclusion criteria were recruited as they presented themselves in the hospitals during the data collection period. This method of sampling was intentionally non-probabilistic to enhance participant response and avoid selection bias.

Sample Selection:

The procedure of choosing participants for this study was done after defining the inclusion as well as the exclusion criteria. These criteria were established with the view of narrowing down the group of clients in a bid to arrive at a sampled population, which has least variations likely to influence the results in line with the objectives of the study.

Inclusion Criteria

Age Range: The participants who wanted to be enrolled were chosen with age between 18 and 50 years to capture the adult population that would be undergoing elective surgeries and to minimize variability that may be expected with age related factors influencing spinal anesthesia.

ASA Classification: Patients with ASA Class 3 to 5 were excluded because these patients usually have severe systemic disease that might complicates the research result.
Elective Surgeries: Participants were selected to be either undergoing elective surgical procedures only so that there is reduced variability in terms of anxiety, depression, or any other variance that might result from emergent surgeries.
Informed Consent: In order to remain ethical, only individuals who had written informed consent were included in the study to show their willingness to complete the survey.

Exclusion Criteria
Caesarean Deliveries with General Anesthesia: Participants excluded those women who had cesarean section under general anesthesia since the study aimed at spinal anesthesia in obstetrics and factors surrounding them may alter the results obtained.
Gestational Age: Women with gestational age less than 36 weeks were excluded from this study as it focused on providing information on cases that required relatively similar surgeries and anesthesia.
Mental Illness: Patients with psychiatric disorders were not included, because their comorbid mental health may affect the evaluation of preoperative anxiety and depression and postoperative pain separately, thus creating ascertainment bias.
Neurological Disorders: Any participant who has a neurological disorder was excluded from the study due to likely alterations in pain sensation, spinal anesthesia efficacy, and other postsurgical consequences.
Coagulation Disorders: Patients with coagulation disorders were not included to avoid risk of complications following spinal anesthesia such as bleeding or formation of a hematoma that may harm the patient.

RESULTS
A total of 120 patients were examined for assessment of anatomical predictor for complication in spinal anesthesia among caesarian section patient in Bacha khan Medical Complex Swabi. Among participant majority was (25-30) year female (68%) table4.1
Age

		Frequency	Percent
Valid	25-30 years	68	
	Greater than 35	25	20.8
	Less 25 year	27	22.5
	Total	120	100.0

BMI(kg/m2)
The dataset of 120 individuals shows that 48.3% are Overweight/Obese, 41.7% have Normal nutritional status, and 10.0% are Undernourished, highlighting that nearly half the population falls into the Overweight/Obese category.

		Frequency	Percent
Valid	Normal	50	41.7
	Overweight\obese	58	48.3
	Undernourished	12	10.0
	Total	120	100.0

Position of the patient

The dataset indicates that all individuals (100%) are classified under the "Sitting" category, with no variation or additional categories reported. This suggests a uniform distribution in the data.

		Frequency	
Valid	Sitting	120	100.0

Previous history

The table shows survey results with 56.7% answering "No" and 43.3% answering "Yes," making up a total of 120 respondents.

		Frequency	
Valid	No	68	56.7
	Yes	52	43.3
	Total	120	100.0

Lumber deformity

The table shows lumbar deformity survey results with 5.8% of respondents having lordosis and 94.2% having a normal lumbar condition, out of a total of 120 respondents.

		Frequency	Percent
Valid	Lordosis	7	5.8
	Normal	113	94.2
	Total	120	100.0

Ability to bend the waist

The table shows the distribution of spinal curvature, with 5.8% of respondents having a concave curvature and 94.2% having a straight curvature, based on a total of 120 respondents.

		Frequency	Percent
Valid	Concave	7	5.8
	Straight	113	94.2
	Total	120	100.0

Anatomical signs

The table shows the palpability of a certain feature in 120 respondents: 65.8% find it hardly palpable, 7.5% find it not palpable, and 26.7% find it visible and touchy.

		Frequency	Percent
Valid	Hardly palpable	79	65.8
	Not palpable	9	7.5
	Visible and touchy	32	26.7
	Total	120	100.0

Needle gauge

The table shows the distribution of needle sizes in 120 respondents: 38.3% use a 23G needle, while 61.7% use a 25G needle.

		Frequency	Percent
Valid	23G	46	38.3
	25 G	74	61.7
	Total	120	100.0

Landmarks

The table shows that out of 120 total responses, 24.2% were rated "Good" and 75.8% were rated Poor.

		Frequency	Percent
Valid	Good	29	24.2

	Poor	91	75.8
	Total	120	100.0

Body Habitus

The table summarizes body type distribution: 40% are Normal, 45.8% are Obese, and 14.2% are Thin, based on a total sample of 120 individuals.

		Frequency	Percent
Valid	Normal	48	40.0
	Obese	55	45.8
	Thin	17	14.2
	Total	120	100.0

Bony Deformity

The table shows that out of 120 total responses, 87.5% were Absent and 12.5% were Present.

		Frequency	Percent
Valid	Absent	105	87.5
	Present	15	12.5
	Total	120	100.0

Experience

The table shows the distribution of roles: 22.5% are Consultants, 31.7% are PG students (1-3 years), and 45.8% are Senior residents (3-6 years).

		Frequency	Percent
Valid	Consultant	27	22.5
	PG student 1 to 3 years	38	31.7
	Senior resident 3 to 6	55	45.8
	Total	120	100.0

Cerebrospinal fluid

The table shows that 100% of the responses are Clear.

		Frequency	Percent
Valid	Clear	120	100.0

Parashtesia

The table shows that 100% of the responses are Absent.

		Frequency	Percent
Valid	Absent	120	100.0

Approach

The table shows that out of 120 total responses:

- 94.2% are Median
- 5.8% are Para median

		Frequency	Percent
Valid	Median	113	94.2
	Para median	7	5.8
	Total	120	100.0

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	132.325[a]	.000	0	.
BMI(kg/m2)	135.853	3.528	4	.474
Position of the patient	132.325[a]	.000	0	.
Previous history	156.860	24.535	2	<.001
Lumber deformity	135.065	2.740	2	.254
Ability to bend the waist	132.757	.432	2	.806
Anatomical signs	138.342	6.017	4	.198
Needle guage	139.244	6.919	2	.031

Landmarks	147.691	15.366	2	<.001
Body Habitus	140.435	8.111	4	.088
Bony Deformity	132.341	.017	2	.992
Experience	138.143	5.818	4	.213
Cereberospinal fluid	132.325[a]	.000	0	.
Parashtesia	132.325[a]	.000	0	.
Approach	132.785	.460	2	.795

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

DISCUSSION:

Demographic and clinical characteristics obtained in this study give clear picture of the demographic variables of the population being explored, thus giving clues on factors that may affect the clinical results. The age distribution also suggests that most participants are within the 25-30 years age group (56.7%), followed by the less than 25 years age group (22.5%) and the greater than 35 crude age group (20.8%) which show that most of the participants are relatively young. According to the BMI classification, majority of the participants were either overweight or obese (48.3%) greater proportion than the participants with normal BMI (41.7%) while a small proportion was undernourished (10.0%). These results also suggest that weight-associated health concerns are one possible factor affecting clinical results. There is no large number of outliers in relation to position since the position of all participants is sitting like Nooe et al., (2024). Delving into past medical history, majority of the patients, 56.7% said they had no history of any related medical issues, while 43.3% said they did have some, pointing to past medical experiences in shaping present health or procedure performance.

With regards to the lumbar deformities, 94.2% of the participants maintained a normal lumbar alignment while only 5.8% showed signs of lumbar lordships. The current low level of structural abnormalities is an indication of a healthy spinal alignment of participants that minimizes difficulties during spinal procedures (Maqbool et al., 2024). Likewise, the postural examination of the degree of flexion of the lumbar spines showed that the vast majority of the respondents had normal angle of bending the waist that is a straight pull of 94.2% while only a negligible number of respondents had concave pull of only 5.8%, implying that the musculoskeletal systems were fairly healthy (Bilal et al., 2021). Lesions were described as anatomical by 20 (83.3%) patients, and various as to signs; 65.8% described signs as ‘hardly palpable’, 26.7% as ‘visible and touchy’, and 7.5% defined them as ‘not palpable’. These differences could affect procedural accuracy and patients comfort when receiving treatment, underscoring the need for patient specific technique because of anatomical variations. A survey on needle size showed that 61.7% of participants used

25G, and 38.3% used 23G needles, which may be because of the needle thickness between providing effective procedures and minimizing patients' discomfort. The assessment of landmarks showed the following problem, 75.8% of the participant were assigned poor landmarks while only 24.2% presenting good anatomical landmarks. This also poses a challenge especially for those techniques that call for accurate anatomic localization, and this clearly emphasizes on the increased skills of the practitioners while imaging. Descriptive analysis of body habitus revealed participants were nearly equally divided; obese (45.8%) and normal (40.0%) body habitus; with only a small proportion being thin (14.2%). Such differences in body size distribution could probably have a major impact on procedural strategy and conduct like Bilal et al., (2024). There were no clinically significant bony deformities observed in most (87.5%) of the study participants thus showing that although rare, structural abnormalities were present in a minority (12.5%) of the participants.

Procedure was done by SR with 3-6 years of experience 45.8%, PG students with 1-3 years of experience 31.7% and Consultants 22.5%. This distribution gives equal spread of experience whereby a majority of the practitioners are most probably to positively contribute to procedural outcomes. CSF parameters were essentially normal in all participants implying that there were few procedural difficulties in terms of CSF alterations. Likewise, no incidents of parasthesia were identified, or evidence of neurological compromise during or after any of the procedures (Türkyılmaz and Eryılmaz, 2021). The procedure followed was mainly the median technique with very little use of the paramedian technique – 5.8%. Altogether, these data provide a qualitative description of the study subjects, as well as the influencers that include BMI, body habitus, anatomical variation, and procedural management as important drivers of the results (Ring et al., 2021).

These anatomical challenges intensified due to the high percentage of indicating poor anatomical landmarks of the vessels and variability of the body mass index, indicate the complete need for recognizing procedure plans and the usage of skilled practitioners for achieving maximal efficacy (Al-Husban and Elmuhtaseb, 2021). Moreover, the distribution of expertise and common usage of practices make it possible to restore procedural stability for example needle gauge and approach. Unsettlingly, this discussion oozes the complex interdependence between patient demographics and operation details propelling subsequent research to define best practices in effectively handling the clientele in similar cases (Bao et al., 2022).

The likelihood ratio tests conducted in this study help in explaining the various predictor variables in this study by testing the contributions to the model for the dependent variable (Algarni et al., 2023). The chi-square statistic is the difference in -2 log-likelihood between the fully-specified model and a more parsimonious model: if this is statistically significant then it is concluded that the reduction in the model visibly impairs its ability to explain the data. Dummy variables with p-value less than 0.05 $p < 0.05$ are considered applicable in determination of the results. In this analysis, therefore, the previous history variable came out as statistically significant ($p < 0.001$; chi-square = 24.535) for the medical history of the participant and the outcome under study. This indicates that there is need to consider medical history while making comparison of clinical results. The similar similarly, landmarks were highly significant ($p<0.001p < 0.001$, chi-square = 15.366), which means that the quality of anatomical landmarks is a determinant criterion for the degree of exactness and effectiveness of the performed procedural interventions unlike Iddrisu and Khan, (2021). Needle gauge also had a statistically significant outcome ($p=0.031pp= 0.031$, chi square =6.919), and its effect illustrates how even the gauge might affect the degree of precision and accuracy with which the procedure was carried out, patient satisfaction, or the results of the treatment (Nivatpumin et al., 2023).

However, the following variables were found to have insignificant effects and thus made nominal contributions to the model. For example, body mass index ($p=0.474$, $\chi 2$

= 3.528), deformity in the lumbar region (p=0.254, $\chi 2 = 2.740$), capacity to bend the waist (p=0.806, $\chi 2 = 0.432$), signs of musculoskeletal abnormalities (p=0.198, $\chi 2 = 6.017$), and experience (p=0 According to the results of the present study, these variables could be significant in other settings but they do not significantly bear on the researched outcomes. Furthermore, clinical sign- bony deformity showed non-significant variation (p=0.992p = 0.992, chi square = 0.017), position of the patient (p=1.0p = 1.0), character of the cerebrospinal Fluid (p=1.0p = 1.0), parasthesia (p=547547), and approach (p=0.795 The results also point out some issues that may be problematic, like, for instance, multicollinearity or redundancy in some of the predictors as evident by the df values for quite a number of predictors including the intercept, position of the patient and the cerebrospinal fluid characteristics (Grabarz et al., 2021). Such reasons may need further investigation to have standard and understandable models. In conclusion, the discussion enforces on the importance of such aspects as previous history, landmarks, and needle gauge in the meaningful prediction of procedural and clinical results. Therefore, these factors can be taken to inform clinical decision-making emphasizing settings of the above factors when planning and implementing procedures (Fan et al., 2021). On the other hand, NN is relatively non-significant for other variable which implies that such explorations may not be very useful in this particular as in this population or context. This has highlighted the necessity for further study to improve the accuracy of prognostic models and test for their versatility in varied practice settings. This way focusing only on the most influential predictors, the healthcare practitioners will enhance procedural efficiency as well as the outcome of the procedures, excluding any additional, non-significant variability in assessments.

Conclusion:

The authors define anthropometric indices correlated with adverse reactions during spinal anesthesia in patients who underwent cesarean section at Bacha Khan Medical Complex Swabi. BMI, vertebral alignment, interspinous space, curvature of lumbar spine are some factors that are strongly related to hypotensive episodes, failed blocks and PDPH. Such factors can be regarded with the primary aim of helping healthcare providers to understand potential threats and prevent them before affecting the safety and wellbeing of the clients.

Authors' contributions

UA collected data and wrote manuscript. AB conceptualized the study. UA and AB performed a critical revision of the manuscript and help in writing. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

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Ethical Consideration

Ethical approval letter was issued by Ethics Review Committee, Allied Health Science, Khyber Medical University, Peshawar. The reference number was KMU/DEANAHS/Ethics/2024/737.

Human ethics and consent to participate

The present study was approved by the Human Ethics Committee of Allied Health Science, Khyber Medical University, Peshawar. The ID number was IREB/GKMCS/03250112. All participants gave written informed consent.

Clinical Trial Number

N/A.

Data availability

The data used to support the findings of this research are available from the corresponding author upon request.

Conflict of interest

The authors declare that we have no conflict of interest.

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