

Factors predicting difficult spinal block: A single centre study

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Abstract

Background and Aims: Several factors determine the success of dural puncture. We aimed to assess the association of first puncture success and number of attempts with characteristics of the patient, provider, technique and equipment.

Material and Methods: This prospective, observational study was performed in 1647 adult patients undergoing surgery under spinal anesthesia. Patient characteristics, anatomical landmarks, spinal bony deformity, provider experience, technique, skin punctures, needle redirections, subarachnoid space depth, and complications, if any, were noted. Difficult dural puncture was assessed by first puncture success and number of attempts (skin punctures plus needle redirections) required for successful needle placement.

Results: First puncture success was obtained in 872 (52.9%) patients. Failed dural puncture occurred in 4 (0.2%) of 1647 patients. Multivariate logistic regression analysis revealed that longer distance from C7 vertebral spine to tip of coccyx ($P = 0.04$), lower subarachnoid space depth ($P = 0.001$), good quality of bony landmarks ($P = 0.001$) and absence of crowded spine ($P = 0.02$) were associated with first puncture success. Male gender, poor or no spinal landmarks, presence of bony deformity and lower level of provider's experience predicted increased number of attempts for successful dural puncture.

Conclusion: First puncture success of spinal block was influenced only by patient's anatomical factors, whereas the number of attempts required for successful block were predicted by both provider and patient factors.

Keywords: Anesthesia, spinal, spinal puncture, spine

Introduction

Spinal anesthesia is a popular technique for several surgical and endoscopic procedures. A technically difficult spinal block in some patients results in multiple attempts at needle placement. Multiple attempts may lead to complications such as spinal hematoma, post dural puncture headache, neurological trauma and permanent neurological damage.^[1]

Previous studies have identified patient characteristics that can help predict potential difficulty in spinal block preoperatively.^[2-4] However, most previous studies have

focused on patient characteristics. Technical- (patient position, approach), provider- (experience) and equipment- (needle size) related factors may also impact the degree of ease or difficulty experienced during spinal block placement. The variable used to determine the degree of difficulty in previous studies is the number of attempts defined as the number of skin punctures. Cognisance has not been given to the number of needle redirections. Needle redirections can lead to neurological complications besides being unpleasant to the patient. Complications occurring during placement of the block (paresthesia, bloody tap) may influence patient outcome.

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The aim of this prospective, observational study was to investigate the association of first puncture success (successful identification of subarachnoid space with only one skin puncture and no redirection of spinal needle) and number of attempts (number of skin punctures plus needle redirections) with factors based on characteristics of the patient, the provider, the technique, and equipment in the Indian population. We also observed complications related to needle advancement into the subarachnoid space.

Material and Methods

After obtaining approval from the hospital ethics committee and informed consent from the patients, this prospective, observational study was performed in 1647 American Society of Anesthesiology (ASA) physical status I-III, adult patients undergoing surgery under spinal anesthesia, from January 2015 to March 2018. The study was registered with the Clinical Trials Registry–India (CTRI/2014/12/005305). Patients with neurological disease, history of seizures, low back pain, prior back surgery, sepsis, drug allergies, infection at local site, coagulation defects or on medications affecting coagulation, and any other concurrent medical illness where spinal anesthesia would otherwise be a relative contraindication were excluded from the study. Presence or absence of hypertension, diabetes, or pregnancy was noted.

The following patient characteristics were recorded prior to placement of the spinal block: gender, age, height, weight, body habitus, anatomical landmarks and spinal bony deformity. Body mass index (BMI) was calculated. Body habitus was assessed subjectively as normal, thin, muscular or obese.^[3] Anatomical landmarks and spinal bony deformity were assessed by physical examination of the lumbar spine of patient. Anatomical landmarks were classified as good (easily palpable lumbar spinous processes), poor (difficult to palpate spinous processes) or none (unable to positively identify spinous processes).^[3] Spinal bony anatomy was rated as normal or abnormal, according to the absence or the presence of kyphosis, lordosis or scoliosis. Distance from C7 vertebral spine to tip of coccyx was noted.

In the operating room, standard monitoring (electrocardiogram, non-invasive blood pressure, hemoglobin oxygen saturation) was established. Intravenous access was secured. Baseline heart rate (HR), blood pressure (BP) was noted. Patients were co-loaded with Ringer's lactate (10-15 ml/kg). Spinal block was performed under aseptic precautions after local anesthetic infiltration. The patient's ability to flex the spine was recorded as normal or inadequate. The anesthesiologist who assessed the landmarks and spinal anatomy and the

anesthesiologist who performed the spinal block were blinded to each other's findings.

Procedure was performed by an anesthesiologist having at least 6 months of training in giving spinal block. All procedures were supervised by a consultant anesthesiologist. Patient position, the spinal level, approach (midline/paramedian), needle size and local anesthetic dose administered was at the discretion of the anesthesiologist performing spinal block. Introducer needle was not used in any patient. Successful dural puncture was determined by retrieval of cerebrospinal fluid (CSF). During the procedure, the number of skin punctures and needle redirections required for successful dural puncture were noted. Successful dural puncture at the initial spinal level (interspace) was classified as first level success. The distance from the skin to the tip of the spinal needle was noted as the skin to subarachnoid space depth (SSD). Not more than three skin punctures were allowed for the first provider. The procedure was taken over by the supervising consultant anaesthesiologist. If the supervising anaesthesiologist was unable to perform a successful dural puncture in another three skin punctures, the procedure was abandoned and considered as failed dural puncture. The patient was then given general anesthesia. Providers level of experience was categorized as postgraduate student (>6 months – 1 year and 1 year - <3 years clinical experience), senior resident doctor (3- 6 years clinical experience); consultant (>6 years clinical experience); and taking-over by supervising consultant. Any change in patient position if required during conduct of the procedure was also noted. Data was collected for occurrence of paresthesia, blood-tinged CSF or bloody tap during the block. The surgical procedure, elective or non-elective and duration of surgery was recorded.

Difficulty encountered in performing dural puncture was assessed by two variables. These were first puncture success (successful identification of subarachnoid space with only one skin puncture and no redirection of spinal needle) and number of attempts (skin punctures plus needle redirections) required for successful needle placement.

Following intrathecal injection of local anesthetic (with or without additives), the patient was placed supine and the level of sensory block at 10 min and the maximum level of block achieved was noted. Incidence of hypotension, bradycardia and requirement for ephedrine or atropine was recorded. The effect of spinal anesthesia was considered satisfactory if the surgical procedure could be performed under spinal block without any supplementation with analgesics or general anesthesia. The effect of spinal anesthesia was considered unsatisfactory if there was sensory and motor blockade, but supplementation with analgesics or general anesthesia was

required for performing the surgical procedure. The absence of sensory and motor block was considered as no effect.

Statistical analysis

Categorical variables were presented as frequency and percentages. Normally distributed continuous variables were presented as mean and standard deviations (SD) and non-normally distributed continuous variables as median with interquartile range (IQR). Chi-square tests were used to see association of free flow of CSF (yes/no) and aspiration (yes/no) with effect of anesthesia (satisfactory, unsatisfactory and no-effect). Multivariate logistic regression analysis was performed to assess the association of factors with first puncture success and results were presented as adjusted odd's ratio (aOR) and 95% confidence interval. Distribution of fitness of number of attempts was assessed using generalized linear model (tweedie regression analysis), representing mixtures of poisson and gamma distribution with a deviance value 1.04. Adjusted OR and 95% C.I. were presented. *P* value <0.05 (two-tailed) was considered statistically significant. SPSS 22.0 statistical package was used for the analysis.

Results

We studied 1647 patients. There were 769 women, of which 295 (17.9%) were pregnant. The number of patients belonging to ASA physical status I, II and III were 1323, 307 and 17 respectively. The overall mean \pm SD age of the patients was 38.0 ± 15.7 (range 18-94) years. Hypertension and diabetes were present in 201 (12.2%) and 60 (3.6%) patients, respectively. Body habitus was normal in 923 (56.0%), thin in 388 (23.6%), muscular in 164 (10.0%) and obese in 172 (10.4%) patients.

Spinal bony landmarks were good, poor and none in 1357 (82.4%), 267 (16.2%) and 23 (1.4%) patients, respectively. The spines were crowded in 134 (8.1%) patients. Spinal bony deformity was present in 4.9% subjects as follows: kyphosis 7 (0.4%); lordosis 24 (1.5%); scoliosis 47 (2.9%); >1 deformity 2 (0.1%). The mean vertebral column length from the seventh cervical spine to coccyx (C7-Cx distance) was 60.5 ± 6.2 cm. The mean \pm SD subarachnoid space depth was 4.85 ± 0.73 cm.

Details of patient position, provider experience and spinal technique are summarized in Table 1. First puncture success (CSF obtained with one skin puncture with no needle redirection) was obtained in 872 (52.9%) patients. Failed dural puncture (inability to locate subarachnoid space) occurred in 4 (0.2%) of 1647 patients. Spinal anaesthesia effect was satisfactory in 1599 (97.1%) and unsatisfactory in

24 (1.4%). No effect was seen in 20 (1.2%) patients despite a successful dural puncture.

Multivariate logistic regression analysis revealed that longer C7-Cx distance, lower SSD, good quality of bony landmarks and absence of crowded spine were associated with first puncture success [Table 2].

Table 1: Details of patient position, experience of provider and spinal technique

Variables	(n=1647)
Patient position, lateral/sitting	503/1144
Change in patient position	30 (1.8)
Spinal approach, midline/paramedian	1583/64
Spinal level, L2-L3/L3-L4/L4-L5	84/1400/163
Needle gauge, 23/24/25/26/27	106/4/1226/261/50
Skin punctures	1.48 \pm 0.98
Redirections	1.31 \pm 2.5
Attempts	2.77 \pm 3.19
Experience C/SR/PG (1-3 yr)/PG (<6 mo-<1 yr)	184/754/525/184
Operator change required	132 (8.0)
Second operator difficulty	54 (3.3)
First puncture success	872 (52.9)
First level success	1456 (88.4)
CSF free flow/aspiration possible	1633/1619
CSF, clear/traumatic	1377/266

Values are numbers, numbers (percent) or Mean \pm SD, as appropriate.

C - Consultant; SR - Senior resident; PG - Postgraduate; CSF - Cerebrospinal fluid; L - Lumbar

Table 2: Multivariate logistic regression analysis for first puncture success

Variable	Adjusted OR	95% C.I.	P
Age	0.99	0.98 - 1.01	0.51
Body mass index	1.03	0.98 - 1.07	0.21
ASA physical status			
ASA I	1	--	
ASA II	1.14	0.74 - 1.76	0.56
ASA III	0.90	0.22 - 3.61	0.88
Hypertension	0.89	0.54 - 1.51	0.69
C7-Cx (cm)	1.02	1.01 - 1.04	0.04
SSD (cm)	0.54	0.44 - 0.66	0.001
Body Habitus			
Normal	1	--	
Thin	0.76	0.55 - 1.03	0.08
Muscular	0.89	0.59 - 1.37	0.61
Obese	0.79	0.46 - 1.34	0.38
Landmarks			
Good	1	--	
Poor	0.43	0.29 - 0.64	0.001
None	0.29	0.09 - 0.97	0.04
Crowded Spines			
Present	0.53	0.31 - 0.90	0.02
Absent	1	--	

OR: Odds Ratio; C.I.: confidence interval; ASA: American Society of Anesthesiologists; C7-Cx: distance from C7 vertebral spine to tip of coccyx; SSD: subarachnoid space depth

Distribution of number of attempts in spinal needle placement is depicted in Figure 1. Factors associated with number of attempts (skin punctures plus needle redirections) are presented in Table 3. Gender, quality of bony landmarks, presence of bony deformity, provider experience, dural puncture level, needle gauge and traumatic tap were found statistically significant variables to predict the number of attempts after adjusting other important variables in the model [Table 3].

Among the complications, 266 (16.1%) patients had a traumatic tap; paresthesia on needle advancement was seen in 198 (11.6%) patients. No patient had pain on drug injection or neurological complications. Intraoperative hypotension and bradycardia were seen in 259 (15.7%) and 82 (5%) patients respectively. The relation of effect of spinal anesthesia with free flow of CSF and aspiration of CSF following dural puncture are shown in Table 4.

Discussion

Difficulties may be encountered during administration of spinal anesthesia resulting in multiple attempts causing patient discomfort and some serious complications. Patient characteristics, and technical, provider and equipment related factors may determine the degree of ease or difficulty experienced during spinal block placement.

The present study demonstrated that good spinal landmarks, absence of crowded spines, longer C7-Cx distance and lower SSD were associated with first puncture success. We used first puncture success (successful subarachnoid space placement of the needle achieved with one skin puncture and

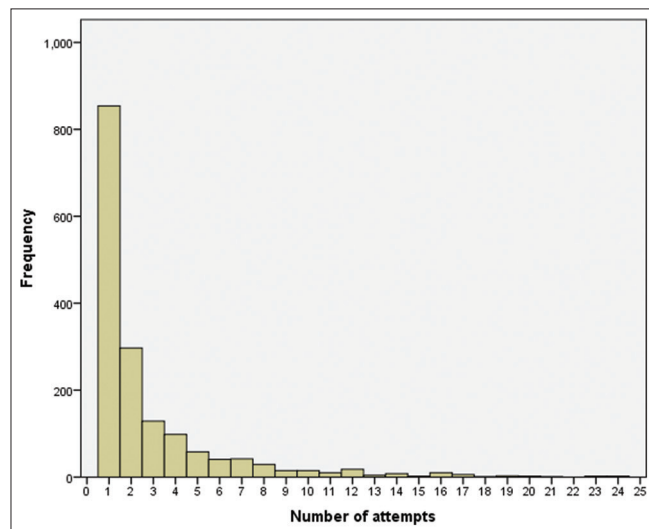


Figure 1: Histogram depicting distribution of number of attempts (skin punctures plus needle redirections)

no needle redirection) and the number of attempts (number of skin punctures plus needle redirections) to assess the factors predicting a difficult neuraxial block. Previous investigators have considered multiple needle redirections through a single skin puncture as one attempt.^[2,3,5,6] We counted each needle redirection as a new attempt as it subjects the patient to added discomfort, risk of injury and complications as much as each skin puncture.

The overall success rate of spinal anesthesia in our study (97.1%) is in accordance with reported success rates of between 90% to 99% in previous studies.^[3,5-7] There were 4 (0.2%) failed dural punctures. Weed *et al.* reported a 6.7% incidence of failed dural puncture.^[8] The effect was unsatisfactory in 1.4% (24 of 1643 patients) and no effect was observed in 1.2% (20 of 1643 patients) patients despite retrieval of CSF. Inadequate concentration of anesthetic agents in the CSF because of the spinal needle being partly inside the subdural space or displacement of the spinal needle from the subarachnoid space that may occur while trying to firmly secure the syringe, contribute to unsatisfactory or no effect.^[9,10] A poor connection between the spinal needle and syringe may lead to leakage of injected volume.^[10]

First puncture success rate was 52.9% (872 of 1647 patients) in this study compared to 64%^[3] and 75%^[11] in previous studies. It is important to note that needle redirections were not included as an attempt in these studies. Our criteria of first puncture success was more stringent as we included every needle redirection as an attempt, and explains a lower first attempt success. First level success was obtained in 88.4% (1456 of 1647 patients).

The number of attempts (skin punctures plus needle redirections) required for dural puncture indicated the degree of technical difficulty in neuraxial block. Male gender, poor quality or no landmarks, spinal bony deformity, needle gauge, dural puncture level and experience of the provider influenced the difficulty in performing spinal block.

BMI is an important determinant for the ease of placement of spinal needle.^[1] BMI affects the subarachnoid space depth.^[12] A lower subarachnoid space depth was associated with first puncture success in the present study. Kim *et al.* also found that the distance from skin to subarachnoid or epidural space was significantly associated with the number of attempts and first puncture success.^[4] Gender did not correlate with first puncture success, which is in accordance with the findings of previous studies.^[3,6]

Quality of spinal anatomical landmarks was associated with technical difficulties of blocks. First puncture with no

Table 3: Factors associated with number of attempts (skin punctures plus needle redirections): A Tweedie General Linear Model regression analysis approach

Variable	Category	Adjusted OR	95% C.I.	P
Gender	Male	1.10	1.02 - 1.19	0.01
	Female	1	--	
Approach	Paramedian	0.88	0.72 - 1.07	0.20
	Median	1	--	
Needle gauge	23 G	1.01	0.88 - 1.17	0.86
	24 G	0.70	0.31 - 1.58	0.39
	26 G	0.82	0.74 - 0.91	0.001
	27 G	0.90	0.73 - 1.12	0.35
	25 G	1	--	
Landmarks	Poor	1.88	1.41 - 2.52	0.001
	None	1.83	1.65 - 2.03	0.001
	Good	1	--	
Body Habitus	Obese	1.01	0.89 - 1.5	0.86
	Thin	1.09	0.99 - 1.19	0.06
	Muscular	0.97	0.85 - 1.10	0.63
	Normal	1	--	
Bony Deformity	Present	1.24	1.06 - 1.45	0.007
	Absent	1	--	
Experience	PG Student >6 months and <1 year	0.82	0.70 - 0.95	0.009
	Senior resident 3 to 6 years	0.80	0.71 - 0.90	0.001
	PG Student 1 to 3 years	0.87	0.77 - 0.97	0.03
	Consultant	1	--	
Lumbar Level	L2-3	1.27	1.09 - 1.48	0.003
	L4-5	1.33	1.18 - 1.49	0.001
	L3-4	1	--	
Position Spinal	Lateral	1.05	0.97 - 1.14	0.22
	Sitting	1	--	
Cerebrospinal fluid	Frank blood	1.76	1.36 - 2.27	0.001
	Blood tinged	1.74	1.58 - 1.91	0.001
	Clear	1	--	
Paresthesia	Present	1.12	1.01 - 1.24	0.05
	Absent	1	--	

Adjusted OR is adjusted Odds Ratio; C.I. is confidence interval; PG is postgraduate

Table 4: The relation of effect of spinal anaesthesia with free flow of CSF and aspiration of CSF following dural puncture

Effect of spinal anaesthesia	Free flow of CSF		Aspiration of CSF	
	Present	Absent	Present	Absent
Satisfactory	1591 (99.5)	8 (0.5)	1582 (98.9)	17 (1.1)
Unsatisfactory	23 (95.8)	1 (4.2)	20 (83.3)	4 (16.7)
No effect	19 (95)	1 (5)	17 (85)	3 (15)
P	0.003		0.001	

needle redirection was frequently successful in patients with good palpability of spinous processes. Patients with poor or no palpable landmarks were associated with a technically difficult spinal block. Previous studies also report that quality of anatomical landmarks is associated with difficulty in performing spinal block.^[4,6] The interspinous gap measured by palpation correlates with ease of access to subarachnoid space.^[13]

Spinal deformity is an important factor for prediction of difficulties during performing neuraxial anesthesia.^[3,5,6,14,15] Our study demonstrated that spinal deformity significantly increased the number of attempts, though it did not affect first puncture success. Likewise, Sprung *et al.* reported that spinal deformity did not affect first-level success, but it significantly increased the number of puncture attempts.^[3] The number of attempts and levels was found to be significantly associated with abnormality of spine.^[16]

The provider's level of experience has been investigated as a predictor of difficulty during spinal puncture with mixed results. Some authors have reported level of experience to be an independent predictor of success, with greater chances of success with a more experienced provider.^[4,5,7,17] Other studies have failed to find an association between the training level and success at neuraxial block.^[3,18] In the present study, the provider with least experience (post

graduate student with >6 months but <1 year experience) had given at least 90 spinal blocks. Senior resident doctor with a higher level of experience took lesser number of attempts at dural puncture as compared to postgraduate students.

However, the number of attempts taken for a successful dural puncture was greater (20%) when the consultant anesthesiologists performed spinal block compared with other resident groups. Anesthesiologists strive to minimize iatrogenic injury to patients and patients with difficult backs were likely to be administered spinal anesthesia by consultants. Operator change due to inability to locate subarachnoid space was required in 8% patients. The second operator experienced difficulty in 3.3% patients.

A dry tap may be encountered in dehydrated patients, the elderly and in spinal stenosis.^[21] Free flow of CSF was not obtained in ten (0.6%) patients despite a successful dural puncture. Aspiration of CSF before local anaesthetic administration was not possible in 24 (1.4%) patients. The lack of free flow of CSF and inability to aspirate CSF were both significantly associated with unsatisfactory or no effect of spinal block. Likewise, Alabi *et al.* reported failed spinal block in two of three patients in whom free flow of CSF was not obtained.^[22] Munhall *et al.*^[20] reported no correlation between the free flow of CSF and failed spinal anesthesia while Levy *et al.*^[23] reported a significantly higher failure rate among patients who had a dry CSF tap.

Paresthesia on needle advancement occurred in 11.6% patients. The incidence of traumatic tap was 16.1%. Both, paresthesia and traumatic tap, were associated with a significantly increased number of attempts at dural puncture. Puolakka *et al.* reported a 12.8% incidence of paresthesia.^[24]

This study has limitations. The sample size was not determined. The patients were not randomized with regard to provider experience that could influence the results. Some predictors were subjective such as quality of landmarks and body habitus.

Conclusion

Examination of the patients' back for bony deformity and quality of anatomical landmarks can determine the potential technical difficulty in performance of spinal block. The successful location of the subarachnoid space at the first skin puncture is influenced by quality of anatomical landmarks, presence of crowded spines, distance from C7 vertebral spine to tip of coccyx and subarachnoid space depth.

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Conflicts of interest

There are no conflicts of interest.

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