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Source / Izvornik: **Local and Regional Anesthesia, 2014, 7, 47 - 52**

Journal article, Published version

Rad u časopisu, Objavljena verzija rada (izdavačev PDF)

<https://doi.org/10.2147/LRA.S68451>

Permanent link / Trajna poveznica: <https://um.nsk.hr/um:nbn:hr:239:151140>

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Download date / Datum preuzimanja: **2024-07-24**



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Factors associated with difficult neuraxial blockade

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Abstract: Spinal and epidural blocks are common practice in anesthesia and are usually used for various surgical or endoscopic procedures. Correct identification and puncture of the epidural or subarachnoid space determine the success or failure of the technique. Multiple attempts and difficult access to the epidural or subarachnoid space is a frequent problem in operating theaters and may be hazardous due to a number of possible acute or long-term complications. In addition, multiple punctures are associated with increased pain and patient discomfort. The aim of this study was to determine the factors associated with a difficult spinal or epidural block, dependent on the patient (age, gender, height, weight, body mass index, and quality of anatomical landmarks), the technique (type of blockade, needle gauge, and patient positioning), and the provider (level of experience). The study was conducted at the Department of Anesthesiology, Resuscitation, and Intensive Care Unit of University Hospital Osijek (Osijek, Croatia) and it included 316 patients who underwent a range of different surgical procedures in neuraxial blocks. There were 219 cases of first puncture success, while the overall success of neuraxial blocks was 97.5%. Five patients (1.6%) were submitted to the alternative technique, ie, general anesthesia. In three patients (0.9%), neuraxial block was partial so they required supplementation of intravenous anesthetics and analgesics. Furthermore, it was found that first puncture success was associated with younger age ($P=0.007$), lower weight ($P=0.032$), and body mass index ($P=0.020$). Spine deformity ($P=0.015$), poor identification of interspinous space ($P=0.005$), recumbent patient position during the puncture ($P=0.001$), and use of a paramedian approach were associated with first puncture failure. Adequate preoperative prediction of difficulties can help to reduce the incidence of multiple attempts, rendering the technique more acceptable and less risky to the patient, and consequently leading to improvement of medical care quality. The attending anesthesiologist should consider an alternative technique (general anesthesia or peripheral nerve block) for a patient if certain difficulties can be predicted.

Keywords: spinal anesthesia, epidural anesthesia, difficulty, first punctures success

Introduction

Neuraxial blocks, such as spinal and epidural block, are common practice in anesthesia and are widely used for a number of surgical and endoscopic procedures.¹ Many factors influence the anesthesiologist's decision to perform neuraxial anesthesia. The most important of them include the type of surgery, absolute or relative contraindications for neuraxial block, and better ability for management of postoperative pain. The anticipated difficulties of the neuraxial blockade and the provider's level of experience are of no less importance. Correct identification and cannulation of the epidural or subarachnoid space determine the success or failure of the technique. Multiple attempts and difficult access to the epidural or subarachnoid space is a frequent problem in operating theaters

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and may be hazardous for a patient. Traumatic placement of a needle and multiple attempts during a neuraxial blockade has been related to numerous complications. Some of them are transient, such as postdural puncture headache and transient neurological symptoms.² However, severe incidents like trauma to neural structures or a spinal hematoma can cause permanent neurologic deficits and long-term disability.³⁻⁶ Also, multiple punctures are associated with pain and patient discomfort.⁷ Several factors associated with technically difficult neuraxial block were demonstrated in earlier studies. These factors primarily include age, gender, body mass index (BMI), and spine deformities. It has been suggested that either an alternative technique (general anesthesia or peripheral nerve block) should be considered for a patient if the anesthesiologist predicts some difficulties or a more experienced provider should take over a difficult procedure at an early stage.⁸ Also, ultrasound may be useful in preoperative assessment of spine anatomy, especially if spine deformities are present.^{9,10} Accurate preoperative prediction of difficulty adds to the delivery of high quality care and can help to reduce the incidence of multiple attempts, rendering the technique more acceptable and less risky to the patient.

The purpose of this study was to determine the factors associated with a difficult spinal or epidural block by investigating the association of first puncture success (a successful block achieved by only one skin puncture) with the factors dependent on the patient, the provider, and the technique.

Methods

This prospective observational study was approved by the University Hospital Osijek Research Ethics Committee (Osijek, Croatia). The study population included 316 patients undergoing various orthopedic, traumatologic, vascular, urologic, gynecological, neurosurgical, or abdominal surgery procedures. Exclusion criteria were patients with neurological disease or coagulation defects, patients medicated with anticoagulation, local infection on site for block performing, and patients refusing spinal anesthesia. Each patient was examined preoperatively by an anesthesiologist and routine laboratory tests were done.

All neuraxial blocks were used as the primary anesthetic technique. The type of block, the level, the approach (median/paramedian), the needle, and patient position (sitting/lying) were based on the choice of the anesthesiologist. Identification of the subarachnoid space required the free flow of cerebrospinal fluid. The technique for identification of the epidural space was based on the provider's level of experience (the loss of resistance or hanging drop technique). Prior to

block administration, gender, age, height, weight, body type (normal, thin, muscular, obese), and spine deformity (kyphosis/scoliosis) were recorded. Spine deformity was assessed by inspection of the patient's back. BMI was calculated as weight divided by height squared (kg/m^2). The quality of anatomical landmarks – categorized as easily palpable, poorly palpable, or nonpalpable spinous processes – was assessed by physical examination of the patient's spine. Also, the provider's level of experience was categorized as a young specialist (≤ 5 years), senior specialist (> 5 years of specialist traineeship), young resident of anesthesiology (≤ 2 years), or senior resident (≥ 2 years in anesthesia practice). All trainees were supervised by the attending anesthesiologist in charge of completing difficult procedures that cannot be performed by a resident. During the procedure the provider measured the distance from the skin to the end of the needle using a sterile ruler. The depth of the spinal/epidural space was calculated as the length of needle (in cm) minus the distance from the skin to the end of the needle (in cm). After performing the block, the needle type and gauge, the type of the block (spinal/epidural), the number of attempts (defined as the number of skin punctures), and the success or failure of the blockade were recorded. Successful surgical anesthesia achieved with only one skin puncture was regarded as first puncture success. Each new skin puncture was considered as another attempt, whether at the initial or another spinal level. Simply redirecting the needle without a new skin puncture was not considered as an additional attempt. The neuraxial block was considered successful if the patient did not require local anesthetic supplementation, a second neuraxial block, or general anesthesia.

Statistical analyses were performed using SPSS® version 20.0 (IBM Corporation, Armonk, NY, USA). Frequency or arithmetic mean and standard deviation were calculated for all data. The difference of numerical variables was analyzed using Student's *t*-test. Comparison of categorical variables was made using the chi-square test. Binary logistic regression was used to evaluate the influence of some variables on first puncture success. $P < 0.05$ was considered statistically significant.

Results

The study population included 316 patients – 182 males (57.6%) and 134 females (42.4%). A major proportion of patients (62%) were orthopedic patients, followed by traumatology patients (12.7%) and abdominal surgery patients (10.8%). The remaining patients underwent vascular, urological, gynecological, and neurosurgical surgery. The youngest

patient was 13 years old, and the oldest was 87 years old. The average age was 50.69 ± 19.291 years. Height ranged from 147–204 cm, while weight ranged from 40–180 kg. The average weight was 82.02 ± 17.393 kg. The average BMI was 27.79 ± 5.317 kg/m² (range: 16.30–58.1 kg/m²). There were 314 spinal epidurals and only two lumbar epidurals. The average depth of spinal space was 6.01 ± 1.259 cm (range: 3–10 cm), and the average number of attempts was 1.49 ± 0.910 (range: one to six attempts). Patient characteristics and technical aspects of neuraxial blocks are outlined in Table 1.

There were 219 (69.3%) first puncture successes, but final success of blockade was 97.5% (308/316) at either the first or second spinal level of puncture. In 15 patients (4.74%), the block was successfully completed by the senior specialist. The remaining eight patients required general anesthesia or addition of local anesthetics, intravenous analgesics, or anesthetics. The correlation between first puncture success and categorical variables is shown in Table 2, while the relationship between numerical variables and first puncture success is displayed in Table 3.

The binary logistic regression statistical method was used to assess the influence of several factors on first puncture success and it was found that if the spine did not have any deformity, the likelihood for first puncture success was 2.6 times higher than with deformity. Also, poor palpability

Table 1 Patient characteristics and technical factors of neuraxial blocks

Characteristic	Number of patients (%) n=316
Provider	
Resident <2 years	36 (11.4)
Resident ≥2 years	25 (7.9)
Specialist <5 years	160 (60.1)
Specialist ≥5 years	65 (20.6)
Needle	
22 gauge	56 (17.7)
25 gauge	154 (48.7)
27 gauge	106 (33.5)
Position during puncture	
Sitting	276 (87.3)
Lying	40 (12.7)
Spine deformity	
Yes	73 (23.1)
No	243 (76.9)
Site of puncture	
Easily palpable	168 (53.3)
Poorly palpable	109 (34.5)
Nonpalpable	39 (12.3)
Approach	
Median	307 (97.2)
Paramedian	9 (2.8)

Table 2 Correlations between first puncture success and categorical variables

Variable	First puncture success, n (%)		X ² , P-value
	Yes	No	
Ward			
Orthopedics	137 (69.9)	59 (30.1)	6.44, 0.367
Traumatology	27 (67.5)	13 (32.5)	
Vascular surgery	5 (55.6)	4 (44.4)	
Abdominal surgery	26 (76.5)	8 (23.5)	
Urology	1 (58.3)	10 (41.7)	
Gynecology	10 (83.3)	2 (16.7)	
Neurosurgery	0 (0.0)	1 (100.0)	
Gender			
Male	126 (69.2)	56 (30.8)	0.001, 0.974
Female	93 (69.4)	41 (30.6)	
Body type			
Normal	27 (75.0)	9 (25.0)	5.04, 0.168
Thin	113 (73.9)	40 (26.1)	
Muscular	18 (62.1)	11 (37.9)	
Obese	61 (62.2)	37 (37.8)	
Anesthesia			
Spinal	217 (69.1)	97 (30.9)	0.891, 0.345
Epidural	2 (100.0)	0 (0.0)	
Provider			
Resident <2 years	32 (88.9)	4 (11.1)	9.44, 0.024*
Resident ≥2 years	17 (68.0)	8 (32.0)	
Specialist <5 years	122 (64.2)	68 (35.8)	
Specialist ≥5 years	48 (73.8)	17 (26.2)	
Needle			
22 gauge	29 (51.8)	27 (48.2)	19.78, 0.000*
25 gauge	101 (65.6)	53 (34.4)	
27 gauge	89 (84.0)	17 (16.0)	
Patient position			
Sitting	202 (73.2)	74 (26.8)	15.46, 0.000*
Lying	17 (42.5)	23 (57.5)	
Spine deformity			
No deformity	188 (77.4)	55 (22.6)	32.14, 0.000*
Present deformity	31 (42.5)	42 (57.5)	
Kyphosis			
Yes	179 (56.65)	110 (34.81)	3.881, 0.0488*
No	12 (3.8)	16 (5.06)	
Scoliosis			
Yes	166 (52.53)	104 (32.91)	5.261, 0.0218*
No	20 (6.33)	26 (8.23)	
Palpability of spinous process			
Easily palpable	137 (81.5)	31 (18.5)	27.40, 0.000*
Poorly palpable	64 (58.7)	45 (41.3)	
Nonpalpable	18 (46.2)	21 (53.8)	
Approach			
Median	219 (71.3)	88 (28.7)	20.19, 0.000*
Paramedian	0 (0.0)	9 (100.0)	

Note: *P<0.05.

of interspinous space reduced the likelihood of first puncture success by 4.17 times. Finally, if a patient was lying down during the puncture, the chance for first puncture success was reduced by 4.29 times.

Discussion

Before any kind of anesthesia, the anesthesiologist must determine which patient is at a greater risk during the perioperative period. Difficult airway, malignant hyperthermia, or perioperative adverse outcome in general anesthesia are well documented in the literature. However, few studies have dealt with the problems in performing neuraxial blockades.^{11,12}

The present study was conducted with the aim of determining the factors associated with a difficult spinal or epidural block. First puncture success (described as a successful surgical anesthesia with only one skin puncture) was used as a measure to assess a difficult neuraxial block.

It was found that technical difficulties and first puncture success correlated with certain patient characteristics. Gender and body type did not correlate with first puncture success, which is in accordance with the findings obtained in previous studies.¹³ In a study conducted on a sample of 848 patients, Chien et al found body type to be only a minor predictor for successful epidural block.¹⁴ In the present study, it was found that the block was easier to perform in younger patients ($P=0.007$), which was expected due to less incidence of spine deformities and probably better compliance during the procedure. Difficulties in performing the block were often associated with higher BMI ($P=0.020$) and weight ($P=0.032$). Patients with higher BMI and weight often have a poorly palpable interspinous space, so determining the space for needle introduction is often problematic. BMI was found to be a very weak predictor of neuraxial blocks difficulties in several previous studies.^{4,13}

Quality of back landmarks (ie, spinous process and interspinous space) was also associated with technical difficulties of blocks in this study. It was found that the first puncture was mostly successful in patients with good palpability of interspinous space ($P=0.000$). In previous studies, the quality of anatomical landmarks was strongly associated with successful anesthesia at the first attempt.³ Furthermore, Kim et al found that the quality of anatomical landmarks differed between first puncture success and first puncture failure groups and it was associated with first puncture success.⁴

Spinal deformity was also an important factor for prediction of difficulties during performing neuraxial anesthesia. The present data demonstrated that spine deformity was an important factor for un(successful) neuraxial block. The first puncture was often successful in patients without spine deformities ($P=0.000$). As the incidence of spine deformities increases with patient's age, it is reasonable to expect block difficulties to occur more frequently in elderly patients, which was supported by the present findings. Sprung et al showed that although spinal deformity did not affect first-level success, it significantly increased the number of puncture attempts.¹³

The present investigation showed some unexpected and interesting results about the effects of the provider's level of experience on first puncture success. It was found that younger residents were the most successful in performing neuraxial blocks ($P=0.024$), which is contrary to former studies.³ This may be accounted for by the fact that younger residents were mostly scheduled in the orthopedic operation room for knee arthroscopy, where they usually performed neuraxial blocks in young sportsmen who had normal BMI, good palpable interspinous spaces, and generally did not have spine deformities.

Table 3 Relationship between patients' numerical variables and success for first attempt of neuraxial block

Variable	First puncture success	n	Mean	SD	t	P
Age (years)	Yes	219	48.77	19.64	-2.702	0.007*
	No	97	55.06	17.81		
Height (cm)	Yes	219	170.81	13.45	-0.558	0.577
	No	97	171.66	10.06		
Weight (kg)	Yes	219	80.46	16.77	-2.149	0.032*
	No	97	85.06	19.27		
BMI (kg/m ²)	Yes	219	27.23	5.39	-2.332	0.020*
	No	97	28.79	5.70		
Depth of spinal space (cm)	Yes	219	5.96	1.22	-1.102	0.271
	No	93	6.14	1.46		

Note: * $P<0.05$.

Abbreviations: BMI, body mass index; SD, standard deviation.

Other predictors of successful neuraxial block in this study included position during the puncture and approach type. It was found that the sitting position was associated with better first puncture success ($P=0.000$), probably due to better opening of the interspinous space. Furthermore, the midline approach was associated with better first puncture success and the paramedian approach was found to be completely unsuccessful ($P=0.000$). A possible explanation for this could be that the midline approach was chosen for the first placement of the needle and another approach was tried when difficulties were present during the first puncture attempt. These results partially correspond to the study conducted by Kopacz et al, which reported that the midline approach had a higher success rate and required fewer attempts than the paramedian approach.¹⁵ Sprung et al found no difference in first-level success or number of attempts for either type of block, regardless of the approach.¹³

The highest percentage of successful blocks in the present study was by using a small spinal 27-gauge needle ($P=0.000$). This is contrary to the results obtained in Tarkkila et al's study of 300 spinal anesthetics using 25-, 27-, and 29-gauge needles, which showed that needle gauge was not a significant factor with respect to the success of neuraxial block.¹⁶ A possible explanation for the present finding could be that 27-gauge needles were used the most in young patients who generally had normal BMI and did not have spine deformities.

In this study, first puncture success was found in 69.3% patients, yet the overall success was 97.5%. Only 2.5% patients needed another type of anesthesia. These results are almost equal to the results of previous studies. In the study of 100 spinal blocks, Harrison and Langham reported a 75% success rate on the first attempt.¹⁷ Sprung et al displayed initial success in 64% patients, and final success was 98%.¹³ Furthermore, in the study conducted by Kopacz et al, the overall success rate was 99%,¹⁵ which is comparable to the results reported here.

This study had several limitations. First, the patients were not randomized, which could influence some of the results (eg, first puncture success was dependent on the provider or some technical factors). Second, the number of attempts in redirecting the needle without a new skin puncture was not registered. And finally, the predictors were mostly subjective, eg, a poorly palpable interspinous space to one practitioner might be nonpalpable to another.

As reported in previous studies, this research also demonstrated some critical factors for predicting difficulties in performing neuraxial blocks. In daily practice, an anesthesiologist must identify the patients with expected difficulties

and apply measures to increase success rates of this technique. Examination of the patient's back for an obvious deformity as well as the quality of spine landmarks must be a cornerstone in preoperative evaluation. In cases of evident spine deformities, usage of ultrasound during the procedure can help to determine epidural or spinal space.^{9,10} A thorough explanation of the procedure to each individual patient and premedication before anesthesia can contribute to better patient compliance. If the first puncture was unsuccessful, the provider must consider changing the patient's position during the procedure or calling a more experienced anesthesiologist for help. Additionally, if an anesthesiologist can predict certain difficulties, an alternative technique (general anesthesia or peripheral nerve block) may be considered.

Finally, it can be concluded that patients in a sitting position with median neuraxial approach during the puncture and those without a preexisting spine deformity and lower BMI are more likely to have first puncture success. In the remaining population, some difficulties are expected, for which prediction is necessary so that the best anesthetic plan can be created to minimize multiple attempts and to maximize block success.

Disclosure

The authors report no conflicts of interest in this work.

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