Original Article

Predictors of difficult epidural placement in pregnant women: A trainees' perspective

Suman Rajagopalan, Krishna Shah, Danielle Guffey[1], Connie Tran, Maya Suresh, Ashutosh Wali

Department of Anesthesiology, Baylor College of Medicine, [1]Department of Biostatistics, Dan L. Duncan Institute for Clinical and Translational Research, Baylor College of Medicine, Houston, Texas, USA

Abstract

Background and Aims: Epidural analgesia is believed to be the most difficult technique to learn for a trainee. The reason for this is not only inexperience of the provider and the complexity of the technique but also patient factors like obesity, spinal deformity and others which makes the epidural placement difficult. The aim of this study was to evaluate some of the common risk factors for difficult epidural placement as perceived by the anesthesia providers during training, with varying level of experience.
Material and Methods: This prospective observational study includes patients who received epidural placement for labor analgesia. Data recorded on these patients included age, height, weight, body mass index (BMI), ease of palpation of the spinous process, level of epidural placement, number of attempts, time taken for epidural placement and experience of the provider. The association between the variables were assessed using logistic regression for first attempt success and Cox proportional hazard ratio for time to epidural placement.
Results: A total of 373 patients received epidural placement for labor analgesia. The mean BMI at the time of placement was 34. The first attempt success rate for the placement of epidural was 67% ($n = 273$). Women with well palpable spinous process were 3.3 times more likely to have a successful first attempt placement irrespective of the provider experience or BMI [3.39 (1.77-6.51), $P < 0.001$]. The time to placement was shorter in patients with good anatomical landmarks [1.58 (1.20-2.07), $P < 0.001$) and when performed by a trainee who had performed a minimum of 20 epidural procedures [1.57 (1.26-1.94), $P < 0.001$).
Conclusion: Inability to palpate the spinous process contributes to multiple attempts at epidural placement when performed by a trainee.

Keywords: Difficult epidural, epidural analgesia, obstetric analgesia, predictors

Introduction

In an academic teaching hospital, the anesthesia trainees under the direct supervision of the faculty anesthesiologist perform majority of epidural procedures in the labor and delivery suite. According to the Accreditation Council for Graduate Medical Education's requirement, an anesthesiology resident is required to perform at least 40 epidural procedures during residency training.[1] In a study by Konrad *et al.*, looking at learning curves for various technical skills in anesthesia trainees, epidural anesthesia was the most difficult task to learn when compared to intubation, brachial plexus block, arterial line placement and spinal anesthesia.[2] The factors contributing to a difficult epidural placement for a trainee are complex technique, inadequate experience and patient factors like obesity, spinal deformities, inability to identify interspinous space, and the distance the catheter is threaded into the epidural space.[3-5] Even with experienced anesthesiologists, the incidence of difficult epidural placement is reported to be as high as 30% in patients undergoing surgery.[3] The studies done looking

Address for correspondence: Dr. Suman Rajagopalan, Department of Anesthesiology, Baylor College of Medicine, One Baylor Plaza, MS: BCM-120, Houston, Texas 77030, USA.
E-mail: srajagop@bcm.edu

Access this article online

Quick Response Code:

Website: www.joacp.org

DOI: 10.4103/joacp.JOACP_340_18

How to cite this article: Rajagopalan S, Shah K, Guffey D, Tran C, Suresh M, Wali A. Predictors of difficult epidural placement in pregnant women: A trainees' perspective. J Anaesthesiol Clin Pharmacol 2019;35:548-52.

at difficult epidural placement in trainees only evaluated the time taken to learn the skill or achieve consistency with the technique, but failed to take patient characteristics into account. In this observational study, we wanted to look at the difficult epidural placement and identify some of the common predictors of difficult placement for a novice trainee.

Material and Methods

This prospective observational study was conducted between 2015 and 2016. The Institutional Review Boards of Baylor College of Medicine, Houston, TX and Harris Health System, Houston, TX approved the study on 1/28/2015. Women who received epidural analgesia for labor during the study time period were included. Exclusion criteria were patients who refused epidural analgesia or who had contraindication to the placement of an epidural catheter (local infection, coagulation defects or neurological deficits). We also excluded the ones where the placement was not attempted by a trainee. Three hundred and seventy-three pregnant women who had received epidural analgesia for the management of labor pain were enrolled in the study. Study-specific data were collected using paper case report forms. Patient characteristics including age in years, weight in kg, and height in cm were recorded. Weight and height were recorded using a stadiometer and a digital weighing scale, respectively. Body Mass Index (BMI) was calculated as weight in kg/(height in m)^2. The following data regarding epidural anesthesia were self-reported by the trainees: 1) ease of palpation of the spinous process (well palpable vs. not well palpable), 2) level where the epidural placement was attempted, 3) number of needle passes, 4) total number of interspaces attempted, 5) time taken for successful placement of the epidural catheter and 6) experience of the provider. The experience of the provider was recorded as those having less than 20 versus more than 20 prior epidural placements.

If bony obstruction was encountered during the placement, the epidural needle was withdrawn slightly, and the needle was redirected into the epidural space. Redirecting the needle without completely disengaging from the skin was not counted as a new attempt. However, a new skin puncture at the same interspace or another interspace was considered as another attempt. An epidural was called difficult when more than one attempt was required to place the epidural catheter. The time for successful epidural placement was defined as the time from the injection of local anesthetic for skin wheal to the application of adhesive to secure the epidural catheter. The faculty anesthesiologist performed the epidural procedure if a trainee was unable to place the catheter within two attempts.

Statistical analyses

The demographic characteristics were summarized using standard descriptive measures. Logistic regression was used to assess the association between the dichotomous dependent variable, i.e., successful epidural placement in the first attempt with independent categorical variables, i.e., ease of palpation of the spinous process and experience of the provider as well as the numerical variable of BMI. Cox proportional hazard regression was used to assess potential predictors of time to successful placement of epidural catheter. Analyses were performed using Stata v12.1 (StataCorp College Station, TX). A $P < 0.05$ was considered statistically significant.

Results

A total of 373 pregnant women who received epidural analgesia for labor were enrolled in the study. The median age was 28.4 years [Table 1]. All epidural placements were performed in the sitting position except in two individuals where it was done in left lateral decubitus position. A 17-guage 9.84 cm Hustead epidural needle was used in all patients. The epidural catheters were placed in the lower lumbar spaces at L3-L4 and L4-L5 in 93% of individuals [Table 1]. The mean BMI on admission for delivery was 34.0. Majority of the epidural were placed by the trainees during their first obstetric anesthesia rotation in the second or third year of training ($n = 312$). The final year (PGY4) residents contributed to about 5% of the placements ($n = 20$), while the rest ($n = 38$) were placed by the faculty when the trainees did not get it in the first two attempts. The spinous processes ($n = 240$) were well palpable in 149 (62%), and not well palpable in 91 (38%) women. 60% of trainees had performed more than

Table 1: Patient characteristics and risk factors for epidural placement

Mean (SD) age in yrs; *n*=372	28.4 (6.1)
Mean (SD) BMI; *n*=359	33.96 (7.26)
Anatomical Landmarks; *n*=240	*n* (%)
Well palpable	149 (62%)
Not well palpable	91 (38%)
Trainee experience; *n*=360	
>20 epidurals	217 (60%)
Primary level of placement; *n*=369	
T12 - L1	5 (1)
L1-L2	1 (0.3)
L2-L3	11 (3)
L3-L4	171 (46)
L4-L5	164 (44)
L (level not specified)	17 (5)
Number of attempts; *n*=361	
1	243 (67%)
2	77 (21%)
3 or more	41 (11%)
Wet Tap; *n*=340	7 (2%)

BMI=Body mass index, SD=Standard deviation, T=Thoracic, L=Lumbar

20 epidural placements prior to enrollment in the study. The first attempt success rate for the placement of the epidural was 67% ($n = 243$) and about 21% more catheters were placed on the second attempt. The faculty had to intervene and perform the epidural placement in 11% of the women. The incidence of wet tap was low at 2% ($n = 7$). Multivariable logistic regression showed that well palpable spinous process correlated with the successful placement of epidural catheter in the first attempt [3.39 (1.77-6.51), $P < 0.001$]. This association was significant in spite of accounting for the BMI of the patient as well as the experience of the provider [Table 2]. The odds for successful first attempt placement of catheter was 3.3 when the spinous process was well palpable.

We also looked at time to placement of epidural catheter, as it is an indirect measure of difficult placement [Figure 1]. We thus assessed the effect of three factors, i.e., BMI, provider experience, and ease of palpation of the spinous process on the time to placement using Cox proportional hazard ratio [Table 3]. Using univariate and multivariate analysis, we found that in patients with well palpable spinous process [1.70 (1.24-2.33), $P < 0.001$] and the trainees with experience of more than 20 epidural procedures [1.77 (1.33-2.34), $P < 0.001$] took less time for epidural placement [Figure 2].

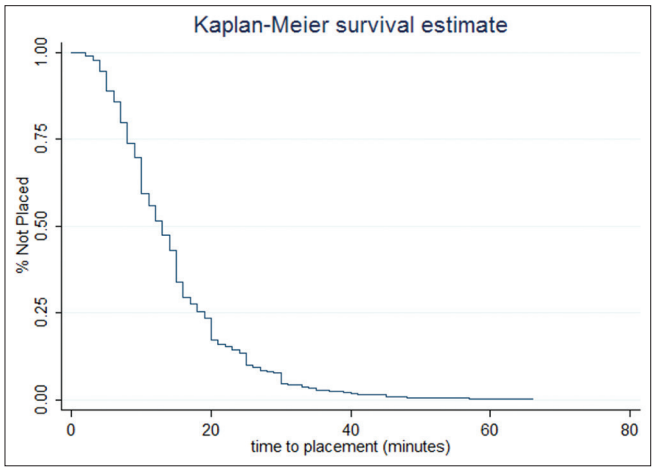

Figure 1: Kaplan-Meier curve that indicates the time to placement of the epidural catheter. The median time to placement was 13 minutes (95% CI = 12,14)

Discussion

At an academic teaching institution, our responsibility is not only to teach the trainees to become proficient in performing epidural procedure, but also to ensure patient safety and satisfaction.[2] Labor epidural analgesia has been commonly used to manage labor pain over the last three decades and studies have shown that difficult epidural placement have been associated with higher complication rates like dural puncture, back pain, epidural hematoma, poor pain control and poor patient satisfaction.[6-11] In this study, we wanted to estimate the incidence of difficult epidural placement in a teaching hospital and focus on identifying some of the predictors of difficult epidural placement as noted by the trainees. It is valuable to identify and assess the potential factors for difficult epidural placement as it helps formulate a safe anesthetic plan for the patient.

The term "difficult epidural placement" has a broad definition. Thus, our aim was to use more concrete factors in defining this term - the rate of first attempt at successful placement and time to placement of epidural catheter to describe the ease of placement. Our study found that identification of spinous process was a significant and an important factor that correlated with first attempt placement by the inexperienced trainees. Moreover, the time taken for placement of catheter was less when the spinous process was palpable. It has been noted in the previous studies in pregnant and non-pregnant population that poor anatomical landmarks were associated with difficult epidural placements.[3,12,13] It is well known that

Table 2: Univariate and multivariable Logistic Regression for first attempt success

First attempt success Variables	Univariate Logistic Regression			Multivariable Logistic Regression		
	Odds ratio	95% CI	*P*	Odds ratio	95% CI	*P*
BMI	0.99	0.96-1.02	0.54	1.02	0.98-1.06	0.32
Well palpable spinous process	3.31	1.87-5.84	<0.001	3.39	1.77-6.51	<0.001
Experience (>20 epidural placement)	1.10	0.70-1.73	0.69	0.93	0.51-1.71	0.82

BMI=Body mass index, CI=Confidence interval

Table 3: Univariate and multivariable Cox Proportional Hazard Ratio for Time to epidural placement

Time to epidural placement Variables	Univariate Cox Proportional Hazard			Multivariable Cox proportional Hazard		
	Hazard ratio	95% CI	*P*	Hazard ratio	95% CI	*P*
BMI	0.99	0.98-1.01	0.22	1.00	0.98-1.02	0.96
Well palpable spinous process	1.58	1.20-2.07	0.001	1.70	1.24-2.33	0.001
Experience (>20 epidural placement)	1.57	1.26-1.94	<0.001	1.77	1.33-2.34	<0.001

BMI=Body mass index, CI=Confidence interval

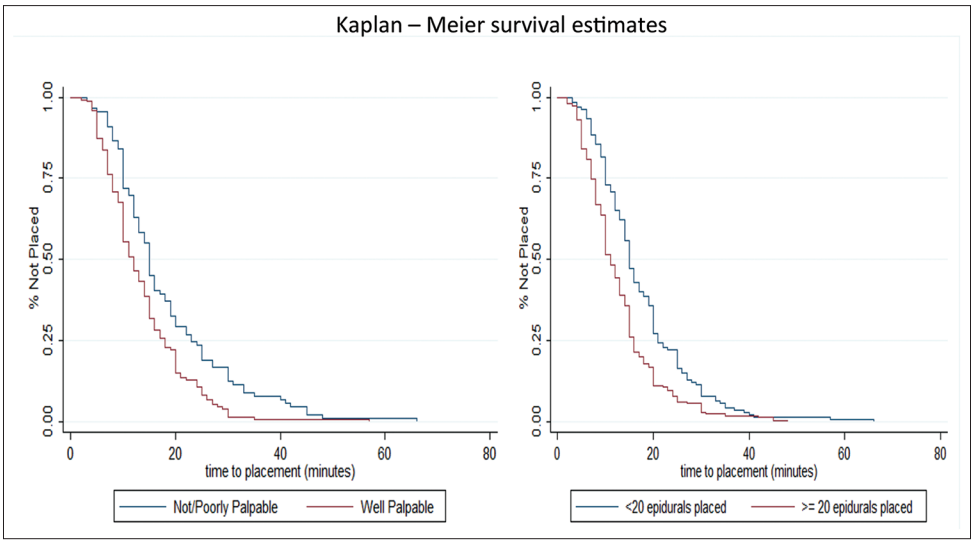

Figure 2: Kaplan-Meier curve showing the time to placement of epidural by palpation of spinous process and provider experience. The curves indicate that the time to placement of the epidural was significantly longer when the spinous process was not well palpable when compared to those that were well palpable ($P < 0.001$). Also, the trainees took longer time for placement if they had not performed at least 20 prior epidurals ($P < 0.001$)

the spinal deformities are associated with altered anatomy, that makes it difficult to palpate the spinous process, requiring multiple attempts at placement.[5]

Trainees are generally taught that obesity is associated with difficult epidural placements; however, this study showed that BMI is not an independent predictor for difficult placement in pregnant patients unless it was associated with poorly palpable spinous process. Although BMI is used as an indicator of obesity, we cannot apply the World Health Organization (WHO) definition of obesity to the parturient in labor, as it does not consider the weight gain during pregnancy. The women's pre-pregnancy weight could have been considered to quantify obesity, but the weight gain is not uniform during pregnancy. Hence, we used the weight of the parturient on admission to the labor and delivery suite. Our study is consistent with a previous study that looked at difficult neuraxial technique in 427 pregnant patients who were obese.[13] The study concluded that obesity was not an independent predictor of difficulty however, inability to palpate the bony landmarks and the patients' ability to flex the back predicted neuraxial difficulty.[13] Many studies in the non-pregnant population have confirmed that BMI only significantly influences the placement in patients with poor landmarks or if there were spinal deformities.[5,12]

Obstetric anesthesia is a sub-specialty rotation and the trainees get to complete a 2-month rotation either in the latter half of PGY2 year or in the PGY3 year of training. We could have looked at years of training in the analysis of technical skills but due to challenges in scheduling we avoided using the training years for experience. As a part of the ACGME requirement, the trainees are required to maintain a log of the number of procedures done. It is believed that about 20-25 epidural placements may be required to reach consistency in epidural placement[14] while proficiency could be achieved after more than 50 placements.[12,15] Drake *et al*. in their study described that there was a steep learning curve with the initial few epidural placements and following the first 10, the average success rate for the subsequent placement was more than 75% as assessed using the cumulative sum analysis (CUSUM) analysis.[15] Hence, we used 20 epidurals as our cut-off for experience level, which is also half the number of epidurals required by the ACGME to be completed during the residency training. In our study, about 40% of the trainees had performed less than 20 epidurals and it was interesting to note that this did not have any significant effect on the first attempt placement. The incidence of dural puncture was not high (2%) when performed by the trainees and was comparable to other published studies.[10] As expected, trainees with fewer epidural placements took longer to place the epidural catheter.

Identifying the risk factors or predictors of difficult epidural placement is important in a teaching hospital, as it would help the anesthesia faculty to facilitate better teaching with fewer complication rates. In patients with poorly palpable spinous process, patient's position could be optimized by using an epidural chair or by asking the patients to arch the back with the convex arch towards the provider. This widens the vertebral spaces and helps with the ease of epidural placement. In the recent years, lumbar neuraxial ultrasound has been used to identify the interspinous space and estimate the depth to the epidural space.[16-18] In individuals with obesity

where the landmarks are difficult to palpate, ultrasound can provide useful information on the spinous processes and interspinous spaces.[17] There is significant evidence to support that with trainees performing the lumbar neuraxial ultrasound technique, success rate is high and rate of catheter replacement has decreased.[16] Hence, in a laboring parturient, identifying the potential predictors of difficult epidural placement and early use of ultrasound should be considered for enhanced learning and for improving patient satisfaction.

There are some limitations to the study. Consistent with observational studies, there were some gaps in the data collection. Even though definitions of palpable spinous process and attempts at epidural placement were explained, there may have been some variation in the assessment as it was subjective.

In conclusion, our study shows that with anesthesia trainees there was a greater likelihood of first attempt success rate and a shorter time to epidural placement in pregnant women with easily palpable lumbar spinous process. The patients' BMI and the providers' experience did not show any correlation with the first attempt placement. In patients with poorly palpable spinous process it may be beneficial to consider ultrasound-guided placement in order to avoid multiple attempts.

Acknowledgements

The authors wish to thank Dr. Shervin Harandi for his help with data collection.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Program requirements for graduate medical education in Anesthesiology. The Accreditation Council for Graduate Medical Education effective. Available from: https://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/040_anesthesiology_2017-07-01.pdf. [Last accessed on 2016 Jul 01].
2. Konrad C, Schupfer G, Wietlisbach M, Gerber H. Learning manual skills in anesthesiology: Is there a recommended number of cases for anesthetic procedures? Anesth Analg 1998;86:635-39.
3. Kim JH, Song SY, Kim BJ. Predicting the difficulty in performing a neuraxial blockade. Korean J Anesthesiol 2011;61:377-81.
4. Ružman T, Gulam D, Haršanji Drenjančević I, Venžera-Azenić D, Ružman N, Burazin J. Factors associated with difficult neuraxial blockade. Local Reg Anesth 2014;7:47-52.
5. Sprung J, Bourke DL, Grass J, Hammel J, Mascha E, Thomas P, *et al.* Predicting the difficult neuraxial block: A prospective study. Anesth Analg 1999;89:384-9.
6. Kent CD, Bollag L. Neurological adverse events following regional anesthesia administration. Local Reg Anesth 2010;3:15-23.
7. Brull R, McCartney CJ, Chan VW, El-Beheiry H. Neurological complications after regional anesthesia: Contemporary estimates of risk. Anesth Analg 2007;59:260-4.
8. Renck H. Neurological complications of central nerve blockade. Acta Anaesth Scand 1995;39:859-68.
9. Benzon HT, Asher YG, Hartrick CT. Back pain and neuraxial anesthesia. Anesth Analg 2016;122:2047-58.
10. Choi PT, Galinski SE, Takeuchi L, Lucas S, Tamayo C, Jadad AR. PDPH is a common complication of neuraxial blockade in parturients: A meta-analysis of obstetrical studies. Can J Anaesth 2003;50:460-9.
11. Bucklin BA, Hawkins JL, Anderson JR, Ullrich FA. Obstetric anesthesia workforce survey: Twenty-year update. Anesthesiology 2005;103:634-53.
12. de Filho GR, Gomes HP, da Fonseca MH, Hoffman JC, Pederneiras SG, Garcia JH. Predictors of successful neuraxial block: A prospective study. Eur J Anaesthesiol 2002;19:447-51.
13. Ellinas EH, Eastwood DC, Patel SN, Maitra-D'Cruze AM, Ebert TJ. The effect of obesity on neuraxial technique difficulty in pregnant patients: A prospective, observational study. Anesth Analg 2009;109:1225-31.
14. Kopacz DJ, Neal JM, Pollock JE. The regional anesthesia "learning curve". What is the minimum number of epidural and spinal blocks to reach consistency? Reg Anesth 1996;21:182-90.
15. Drake EJ, Coghill J, Sneyd JR. Defining competence in obstetric epidural anesthesia for inexperienced trainees. Br J Anaesth 2015;114:951-7.
16. Vallejo MC, Phelps AL, Singh S, Orebaugh SL, Sah N. Ultrasound decreases the failed labor epidural rate in resident trainees. Int J Obstet Anesth 2010;19:373-8.
17. Balki M. Locating the epidural space in obstetric patients-ultrasound a useful tool: Continuing professional development. Can J Anaesth 2010;57:1111-26.
18. Perlas A, Chaparro LE, Chin KJ. Lumbar neuraxial ultrasound for spinal and epidural anesthesia: A systematic review and meta-analysis. Reg Anesth Pain Med 2016;41:251-60.