Original Article

Success rate and outcome of labor epidural among variable levels of residents and practicing anesthesiologists in an academic medical center in Saudi Arabia

ABSTRACT

Background and Aims: This study aimed to highlight differences in success rates and patient outcomes during epidural insertion among anesthesia staff, junior trainees, and staff anesthesiologists.

Methods: We included all women who received a labor epidural between January 1, 2020 and April 30, 2022. The cases were divided into three groups: junior residents, senior residents, and staff anesthesiologists.

Results: Among 822 cases included in analysis, 92, 240, and 490 catheters were placed by junior residents, senior residents, and staff anesthesiologists, respectively. Although the success rate among junior residents (90.7%) was lower than those of senior residents (97%) and staff anesthesiologists (95.1%), the difference was not significant ($P = 0.067$). The mean procedural time in minutes was significantly longer in the junior resident's group (18.1 min) compared to the senior residents (14.18 min) and staff anesthesiologists (14.87 min) ($P < 0.001$). A significant difference was observed in the number of needle pricks and catheter insertion attempts when comparing the junior residents, senior residents, and staff anesthesiologists' groups ($P < 0.001$). In the logistic regression analysis, procedural time remained the only predictor of epidural success.

Conclusions: With the success rate above 90%, junior anesthesia trainees require more time and attempts to insert labor epidurals. It is essential that training programs provide opportunities for anesthesia trainees to become proficient in their epidural insertion techniques prior to clinical practice.

Key words: Analgesia, clinical skills, experiential learning, learning curve, medical education, obstetric anesthesia

Introduction

Epidurals are currently the gold standard of pain relief in labor. High satisfaction rates along with a relatively minor effect on the fetus have made epidurals the most popular method of pain relief during labor.[1-4] As a result, delivery wards offer the greatest opportunity for anesthesia trainees to perform epidurals. However, the common perception is that labor epidurals inserted by junior trainees may not carry the same success rate as those inserted by more senior staff.

Epidural insertion is an essential and complex skill for which all anesthetists must attain proficiency. Yet, it is one of the harder anesthesia skills to attain. Konrad *et al*.[5] revealed that

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Sara H. Farsi

Department of Anesthesia and Critical Care, King Abdulaziz University Hospital, Jeddah, Saudi Arabia

Address for correspondence: Dr. Sara H. Farsi, Department of Anesthesia and Critical Care, King Abdulaziz University Hospital, P.O. Box 80215, Jeddah 21589, Saudi Arabia.
E-mail: sfarsi@kau.edu.sa

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trainees achieved a 90% success rate in intubations and spinal blocks after performing 57 and 71 procedures, respectively. However, the same study revealed that even after inserting 90 epidurals, the trainees had a mere 78% success rate. Even brachial plexus blocks which are often perceived as more complex carried a steeper learning curve with an 87% success rate after preforming 62 procedures.

Not only are labor epidurals used as the sole form of pain control for many women in labor but also they alleviate stress during labor and are useful in the event of an instrumental vaginal delivery or cesarean section.[6] This makes it vital that we identify and address any factors that may influence their effectiveness for labor analgesia and probable other emerging indications.

Our primary aim was to assess the effectiveness of epidural analgesia via epidurals performed by novice and advanced trainees versus certified anesthetists. The secondary aims were to assess number of needle pricks, catheter insertion attempts, and duration of procedure among various groups.

Methods

This study was conducted at (Name of Institution). We obtained ethical approval from the (Name of Institution) Institutional Review Board (IRB) (no *****). The requirement for informed consent was waived by IRB due to the retrospective study design. This study included women who received an epidural between January 1, 2020 and April 30, 2022. Inclusion criteria included all women admitted to the labor ward for normal vaginal delivery who requested an epidural for labor. Exclusion criteria: Women admitted to the labor ward who were not offered an epidural due to premature labor or planned cesarean section, who were admitted for a vaginal delivery but refused an epidural, who had no epidural attempt made due to medical conditions or unavailability of anesthesia physicians, and who had an epidural inserted for cesarean section without an attempt for vaginal delivery. In Saudi Arabia, anesthesia residency is a 5-year training program. Junior anesthesia residents were in their first or second year of training, and senior residents (SRs) were in their third, fourth, or fifth year of training. We defined anesthesia staff as those who had completed their residency training and were licensed to practice as anesthetists by the Saudi Council for Health Specialties.

At our center, junior trainees insert labor epidurals under the supervision of a staff anesthetist. Third-to-fifth-year trainees insert labor epidurals unsupervised. After inserting and testing an epidural, it was bolused (primary bolus) with a standard 10 mL of 0.1% bupivacaine mixed with 2 μg/mL of fentanyl. The same solution was used to maintain epidural analgesia (secondary infusion). The infusion was administered at a 5–12 mL/hour rate and adjusted by a nurse based on the patient's comfort.

As part of a quality improvement project, labor and delivery unit nurses routinely completed an epidural insertion parameter using a formerly approved data collection. The collected data included the name of the anesthetist, procedure start time, procedure end time, number of needle pricks, number of catheter insertion attempts, initial bolus success, and epidural infusion success. Primary bolus failure was defined as patient vocalizing inadequate pain relief requiring an additional epidural bolus or an alternative method of pain relief 1 hour after epidural insertion. Secondary infusion failure was defined as patient vocalizing inadequate pain relief more than 1 hour after epidural insertion and receiving additional pain relief such as nitrous oxide or narcotic administration. The epidural induction time was when the anesthetist infiltrated the patient's skin with a local anesthetic. The epidural ended when the anesthetist began to fix the catheter to the patient's back. The number of epidural pricks was defined as the number of epidural needle reinsertions at different spinal levels. The number of catheter insertion attempts (CIAs) was defined as the number of sites the anesthetist tried to insert the epidural catheter through the epidural needle.

Statistical analysis

Data analysis began by identifying and removing presumed erroneous outliers. Continuous variables were subsequently screened for normality of distribution using the Shapiro–Wilk test, which revealed that all four continuous variables (procedure time, number of CIA, number of pricks, and number of pricks/CIA) were non-normally distributed. Consequently, further bivariate inferential tests on continuous variables were nonparametric, using the Mann–Whitney U test when comparing two case groups and the Kruskal–Wallis one-way analysis of variance when comparing more than two case groups. Intergroup comparisons of nominal and ordinal variables were performed using Pearson $\chi 2$ analysis or Fisher's exact test, as appropriate. For all bivariate analyses, a Bonferroni-like adjustment was made to the threshold for statistical significance, reducing the standard $P \leq 0.05$ to $P \leq 0.005$.

All analyses were two-tailed and performed using the statistical package for social sciences (SPSS version 28).

Results

Case selection

Among the 929 cases, the level of expertise of the physician performing epidural (junior resident, senior resident, or staff anesthesiologist) was not identified for 49, which were excluded from further analysis, leaving 880. Subsequently, we identified extreme outliers using the descriptive data function in SPSS. The procedural time ranged from 1 to 735 min, and both extremes were considered highly unrealistic. This was a concern because erroneous outliers (due to possible entry errors or clinical factors causing delays) could significantly skew the outcomes. Therefore, a frequency plot was created to identify potential thresholds to exclude cases with an unrealistically low or high time for procedure completion. We included in our study procedures that were in the middle 90^{th} percentile (822 patients) and excluded the outliers (58 patients). Among the 822 patients included, 92, 240, and 490 had their epidural catheters placed by junior residents (JRs), SRs, and staff anesthesiologists (SAs), respectively [Figure 1].

Notably, a 70% increase was observed in the percentage of procedures completed by SR over JR within 5–10 min, with the percentage among SA being 53% higher than that among JR. The percentages of cases completed within 11–20 min were similar in the three groups, while the percentages for 21–35 min were overall 32.2%.

Procedural factors and outcomes by level of physician expertise

Table 1 summarizes JR, SR, and SA comparisons in terms of the two primary outcomes (effectiveness in primary bolus delivery and effectiveness in infusion of analgesic delivery) and three procedural factors (mean procedural time, mean number of CIA, and mean number of needle pricks). For each procedural factor, JRs were significantly outperformed by SR and SA, even at the Bonferroni-adjusted threshold of $P = 0.005$. However, no significant differences were observed in any of the two outcomes.

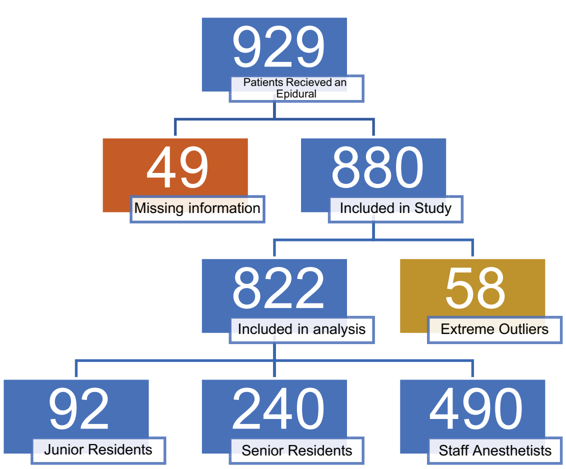

Figure 1: Breakdown of patients included in study

Predictors of Outcomes

Procedural effectiveness

The primary bolus was effective in 634 (95.3%), the secondary infusion in 555 (83.5%), and both in 549 (82.6%). The two main measures of procedural effectiveness—effective primary bolus and effective secondary infusion—were strongly linked ($\chi 2 = 96.79$; degrees of freedom, df = 1; $P < 0.001$). Out of the 634 instances in which the primary bolus was administered successfully, the secondary infusion was successful in 549 (86.6%). Of the 555 cases in which the secondary infusion was successful, the primary bolus was administered effectively in 549 (98.9%).

Table 2 compares cases involving successful and unsuccessful primary bolus deliveries, infusion and overall (bolus+ infusion). Effective primary bolus delivery was associated with a shorter mean procedural time, fewer CIA, and fewer needle pricks. Effective infusions were associated with a reduced procedural time (albeit only at $P = 0.017$ for the 5–30 min time window), fewer CIA, and fewer needle pricks. In binary logistic regression, procedural time was associated with effective secondary infusion.

Discussion

Our findings confirmed that a more experienced anesthetist results in a more successful epidural insertion, with fewer needle pricks and less time. In this study, JRs spent an average of 5 min longer at epidural insertion than their senior colleagues. This may not seem long. However, for an anxious patient with frequent painful contractions, patients close to

Table 1: Comparison between the three groups in terms of outcomes

Group	JR (n=92)	SR (n=240)	SA (n=490)	P
Primary bolus effective (Yes)	90.7%	97.0%	95.1%	χ^2=5.413 (df=2), P=0.067 (NS)
Secondary infusion effective	77.8%	87.1%	82.5%	χ^2=3.809 (df=2), P=0.15 (NS)
Mean procedural time (min)	18.01	14.18	14.87	P<0.001 JR > SR, SA
Mean number of [g]CIA	1.23	1.11	1.11	P<0.001 JR > SR, SA
Mean number of needle pricks	2.17	1.45	1.60	P<0.001 JR > SR, SA

[a]JR=Junior residents; [b]SR=Senior residents; [c]SA=Staff anesthesiologists; [e]df=Degree of freedom [f]NS=Not significant; [g]CIA=Catheter Insertion Attempts

Table 2: Factors influencing the effectiveness of epidurals

Factors	Primary Bolus			Epidural Infusion			Overall Effectiveness (Bolus + Infusion)		
	Effective (n=750)	Not Effective (n=38)	P	Effective (n=559)	Not effective (n=112)	P	Effective (n=549)	Not effective (n=116)	P
Mean procedural time	14.73	19.87	$P<0.001$	14.66	17.32	$P=0.003$	14.65	17.16	$P=0.004$
Mean number of catheter insertion	1.11	1.32	$P<0.001$	1.10	1.18	$P<0.001$	1.10	1.18	$P<0.001$
Mean number of needle pricks	1.54	2.38	$P<0.001$	1.50	1.77	$P=0.002$	1.50	1.76	$P<0.001$

delivery, or those with fluctuating fetal tracing, there may be a significant duration time.

Novice anesthesia trainees experienced more difficulty locating the appropriate epidural needle insertion site and epidural space. This was reflected in the significant difference in the number of CIA and needle pricks between JR and SR ($P < 0.001$). A higher number of needle pricks not only cause patient discomfort but also lead to skin hematomas and a higher risk of dural punctures.[7] The lower needle pricks required by seniors can be a result of them having a better tactile sense with the epidural needle and their ability to properly position patients and identify the optimum spinal level. The fewer CIA could be a result of better recognition of the "loss of resistance" that signifies entrance into the epidural space. Not only are these factors important regarding patient comfort but also our study found that these factors were strongly associated with epidural bolus and infusion success.

Anesthesia training programs must identify methods to assist trainees in gaining the necessary skills while maintaining high-quality patient care. Traditionally, anesthesia trainees developed their skills using an apprenticeship model of "see one, do one". This method may not suit every trainee or every program as there is often a variation in skill acquisition and case exposure from one trainee to the next. Fitts and Posner's learning model of motor skill acquisition comprising three stages may explain why JRs struggle to locate the epidural space.[8] In the first stage, cognition and performance are erratic, and the procedure is performed in steps. This is reflected in the apparent lack of direction in epidural needle insertion and a longer procedural time. That stage is followed by an integrative stage in which knowledge is transformed into appropriate motor behavior. Finally, after further deliberate practice, the trainee reached the autonomous stage, where the task was performed smoothly. The findings of this study further emphasize the need to incorporate simulations into healthcare training. It will allow trainees to overcome the initial erratic phase of skill learning in a laboratory before performing their skills on patients. Using an epidural simulator, trainees may be able to refine their skills in a low stress environment at their own pace with individualized feedback to become more direct and purposeful. Not only will this assist trainees to develop their insertion technique. Instructors will also be able to share methods to improve success such as correct patient positioning and using tactile as well as ultrasound guidance to identify an epidural space. Simulation training does not require investing in an expensive high-fidelity epidural simulator. One study demonstrated that using a simple banana may be as effective as using an anatomically correct simulator.[9]

Our study also revealed the risk factors for labor epidural failure. Previous studies documented an 83.1–91.5% epidural success rate.[10-12] After the initial epidural bolus, 95% of the women in our study were pain-free. However, as labor progressed, only 85% of women remained pain-free until delivery. This may be due to many factors, including the dynamic nature of labor pain and the effectiveness of epidural boluses versus infusions.[13,14] Although, like previous studies, we revealed a decrease in epidural success rate among JRs, no statistical significance was observed.[10-12] Furthermore, in our study, success was linked to reduced procedural time ($P = 0.017$), fewer CIA, and fewer needle pricks. In the logistic regression analysis, procedural time remained the only predictor of success. One explanation for this finding may be that many risk factors for difficult epidural insertion, such as obesity and scoliosis, are associated with a higher epidural failure rate.[15,16] Based on these findings, hospitals should consider developing guidelines using these predictors to improve epidural effectiveness and patient comfort. This may include limiting the procedural duration or number of needle pricks before the anesthetist utilizes adjuncts such as ultrasound or a more experienced anesthetist.

This study has several limitations. First, this was a single-center retrospective study that depended on observing nurses' assessments of epidural insertion and effectiveness. Thus, there is a possibility of lapses in the observation, pain evaluation, and time recording. Second, we did not include factors affecting epidural difficulties or labor pain intensity, such as body mass index, spinal deformities, patient parity, and use of labor induction agents.

Conclusions

In conclusion, junior trainees had a high overall high success rate but required more time and maneuvers to correctly locate the epidural space in laboring women when compared to senior anesthesia trainees and staff anesthetists. It is essential that training programs provide opportunities for anesthesia trainees to become proficient in their epidural insertion techniques prior to clinical practice.

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Conflicts of interest
There are no conflicts of interest.

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