COMPARISON OF LEARNING CURVES BETWEEN ACOUSTIC PUNCTURE ASSISTED DEVICE-CONFIRMED ANESTHESIA AND CONVENTIONAL LOSS OF RESISTANCE TECHNIQUE FOR LUMBAR EPIDURAL BLOCKS

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Abstract

Background: The ease of learning the epidural anesthesia using the APAD was never tested or compared to other conventional techniques.

This work aims to compare between the learning curve of the epidural catheter placement using the traditional loss of the resistance technique and the acoustic puncture assisted device.

Methods: 30 first year anesthesia residents with no experience in performing an epidural anesthesia were enrolled in this study. Group I consisted of 15 first year residents performing there first 60 epidural using acoustic puncture assisted device while Group II consisted of another 15 first year residents performing there first 60 epidurals using the traditional loss of resistance technique with a glass syringe.

Results: The success rates of group I and group II reached 90% after the 28th and 44th attempt respectively the time to perform the epidural and the number of attempts was reduced much faster during the learning period in group I than in group II. The complications that occurred during the learning period were lower in group I than in group II.

Conclusion: Epidural procedure is easier, safer, and faster to learn using the APAD rather than the conventional loss of resistance using a glass syringe technique.

Keywords: Learning Curves; Acoustic Puncture Assisted Device; Lumbar Epidural Blocks.

Introduction

The use of epidural anesthesia is a common practice, as it provides excellent analgesia that can be maintained as needed, by administration of local anesthesia through a catheter placed in the epidural space.

Successful performance of epidural anesthesia requires specialized training and lot of experience. The more frequent the procedure is performed, the success rate on first attempts goes up and the time to locate the epidural space goes down. The learning curve graphically depicts the experience required to successfully perform epidural procedures.

Many techniques are available to help determine the location of the epidural space, namely the loss of resistance (LOR) technique with a glass syringe (the conventional method), the Episure™

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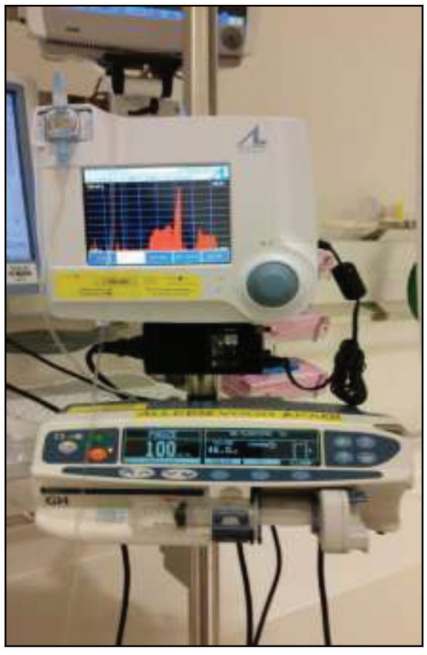
AutoDetect™ Syringe[1], the hanging drop technique, and the acoustic puncture assisted device (APAD)[2]. The APAD is a device used to locate the epidural space, by sensing LOR when the epidural needle passes through the ligamentum flavum. The device displays a pressure tracing on a graph and an audible signal marks the event[3]. In 2011, Lechner reported the effectiveness and the ease of using the APAD to perform epidural anesthesia[4]. However, the ease of learning epidural anesthesia using APAD was never tested nor compared to other conventional techniques.

The primary objective of this study is to compare the learning curves of the conventional glass syringe and APAD to detect the LOR during epidural catheter placement procedures. The secondary objective is to detect any differences in the rates of complications that occurred during the training period using each technique.

Materials and methods

Thirty first-year anesthesia residents, with no previous experience in performing epidural anesthesia, were enrolled in this study. They were randomly divided into two equal groups using a computer-generated sequence of random numbers. Prior to performing any epidural anesthesia procedures, all residents were required to attend a workshop on how to perform an epidural anesthesia procedure using ether APAD (Figure 1) or the conventional LOR technique with a glass syringe. The workshop included a video and a demonstration by a consultant.

Fig. 1
APAD device (Medky equipment's Schansestraat, the Netherlands)



The residents were split into two separate groups, equal in number: Group I consisted of 15 first-year residents performing their first 60 epidural procedures using APAD, while Group II consisted of a different 15 first-year residents performing their first 60 epidural procedures using the conventional loss of resistance technique with a glass syringe. An experienced anesthetist supervised every resident in both groups, as they each perform the epidural anesthesia procedures. All supervising anesthetist have at least 6-year experience with epidural anesthesia.

Study design and patient selection

After the study protocol was reviewed and approved by the Ethics Committee of the Alexandria Faculty of Medicine (no: 0303777) it was registered in the Pan African Clinical Trial Registry (www.pactr.org) database and assigned the number PACTR201711002739268. We enrolled 1,800 patients, who were scheduled for surgery under general anesthesia and lumbar epidural analgesia. A written informed consent and a complete history were obtained from all patients participating in the study. The patients were then subjected to thorough examinations and routine laboratory investigations. Patients were randomly divided into two equal numbered groups, using a computer-generated sequence of random numbers.

Inclusion criteria were as follows: age between 21 and 60 years, American Society of Anaesthesiologists (ASA) physical status I to II and body mass index (BMI) less than 24 kg/m^2. Exclusion criteria were local site infection, previous spine surgery and deformity, coagulation disorders, neuromuscular disorders, allergy to local anesthetics, opioids or latex, previous epidural catheter insertion, and patients not willing to participate.

All study procedures were performed 30-45 minutes in advance of the surgical procedure, in a

room dedicated to the performance of regional block anesthesia procedures. Standard monitors (three-lead electrocardiogram, non-invasive blood pressure, and pulse oximetry) were applied, intravenous access was established, and 1-2 mg intravenous midazolam was administered as needed for anxiolysis to all patients.

Patients were placed in the sitting position, and the anatomic landmarks (iliac crests, spinous processes, interspinous gaps) were palpated to determine the location of the neuraxial midline and intervertebral spaces. After proper sterilization and draping of the patients back, epidural anesthesia was performed using a 16-gauge Tuohy epidural needle. A maximum of four attempts was allowed for epidural space (EDS) localisation, including either redirection in the same space or selection of a different space; more than four attempts to locate the epidural space was considered as failure.

The primary end points for successful localisation of the EDS were an acoustic dip and a constant pressure trace in the APAD and loss of resistance in the control group.

Residents in Group I located the EDS with the APAD device (Medky equipment's Schansestraat, The Netherlands). Anatomical landmarks were used to identify point of entry and the change in pressure and the loss of resistance were used to identify the epidural space.

The APAD has a monitor that displays a visual graph and a speaker that generates an audible sound in response to a change in pressure. A disposable kit is connected to the infusion pump via a 50 mL saline filled syringe mounted on the infusion pump and the other end is connected to the epidural needle through a transducer. The diaphragm of the transducer senses the pressure changes as the epidural needle is advanced through the different tissue layers. Pressure changes are displayed visually as a graph on the monitor, as well as by a changing sound pitch. The higher the pressure the higher the pitch of the tone.

Residents in Group II located the EDS with the conventional saline filled LOR syringe. The midline (interspinous ligament) and the location of each interlaminar space were identified by using the anatomical landmarks. The Tuohy needle was introduced until it reached the epidural space using the conventional manual LOR technique.

The success rate, number of attempts which included (repositioning of the needle and changing the space of entry of the Tuohy needle), time taken for space localisation (time in seconds taken from skin puncture with epidural needle until the successful space localisation within 4 attempts), complications (dural puncture, blood in catheter and root irritation) were recorded.

In both groups, a test dose of 5 ml of 2% lignocaine with adrenaline was administered to check for correct catheter position.

Statistical analysis

Data were analysed using SPSS software package version 20.0. Qualitative data were described using number and percent. Qualitative data were described using range (minimum and maximum), mean and standard deviation. T-test was used to compare between both groups. Chi-square test was used for categorical variables. A value of $P < 0.05$ was considered statistically significant.

Results

1,800 patients were recruited over a period of 8 months. Comparison of the demographic data of the patients enrolled in that study revealed no statistical difference in age, sex and the body mass index between the two groups (Table 1).

Table 1

Patients' characteristics. Data is presented as mean ± standard deviation

	Group I (n = 900)	Group II (n = 900)	p - value
Age (years)	42.44 ± 9.84	45.8 ± 9.57	0.34
Gender (male/ female)	461/439	458/442	0.88
Body mass index (kg/m2)	22.1 ± 2.24	21.94 ± 2.3	0.53

Figure 2 shows that the success rate of the group of residents using the APAD to learn the epidural anesthesia reached 80% after the 13th attempt and 90% after the 28th attempt. The success rate kept increasing until it reached 100% after the 31st attempt and after that was maintained between 93% and 100%.

For the group of residents using conventional LOR, the 80% success rate was reached after the 25th attempt and the 90% success rate was reached after the 44th attempt.

The overall success rate during the learning period for residents in Group I was 87.6% and 78.1% for Group II (p <0.0001).

By comparing the mean time needed to perform an epidural anesthesia between the first attempt and the attempts that followed (in the same group), the first significant decrease in time to successful performance in Group I was noted after the 19th epidural attempt, with a p value of 0.0024; while in Group II, it was noted after the 31st performance with a p value of 0.0102. The time to perform the epidural was progressively decreasing in both groups until it reached 23.6 sec in Group I and 52.4 sec in Group II, as shown in Figure 3.

Table 2
Complications

Complications	Incidence of complications %		P - value
	Group I (n = 900)	Group II (n = 900)	
Failure rate	12.3%	21.8%	<0.001
Dural puncture	4.88%	9.55%	0.0068
Post-operative headache	6.89%	15.56%	<0.001
Blood in the epidural catheter	12.6%	11.7%	0.683
Post-operative back pain	24.4%	37.7%	<0.001

Fig. 2
Success Rate vs. Number of Attempts

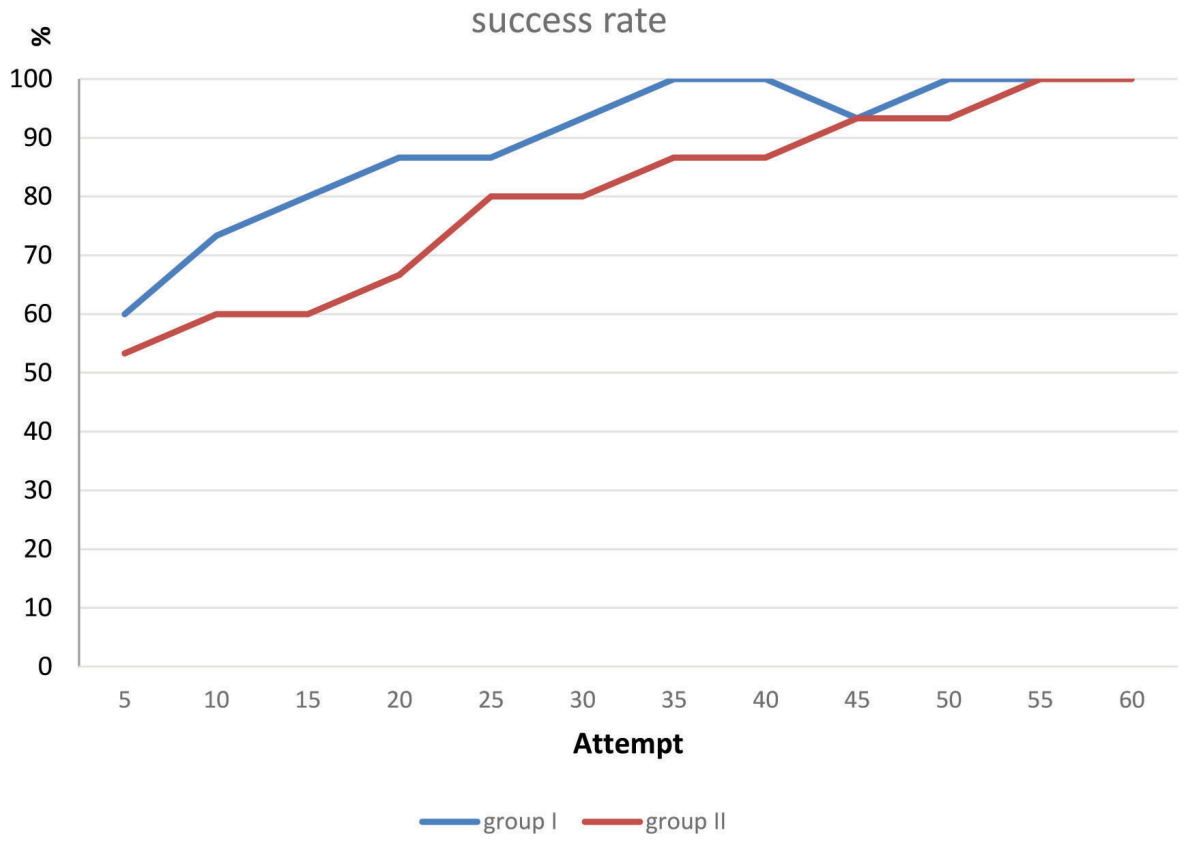


Fig. 3

Time to Successfully Perform Epidural Anesthesia vs. Number of Attempts

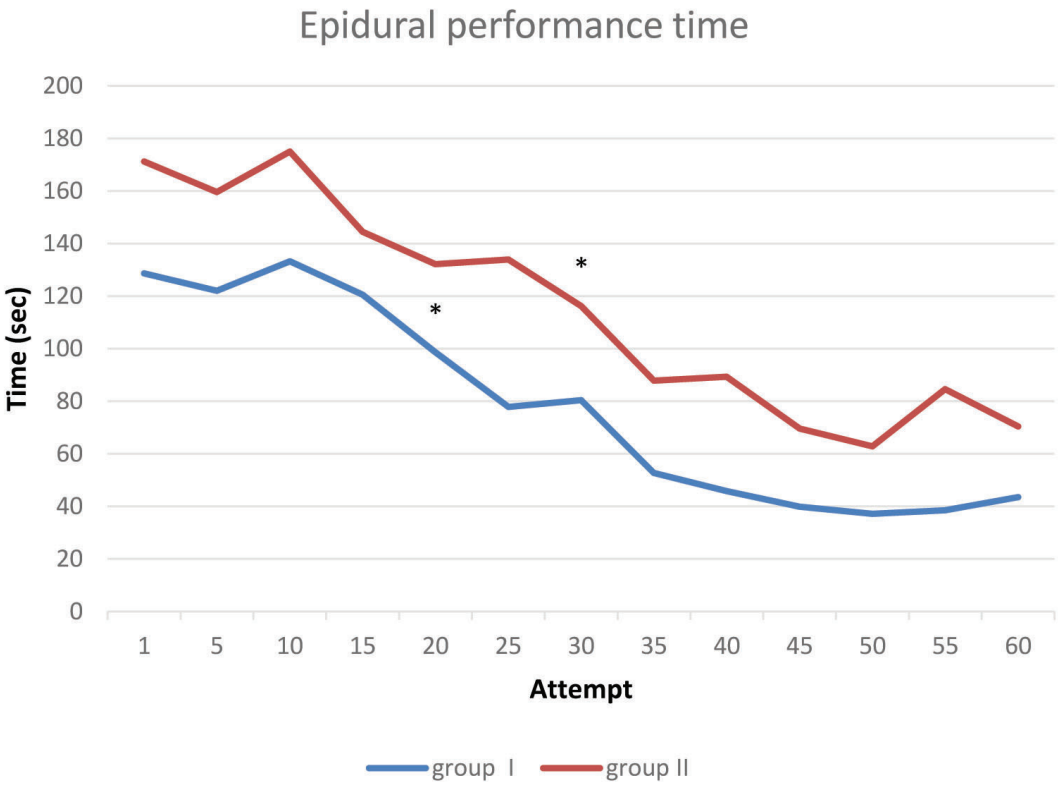
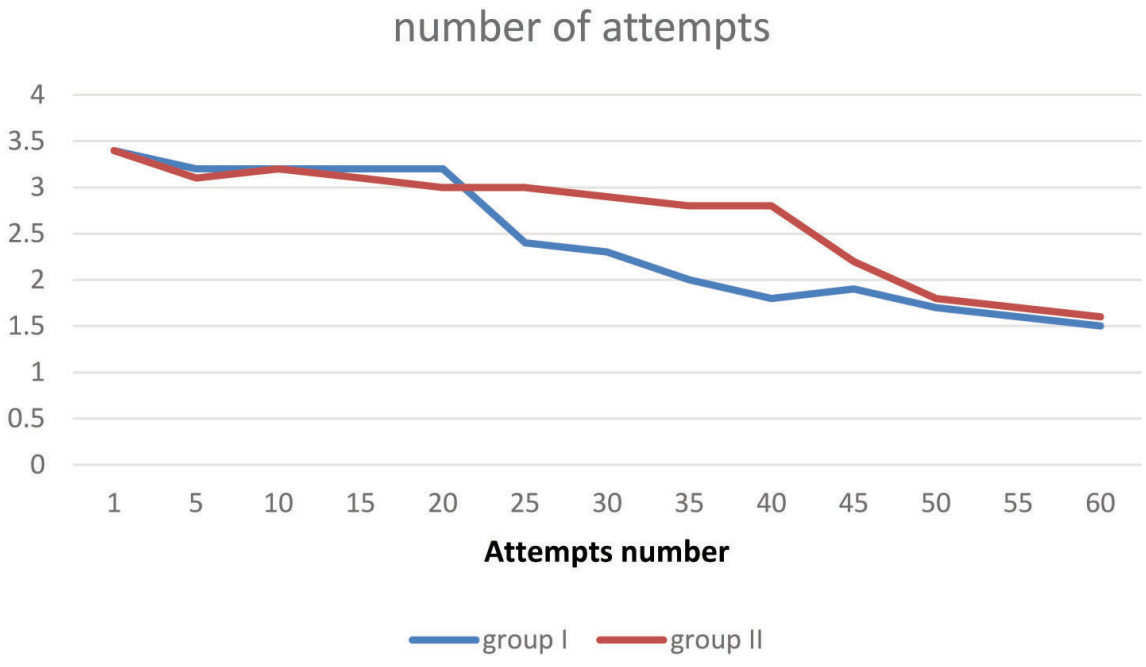


Fig. 4

Number of Attempts Required vs. Cumulative Number of Patients Given Procedures



The first significant decrease in the number of attempts in Group I was noted after the 23rd patient (p value of 0.0085). See Figure 4.

In Group II, no statistically significant difference was noted, when the number of attempts required to perform the first epidural compared to all subsequent epidural procedures up to the 41st patient (p = 0.024).

There was a statistically significant difference in the dural puncture rates between Group I and Group II (p = 0.0068). The dural puncture rate was much lower for Group I (4.88%) compared to that for Group II (9.55%). Incidence of post-operative back pain was statistically significantly higher in Group II than in Group I (p <0.0001).

Discussion

Acquiring the skills to successfully perform epidural anesthesia with the fewest number of attempts requires lot of practice. During the learning period, the incidence of complication is higher and the time to perform such a procedure is longer than if it is done by an experienced anesthetist. Any technique that reduces the learning curve time will decrease the number of complications and the morbidity during the training period. The challenge is to be able to determine which method is recommended for residents who are learning to perform epidural anesthesia[5].

In 1996, Dr. Dan J. Kopacz[6] published a paper discussing the learning curve of the epidural anesthesia using the conventional LOR technique. He concluded that the minimal number of epidural anesthesia procedures needed to be performed by a new anesthetist to reach a success rate of 90% was 60 cases.

In 1998, Dr. Konrad described the learning curves of different anesthetic procedures and concluded that epidural anesthesia is the most difficult anaesthetic procedure to learn. It needed 90 attempts to reach 80% success rate. In the current study, the residents did not have any training before the study, and they were not closely supervised by an experienced anesthetist. In addition, the epidural procedure was performed in left lateral decubitus position, using the conventional LOR technique[7].

In the present study, the success rate of 90% was reached faster than reported in the previously mentioned studies done by Dr. Dan Kopacz and Dr. Konrad. The residents in Group I reached the 90% success rate after they performed 28 cases, while Group II needed 44 cases to reach the 90% success rate. The differences in the results may be due to the tutorials given to the residents before the study, the presence of an experienced anesthetist during the procedure, and the use of the sitting position with a midline approach for performance of the epidural procedure.

The group of residents using APAD to perform epidural had an all over success rate of 87.6%, which is statistically significantly more than the group of residents using the conventional LOR technique, who had an all over success rate of only 78.1% only. This leads to the conclusion that the time needed to learn to perform epidural using the APAD is much less than that needed with the conventional LOR using a glass syringe.

Comparing the mean time taken by the residents to locate the epidural space in their first patient compared to subsequent patients, we found that the first significant decrease in time noted was after the 19th case in Group I that used APAD, while in Group II using the conventional LOR method no statistical difference was noted until the 31st case, suggesting that the APAD method is easier to learn. This is also confirmed by comparing the number of attempts needed to locate the epidural space. We found out that the average number was statistically significantly less after the 23trd case in Group I and after the 41st case in Group II.

In 2016, Mittal et al. compared the Acoustic puncture assist device versus the conventional LOR technique for epidural space identification, where the anesthetist who performed either technique had at least 8 years of experience. The mean time needed by the experienced anesthetist to locate the epidural space was 19 sec when using the assisted acoustic device, compared to 127 sec[8] For first timers to perform the epidural using the same device it was not before the 19th case that a significant decrease in the time of performing the epidural was noted then a sharp decrease in the time was noted till it reached 23.6 sec after performing 60 epidural anesthesia cases.

Mittal et al. also reported that the mean time

needed by an experienced anesthetist to locate the epidural space using the conventional LOR technique was 48 sec while in this study it was 158 sec and decreased until it reached 52.4 sec after performing 60 epidural anesthesia procedures[8]. The first significant decrease in the time required to locate the epidural space was noted after the 31st case, which is much later than the first significant change in in Group I, suggesting that the learning process is easier and much faster using APAD. A comparison of the first significant change in the number of trials in each case to locate the epidural space also led to the same conclusion, as the first significant decrease in the number of trials in Group I was after the 23rd case and after the 41st case in Group II.

As for complications in our study, we found out that there was a statistically significant less incidence of dural puncture, headache and back pain in the group using APAD than with the group that used the conventional LOR method. However, there was no statistically significant difference, when comparing the presence of blood in the epidural catheter.

During the learning period, using APAD resulted in a decrease in the incidence of the total complications, when performing epidural anesthesia procedures.

The number of newly untrained residents was limited and that was considered as a limitation in this study.

Conclusion

In conclusion, it seems that it is easier, safer, and faster to learn epidural using APAD than using conventional glass syringe LOR technique.

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Conflicts of interest: All authors declare that there are no conflicts of interest.

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