Ultrasound imaging improves learning curves in obstetric epidural anesthesia: a preliminary study

[L'échographie améliore les courbes d'apprentissage en anesthésie épidurale obstétricale : une étude préliminaire]

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Purpose: Epidural anesthesia may be difficult in pregnancy. We intended to evaluate the teaching possibilities of ultrasonography as a diagnostic approach to the epidural region.

Methods: Two groups of residents performed their first 60 obstetric epidurals under supervision. One proceeded in the conventional way using the loss of resistance technique (control group = CG). The other group proceeded in the same way but was supported by prepuncture ultrasound imaging, giving them information about the optimal puncture point, depth and angle (ultrasound group = UG). Success was defined as adequate epidural anesthesia requiring a maximum of three attempts, reaching a visual analogue scale score of less than 1, while neither changing the anesthesia technique, nor starting at another vertebral level. In addition, intervention by the supervisor was defined as failure.

Results: In the CG we observed a success rate of 60% ± 16% after the first ten attempts followed by a nearly continuous rise of the learning curve. Within the next 50 epidurals the rate of success increased to 84%. In the UG the rate of success started at 86% ± 15%. Within 50 epidural insertions it rose up to a level of 94%. The difference between the two groups remained significant ($P < 0.001$).

Conclusion: Using ultrasound imaging for teaching epidural anesthesia in obstetrics we found a higher rate of success during the first 60 attempts compared to conventional teaching. We believe this shows the possible value of ultrasound imaging for teaching and learning obstetric regional anesthesia.

Objectif : *L'anesthésie épidurale peut être difficile à réaliser pendant la grossesse. Nous avons voulu évaluer les possibilités d'apprentissage de l'échographie comme approche diagnostique de la région épidurale.*

Méthode : *Deux groupes de résidents ont réalisé leurs 60 premières anesthésies épidurales sous supervision. Un premier groupe a procédé de manière traditionnelle selon la technique de perte de résistance (groupe témoin = GT). L'autre groupe a fait la même chose, mais bénéficiait de l'assistance de l'échographie qui donnait des informations sur les meilleurs site, profondeur et angle de ponction (groupe d'échographie = GE). La réussite était une anesthésie épidurale adéquate exigeant au plus trois essais, affichant un score de moins de 1 à l'échelle visuelle analogique et n'exigeant pas de modifier la technique anesthésique, ni de faire la ponction à un autre niveau vertébral. De plus, l'intervention d'un superviseur constituait un échec.*

Résultats : *Un taux de un succès de 60 % ± 16 % a été noté dans le GT après les 10 premières tentatives suivies par une hausse presque continue de la courbe d'apprentissage. Pendant les 50 anesthésies suivantes, le taux est monté à 84 %. Dans le GE, le taux a été d'abord de 86 % ± 15 %, puis, pour les 50 anesthésies suivantes, il s'est élevé à 94 %. La différence intergroupe demeurait donc significative. ($P < 0,001$).*

Conclusion : *L'utilisation de l'échographie dans l'enseignement de l'anesthésie épidurale obstétricale, comparée à la méthode traditionnelle d'enseignement, a montré un taux de succès plus élevé pendant les 60 premiers essais. Cette expérience démontre la valeur de l'échographie dans l'enseignement et l'apprentissage de l'anesthésie obstétricale régionale.*

THE major problem in epidural anesthesia is that there is no diagnostic information on the optimal puncture point and direction of needle (expected angle and depth). The epidural space is usually detected by "loss of resistance" (LOR), an almost blind puncture technique.

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Funding: Departmental; Forschungsförderungsprogramm der Universität Heidelberg.
Assessed January 23, 2003.
1st revision assessed April 9, 2003.
2nd revision accepted September 8, 2003.

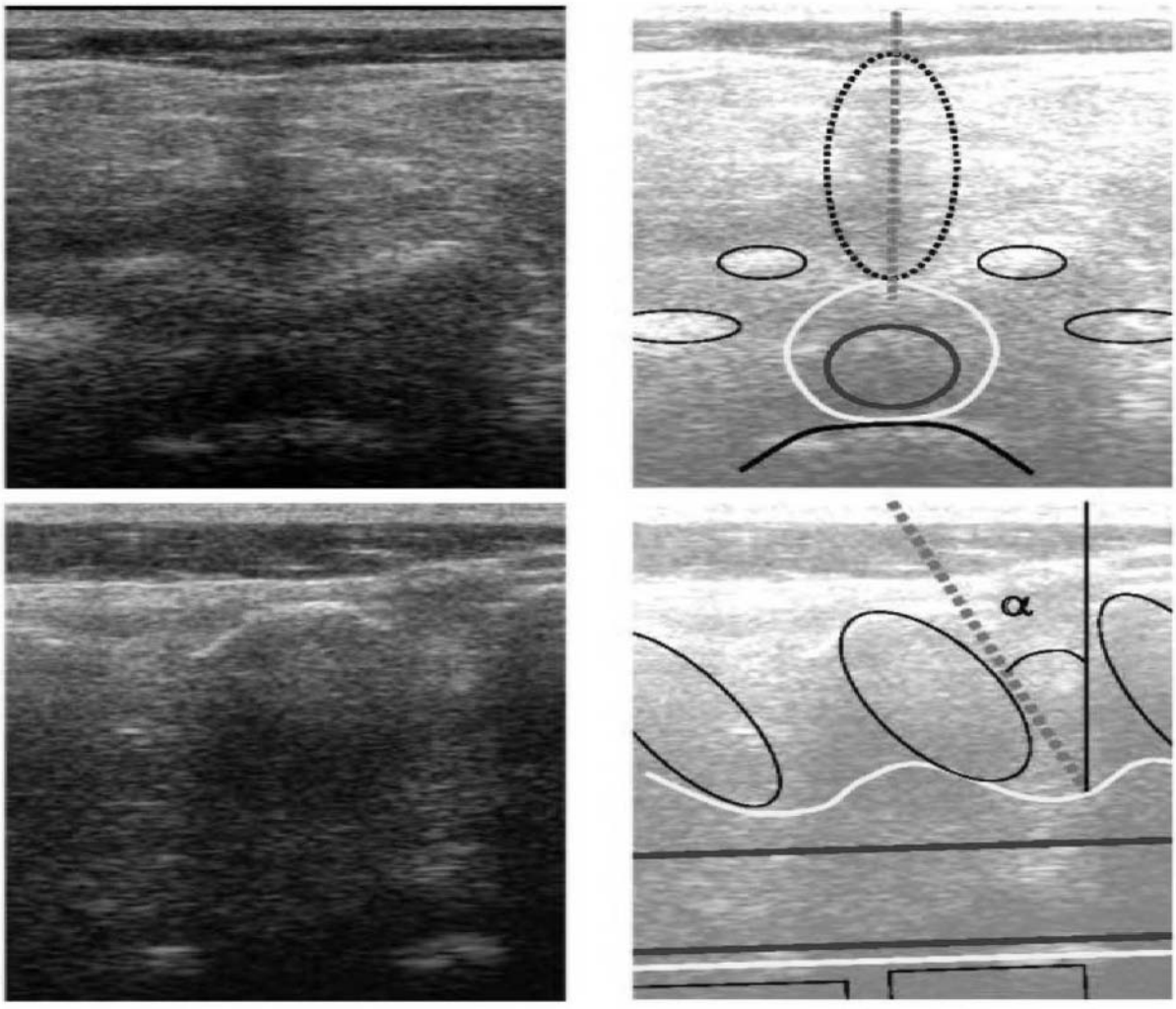

FIGURE 1 Lumbar transversal and longitudinal scans of the epidural space. The original ultrasound image is on the left and a descriptive diagram is on the right. Bony structures are drawn in black, outer borders of the epidural space are grey, and the inner borders of the epidural space are presented in a darker shade of gray. The angle alpha is the angle between the perpendicular line from the skin to the epidural space and the slightly deviating needle trajectory (dotted line) describes the expected puncture access.

Ultrasonography, used as a visual aid, could help place the needle and local anesthetics at the correct point.[1–3] As we learned from different studies, it seems to be an effective diagnostic tool to facilitate performance of regional anesthesia.[4–6]

Teaching obstetric regional anesthesia to residents usually begins after having taught theoretical, practical and organisational basics. One teaching concept is to provide complete supervision for the first 30 to 50 attempts. A supervisor is permanently present in the operating room and actively supports the procedure. Another concept is to perform regional anesthesia with "on demand" supervision. As soon as problems occur - and only then - does the instructor actively support the procedure. In both cases the supervisor is responsible for the resident's performance and an adequate quality of analgesia.

The aim of this study was to evaluate the teaching possibilities of ultrasound imaging as a diagnostic approach to the epidural region. It focused on the rates of success in obstetric epidural anesthesia using ultrasound imaging in comparison to the rates of success obtained in a control group.

Material and methods

Two groups of residents (five per group) performed their first 60 obstetric epidurals under supervision. One group used the conventional "LOR" technique (control group = CG). The other group proceeded in the same way but was supported by prepuncture ultrasound imaging, giving them information about the optimal puncture point, depth and angle of needle insertion (ultrasound group = UG). Randomization of the residents into the two groups was prospective, using a closed envelope technique.

Residents were alone to insert the epidural. In both groups the supervisor was readily available for assistance. All ultrasound examinations and the supervision was done by a single anesthesiologist (T.G.).

Success was defined as adequate obstetric epidural anesthesia requiring a maximum of three attempts, reaching a visual analogue scale score of less than 1 during the entire procedure, while neither changing the anesthesia technique, nor starting at another vertebral level. In addition, every need for intervention by the supervisor was considered a failure.

Decision on success or failure was made by the supervisor according to the study criteria. Exclusion criteria were emergencies, contraindications to epidural anesthesia, or missing consent.

For ultrasound imaging we used a Kretz® (Marl, Germany) Sonoace 6000 ultrasonograph equipped with a 5.0-MHz curved array probe and a 7.5-MHz linear GE LQ 400 ultrasound system. Scanning was performed in the transverse and longitudinal planes. Using the ultrasound images, the optimal vertebral level, angle and depth of the needle trajectory were identified (Figure 1). We measured the epidural space depth (i.e., the distance from the skin to the yellow ligament) by ultrasonography and calculated the subsequent needle depth in relation to the puncture angle.

We used a puncture set manufactured by Braun® (Melsungen, Germany) with a 17-gauge Tuohy needle. A multi-orifice closed tip epidural catheter was inserted 4 to 5 cm into the epidural space and a 3-mL test-dose of the local anesthetic was injected. The epidural anesthesia was performed with 11 to 15 mL of bupivacaine (plain; 2.5 mg·mL^{-1}) plus 10 µg of sufentanil for vaginal delivery and with 14 to 16 mL of bupivacaine (plain; 5.0 mg·mL^{-1}) with 20 µg of sufentanil for Cesarean delivery.

Data were analyzed using the Chi squared test (with Yates correction where appropriate) or Students' t test. For statistical analysis we used software from Excel 97™ Microsoft™(Redmond, WA, USA) and Primer Biostatistics 4.04™ (Mc Graw Hill Inc., NY, USA). Data are presented as mean ± SD unless stated otherwise.

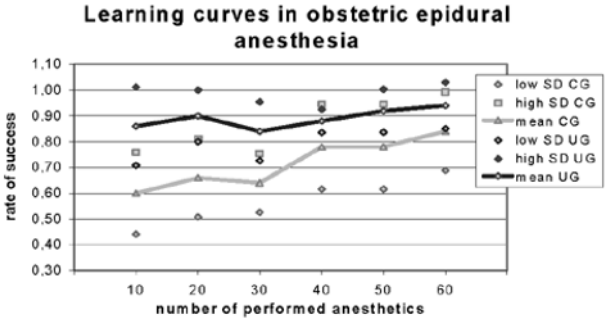

FIGURE 2 Mean (± standard deviation) learning curves of epidural anesthesia performed with and without pre-puncture ultrasound imaging. The difference between the ultrasonography and the control group remained significant ($p < 0.001$). SD = standard deviation; CG = control group; UG = ultrasonography group.

Results

A total of 600 epidural anesthetics were performed during this study (300 in each group). Usually, all participating residents had worked in an anesthesia department for three to four years. Their experience in regional anesthesia ranged from 10 to 30 spinal anesthetics and from 5 to 16 epidural anesthetics in different specialities. They needed 65 to 120 days to complete their first 60 obstetric epidural anesthetics.

In the CG we observed a success rate of 60% ± 16% after the first ten attempts. The learning curve showed a nearly continuous rise. After 30 attempts there was a significant improvement in success. Within 60 epidurals the rate of success had increased to a level of 84% ± 15% (Figure 2).

In the UG the rate of success started at a higher level than in the control group; the rate of success was 86% ± 15% after the first ten procedures. Within 50 epidural punctures it rose to a level of 94% ± 9%. In the UG the learning curve was flat, i.e., there was no significant improvement of learning over time. Nonetheless, success rates remained at a higher level than in the CG ($P < 0.001$).

Standard deviation decreased over time in both groups indicating the continuing learning process.

Discussion

This study was conducted to validate the educational possibilities of ultrasound imaging for teaching obstetric regional anesthesia. We analyzed the learning curves and the effects of diagnostic ultrasound imaging on success rates.

Using ultrasonography the learning curves started at a mean level of 86% and rose up to a mean success rate of 94% after 60 epidurals. In comparison, the CG started at 60% and reached a maximum of 84%.

There are only few studies investigating the learning process and the rate of success of regional anesthesia procedures.[3,7–9] The learning curves reported do not differ importantly from ours. So far, no study was able to show that the learning process could be influenced.[7] The typical learning curve shows an early success peak followed by a trough. In our study, the learning curves of both groups showed a similar shape.

Standard deviation decreased over time in both groups. The reduction of confidence intervals has been shown to be related to the steadily improving learning process.[3] In the UG this reduction was of about one third and was more distinct than in the CG.

To achieve a level of success that is believed to be consistent with competency (i.e., 90%) Kopacz postulated that a minimum of 60 epidural anesthetics should be performed by each resident.[3] Using our definition of success this level was reached after 20 attempts in the UG but could not be maintained until after 45 procedures. In the CG the mean success rate did not reach this level after 60 procedures.

The number of residents participating in this study was relatively small. A single "slow learner" in a group may change mean values dramatically. Great differences in cognitive and perceptual abilities may have lead to a wide scatter of success rates.

There are several factors directly and indirectly influencing "success". Among these are confidence, experience, and knowledge about what will be done. Ultrasound imaging can positively influence knowledge (about the optimal needle trajectory) and therefore confidence but, initially, it has no effects on experience.

We have not, yet, been able to analyze what will happen to success rates when residents start performing epidural anesthesia alone, without the assistance of ultrasonography. Our first observations suggest that, once the procedure is learned and "internalized", rates of success will remain at sufficiently high levels. A second problem might be the combination of learning ultrasound imaging and epidural anesthesia in one step. Studies with larger groups of residents will be necessary to generate a more representative learning curve and to recommend a minimum number of cases to be performed to achieve competence.

Using ultrasound imaging, the learning conditions and outcome of residents' training can be further improved, especially regarding regional anesthesia. In the future, ultrasound imaging may even give immediate feedback if it is used for online imaging. We have shown its clinical capacities in earlier studies[4–6] and believe it is a useful diagnostic tool for anesthetic education.

In this study we were able to show the possible value of ultrasound imaging for teaching and learning obstetric epidural anesthesia.

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