Experience Is Not Enough

Repeated Breaches in Epidural Anesthesia Aseptic Technique by Novice Operators despite Improved Skill

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Background: Invasive procedures such as epidural anesthesia carry risks for complications such as erroneous placement arising from inadequate manual skills and infection secondary to breaches in aseptic technique. Although it is assumed that improvement in aseptic technique parallels improved dexterity, this assertion remains unproven. The aim of this study was to determine whether increased proficiency in the manual skills for epidural anesthesia is associated with improved aseptic technique.

Methods: Second-year anesthesia residents were repeatedly videotaped performing epidural anesthesia over 6-month periods. Three independent examiners blinded to the level of training of the residents evaluated the procedures for manual skills and aseptic technique. Each procedure was graded using a manual skills checklist, a global rating scale, and an aseptic technique checklist. The main outcome measures were the scores for these three tools.

Results: Thirty-five sessions were videotaped over 1 yr. Interrater reliability was nearly perfect. A strong positive association was found between increased experience and manual skills, as reflected by the scores achieved on both the manual skills checklist and the global rating scale. In contrast, a nonsignificant or very weak correlation was found between the aseptic technique checklist total scores and the number of epidurals performed.

Conclusion: Manual skills for invasive procedures improved with increasing experience, but aseptic technique did not, despite formal teaching. These findings reflect major gaps in the understanding and teaching of the principles of aseptic technique, most likely due to lack of structured training. Educational initiatives are needed to correct these teaching gaps.

INVASIVE procedures, wherein a clinician inserts a device into a sterile body area, are associated with two principal categories of risk: erroneous placement (e.g., in the wrong blood vessel or cavity) and contamination during the procedure. It is assumed that training under expert guidance and subsequent practice will minimize the potential for either of these outcomes. Although uncommon, central nervous system infection or inflammation can result devastating consequences, such as paralysis or death.

Anesthesiology residents are usually taught regional anesthesia on a one-on-one basis by experienced attending staff during the first epidural catheter insertions. Two aspects are important to the performance of epidural anesthesia: the "technical" elements, involving correct anatomical placement of the catheter; and asepsis, aimed at prevention of contamination. Emphasis on both elements is important, particularly in light of the fact that recent studies have quoted a much higher incidence (i.e., up to 1 in 800) of infectious complications associated with neuraxial anesthesia than was previously thought (i.e., less than 1 in 100,000).

This study was performed in an obstetric population for which the literature shows a lower complication rate than that of the general population. It is, however, where most residents receive their epidural anesthesia training and where their future aseptic practice for regional anesthesia is shaped. With practice, the technical success rates for epidural anesthesia are close to 95%. Although it was shown that novice operators perform sterility breaches and it is presumed that improved expertise in sterile technique parallels improved procedural skills, this assertion remains unproven.

We hypothesized that the increased experience acquired in a structured training program that taught technical and aseptic elements of the procedure would be associated with progressively greater proficiency in both elements. We tested this hypothesis using video recordings of actual epidural anesthesia procedures.

Materials and Methods

Consent

The study was approved by the Institutional Research Ethics Board of Mount Sinai Hospital, a University of Toronto teaching hospital, Toronto, Ontario, Canada. Postgraduate year 2 anesthesia residents (second year of residency after graduating from medical school) performing a 6-month rotation were recruited consecutively over 1 yr. These residents get only 2 months of anesthesia exposure during their first year. During their second-year rotation at our center, they spend 1–2 days and 1–2 calls a week on the labor floor, where they get the bulk of their obstetric anesthesia exposure.
of their epidural anesthesia training. Written informed consent was obtained from both the residents and the participating patients.

**Procedures**

The residents filled out a questionnaire regarding their previous experience with epidural anesthesia. Those who had previously performed epidurals were excluded. The residents attended didactic lectures on epidural catheter insertion. These included anatomy, technical aspects, approach to common problems, complications, and contraindications. They also received a lecture dedicated to asepsis during epidural anesthesia performance. After the lectures, the residents observed five procedures consistent with the manual skills and aseptic techniques taught, and participated in an additional five procedures with a "scrubbed" experienced attending anesthesiologist. The residents then performed the procedure during five more sessions with an attending anesthesiologist present in the room. They received verbal feedback during all these sessions. The residents then proceeded to perform the procedure independently with access to immediate assistance from an in-house attending anesthesiologist.

Over a 6-month period, the residents were videotaped three or four times while performing epidural catheter insertion independently. All epidural catheters were inserted in the sitting position between L2 and L4 levels, using the midline approach and a standard 17-gauge epidural needle and catheter (Arrow, Reading, PA). Videotaping sessions were only performed during daytime to control for workload and fatigue factors. Each resident maintained a procedural log and each was recorded at least once when the following number of epidurals had been completed: less than 30, 30–90, and more than 90. As much as possible, the residents were videotaped when performing epidural procedure numbers 1, 30, and 91. However, this was not always feasible because of the limitations imposed by patient consent, resident scheduling, and recording daytime sessions only, because residents sometimes perform more than 10 epidural anesthesia procedures during night call. No less than 20 procedures were performed after each recorded session before the resident was videotaped again.

**Recording and Blinding**

Videotaping was performed by two of the authors using a Canon ZR400 digital camcorder (Canon, Lake Success, NY) mounted on a tripod. The videotaped sessions began with the initial preparation and equipment setup and ended at the time when the catheter was secured. Videotaping was done in a manner that ensured proper masking of the resident’s identity and level of previous epidural anesthesia experience (*i.e.*, number of epidural insertions performed), as well as the date the session was taped. This was achieved by videotaping only the residents' hands throughout the procedure and removing the date tags from the tapes.

A graded checklist for proper aseptic technique during epidural anesthesia procedures was compiled based on current literature recommendations and the sterility breaches observed during a previous study (appendix 1). This checklist was revised and approved by a panel of obstetric anesthesiologists using the Delphi technique. The Delphi technique is an iterative process with experts in an area that establishes content validity by consensus through repeated questionnaires. Manual skills were assessed by a previously validated scaled checklist and a global rating scale (appendices 2 and 3). The residents were not given the task-specific checklists; however, all of the specific stages of both checklists were covered during the lectures. Feedback for both technical and aseptic aspects was given only during the 15 supervised sessions after which residents continued performing epidural anesthesia independently. The recorded sessions were copied from the camcorder to a digital videodisc in random order and were then graded by three examiners, trained by the principal investigators to independently evaluate subjects for manual skills and aseptic practice. The examiners were blinded to the resident’s identity and level of experience at each session. The authors who videotaped the sessions were not involved in grading them. The videotaped sessions were not observed by the residents or the examiners before the end of the rotation.

**Statistical Analysis**

Analysis was performed using SAS System version 9.1 (SAS, Cary, NC). Sample size was based on a previous study of epidural anesthesia skills assessments performed by the authors. Intraclass correlation coefficients were calculated to assess the agreement among examiners, where *P* values less than 0.05 suggest that agreement is greater than expected by chance alone. The following ranges of *κ* were used to determine the level of agreement: *κ* ≥ 0.80, near perfect agreement; 0.61 < *κ* < 0.80, substantial agreement; 0.41 < *κ* < 0.60, moderate agreement; 0.21 < *κ* < 0.40, fair agreement; 0.00 < *κ* < 0.20, slight agreement; and *κ* < 0.00, poor agreement.

To test whether higher total scores on the manual skills checklist, global rating scale, and aseptic technique checklist are associated with greater experience, a series of random effects regression models using an autogressive covariance structure was performed. The total scores were the outcome measures used in these tests, and the number of epidurals performed was the predictive variable. Resident was included as a random effect to control for the relatedness of observations taken on the same individual.
Results

A total of 35 sessions by 11 residents were videotaped over 12 months. Interrater reliability was nearly perfect for all three measures: manual skills checklist (intraclass correlation coefficient 0.91), global rating scale (intraclass correlation coefficient 0.90), and aseptic technique checklist (intraclass correlation coefficient 0.91). In all cases, the $P$ value was less than 0.001.

To test whether higher total scores were associated with greater experience, a series of random effects regression models using an autoregressive covariance structure was performed, and given the high reliability of scores across the three raters, the scores were averaged into a single score for this component of the analysis.

Scores for the three evaluation tools categorized into early (<30 epidural procedures performed), middle (31–90 epidural procedures performed), or late (>90 epidural procedures performed) rotation are summarized in table 1.

The scores for individual item for each assessment tool are summarized in table 2.

A significant relation was found between the number of epidural procedures performed and the manual skills checklist scores ($F = 80.62$, $df = 1.23$, $P < 0.0001$). The correlation between manual skills checklist scores and the number of epidurals performed was 0.84 ($P < 0.0001$), suggesting a strong positive association between the two sets of measurements (fig. 1). Similarly, a significant relation was found between the number of epidural procedures performed and the manual skills global rating scale scores ($F = 34.91$, $df = 1.23$, $P < 0.0001$), with a correlation between global rating scores and the number of epidurals performed of 0.70 ($P < 0.0001$; fig. 2). In contrast, no relation was found between the number of epidural procedures performed and the aseptic technique checklist total score ($F = 1.67$, $df = 1.23$, $P = 0.21$), with a nonsignificant or very weak correlation between the aseptic technique checklist total scores and the number of epidurals performed ($R = 0.23$, $P = 0.21$; fig. 3).

Discussion

Historically, infections secondary to neuraxial anesthesia were thought to be rare. More recent data suggest that this may not be the case. In the United States, infection is the most common cause of neuraxial injury claims in the obstetric population. It is even more common in the nonobstetric population, with a reported incidence as high as 1:800. In contrast, there was no similar improvement in aseptic technique, as reflected by the aseptic technique checklist scores. Cohen and Samet reported similar problems of unintentional contamination during the performance of epidural catheter insertion by inexperienced clinicians. Other studies have also reported operator inexperience to be a risk factor for catheter contamination. Such findings imply that greater experience is associated with better aseptic technique, an assumption that is not supported by the current study.

Although initial performance anxiety in novice operators may account for some of the breaks in sterility early on, residents in the current study did not demonstrate adequate improvement in aseptic technique even in later stages, after achieving satisfactory manual skills. This discrepancy was happening despite formal aseptic technique instruction during the initial didactic and practical teaching. The most significant conclusion of the study is that in contrast to the teaching of manual skills, our didactic and practical teaching of the aseptic principles as they should be applied to epidural anesthesia was, as our results clearly demonstrate, insufficient. Because we as teachers mostly judge the efficiency of our teaching by the residents' ability to independently insert epidurals that work well, we do not pick up on these deficiencies. There may be several reasons why a process of didactic teaching and supervised hands-on procedures, followed by multiple independent performances, was enough to achieve a good learning curve resulting in satisfactory manual skill, without a similar improvement in aseptic technique. The final responsibility lies of course with us as teachers, for making erroneous assumptions about the
residents’ background knowledge during the teaching sessions. As a result, the residents failed to translate the general principles they were taught during their medical school and clinical experience to the specifics of epidural anesthesia technique. These gaps in the knowledge of aseptic technique principles most likely originate from insufficient emphasis on sterility practice during the teaching of basic skills in medical school. In many cases, residents are told as medical students that certain skills or processes would be learned when they became residents, but once they became residents, they were expected to have learned them in medical school. This is likely a recurrent oversight by teachers throughout the clinical stages of medical education.

These results emphasize that what is sufficient for teaching manual skills is not adequate for the teaching of aseptic technique. Residents, like all of us, tend to concentrate on the technical aspects of the procedure. By the time they become comfortable with their manual skill, their aseptic practice is fixed into a routine. For the same reason, it is also possible that the practical instruction tended to concentrate more on the technical aspects, which are easier to notice and comment on, as well as understand and assimilate, as opposed to the less tangible aseptic principles. Therefore, the teaching of aseptic technique for any skill must be highly specific, and possible pitfalls should be demonstrated for each of residents’ background knowledge during the teaching sessions. As a result, the residents failed to translate the general principles they were taught during their medical school and clinical experience to the specifics of epidural anesthesia technique. These gaps in the knowledge of aseptic technique principles most likely originate from insufficient emphasis on sterility practice during the teaching of basic skills in medical school. In many cases, residents are told as medical students that certain skills or processes would be learned when they became residents, but once they became residents, they were expected to have learned them in medical school. This is likely a recurrent oversight by teachers throughout the clinical stages of medical education.

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the different stages of the skill taught within the general principles of sterility.

Another possible reason of why gained experience was sufficient for improvement of only the manual skills is the inherent feedback (tactile and other) that exists for the technical aspects, even during unsupervised sessions. There is no similar feedback for sterility. However, this is only a partial explanation. Manual skill items such as maintaining control of the needle or not threading the catheter too deeply do not provide feedback, but residents still improved in the performance of these tasks. There was no parallel improvement for the aseptic technique tasks. We must change this by repeatedly emphasizing these principles throughout the rotation.

Problems with technical skills instruction include a lack of uniformity in skills that are taught and variability in teaching strategies. Physicians often learn aseptic technique in a “learn-as-you-go” fashion without adequate formal structured teaching, particularly in regard to underlying principles.23 A review of the medical education literature between 1970 and 2000 revealed a void in studies that examine the teaching of aseptic principles to medical students.20 This gap in the literature may relate to the relative minor importance such training is given in medical curricula. This lack of structured formal training is further compounded by the fact that what is considered “essential” for aseptic technique in regional anesthesia is controversial, as previous surveys have shown.24

Most practitioners appreciate the obvious requirements of sterile gloves, masks, and skin preparation for sterility24; however, the less obvious principles are not strictly observed and probably not well taught. This was demonstrated by the particularly poor adherence to the less palpable sterility principles such as “movement within or around a sterile field must not contaminate the field.”11 Central to this principle is the concept that bacterial fallout from the body or clothing is a potential source of contamination when crossing over a sterile field. In practice, breaching this principle was reflected by the low grades achieved in checklist items such as “works in a manner that minimizes crossing of bare forearms over the sterile field/equipment.” This is not a tangible principle like washing hands or wearing gloves and is therefore easy to overlook. Its performance, however, is easily assessed, similar to global rating scale items such as “time and motion.” In most cases, the residents did not recognize the breaches they performed and no corrective action was taken, emphasizing the need for repeated exposure to supervision and teaching at a later phase in the rotation.

Several potential limitations of our study warrant comment. Blinding was problematic in our study, because audio input had to be used with the sessions to enable the grading of some of the stages. However, we do not believe that the results were biased considering that a large number of sessions were being graded in random order and at a time distant from the actual performance of the procedures. Furthermore, not all of the reviewers knew the residents, and interrater agreement was excellent. Another limitation is that the videotaping itself created added pressure on the residents and may have changed performance. But if this were the case, we would have expected an effect on both their manual skills and aseptic technique performances, resulting in minimal discrepancy between the two learning curves.

We attempted to standardize the timing of the recordings to achieve exposure to the full range of the residents’ experience. Although it was not possible to achieve identical timing for recording all residents, the recordings were done at three time frames of early, middle, and late rotation, and no less than 20 sessions separated each recording from the previous one. Furthermore, the number of epidurals was treated as a continuous measure in the repeated-measures tests, and changes were tracked within subjects.

We do not believe that the residents’ performance in the current study was unique.19 Although some studies showed inexperience to be a risk factor for central venous line contamination,8,9 none compared aseptic technique within the same group, but rather between different groups of operators. This kind of data does not provide any insight into the differences between novice and experienced operators and the evolution between these stages. Furthermore, it was shown that in some cases, experienced attending physicians perform more breaches than residents.25 Epidural anesthesia was shown to be the most complex and difficult-to-learn fundamental skill in anesthesia.26 Therefore, it may not be comparable to results from studies looking at central venous line insertion. The added manual complexity and slower learning curve may be contributing factors to the relative disregard of aseptic technique during this procedure.

Fig. 3. Sterility checklist total score versus number of epidurals performed.
Students will only be as good as their teachers. As our findings show, experience is not enough to reduce mistakes in aseptic technique. We now believe that residents must be reassessed later on during their rotation, once they have become more comfortable with the skill, and their aseptic practice must be reevaluated. Video-taping of performances, as a tool for capturing and demonstrating breaches in sterility before bad technique is rooted, may prove highly efficient, as previous work demonstrated.27

In conclusion, we demonstrated a learning curve for improvement in the technical skills involved in the placement of an epidural catheter; we have also shown that there is no similar learning curve for aseptic technique. Infectious complications associated with regional anesthesia are potentially devastating. Physicians seem to improve their technical skills with experience, but not their aseptic technique. These deficiencies may be overlooked because of the emphasis put on manual skills during teaching and assessment of procedure performance. Educational insights are needed and initiatives developed to correct these discrepancies.

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References


Appendix 1: Examiner’s Checklist for Aseptic Technique

1. Removes rings and watches
2. Washes hands and arms upon entering the room
3. Wears a hat and puts on a fresh facemask
4. Opens the epidural tray in the correct manner and sequence (top flap opened away from operator)
5. Washes hands with alcohol gel and air dries
6. Dons gloves in a sterile fashion
7. Puts the scalp aseptically and waits for the solution to dry
8. Applies the drape in a cuffed and sterile manner
9. Works in a manner that minimizes crossing of bare forearms over the sterile field/equipment
10. Holds the anesthetic receptacle away from the sterile area to allow assistant to pour in required solutions
11. Keeps all epidural equipment on the sterile tray when not in use
12. Maintains control over the catheter tip to avoid contamination
13. Dries the entry site of the epidural catheter and covers it with a sterile dressing while maintaining sterility (this requires keeping one hand sterile over the catheter insertion site, while partially removing the drape with the other hand to allow the nurse to apply the dressing)
14. Further removal of any residual antiseptic or blood in the surrounding area is completed only after the entry site itself is protected by the sterile dressing
15. Maintains vigilance over all sterile fields and equipment and notes any potential breaks in technique

0 = Did not perform; 1 = inadequately performed; 2 = adequately performed.

Appendix 2: Examiner’s Manual Skills Checklist for Epidural Anesthesia

1. Ensures patient is positioned comfortably and safely in the middle of the bed
2. Adjusts height of bed appropriately
3. Carefully prepares a sterile work surface
4. Pours antiseptic solution (or has nurse pour it) without contaminating the epidural set

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5 Washes hands and puts on gloves in a sterile fashion
6 Optimally positions himself or herself for the procedure
7 Prepares the skin at the back widely and aseptically (skin prep × 3)
8 Allows solution to dry
9 Neatly lays out and prepares all necessary equipment (needles, syringes, local anesthetic)
10 Asks patient to arch her back
11 Places drape over patient's back in a sterile fashion
12 Landmarks site of injection after palpating iliac crests
13 Warns patient of needle insertion
14 Infiltrates subcutaneous layers with local anesthetic
15 Places epidural needle with correct positioning of bevel
16 Inserts epidural needle through skin, through subcutaneous tissue, and into ligament before attaching the syringe
17 Attaches air/saline-filled syringe to the needle hub with needle well controlled
18 Braces hand(s) holding the needle against patient's back in complete control of the needle
19 Slowly advances needle through supraspinous and interspinous ligaments and into ligamentum flavum while applying pressure on the plunger (continuous or intermittent)
20 Identifies loss of resistance and immediately releases pressure on the plunger
21 Notes depth of needle insertion before threading catheter
22 Warns patient about possible paresthesia during catheter threading
23 Detaches the syringe and threads the catheter to a depth of 4-5 cm
24 Pulls the needle out while maintaining correct catheter placement
25 Carefully aspirates from catheter
26 Injects test dose through flushed filter
27 Fixes the epidural catheter securely

0 = Did not perform; 1 = inadequately performed; 2 = adequately performed.

Appendix 3. Global Rating Scale for Epidural Anesthesia

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<tr>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation for</td>
<td>Did not organize</td>
<td>Equipment generally organized;</td>
<td>All equipment neatly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>procedure</td>
<td>procedure well; has</td>
<td>occasionally has to stop and</td>
<td>organized, prepared, and</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>to prepare equipment</td>
<td>prepare items</td>
<td>ready for use</td>
<td></td>
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<tr>
<td>Respect for tissue</td>
<td>Frequently used</td>
<td>Careful handling of tissue but</td>
<td>Consistently handled tissues</td>
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<tr>
<td></td>
<td>unnecessary force on</td>
<td>occasionally caused inadvertent</td>
<td>appropriately with minimal</td>
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<tr>
<td></td>
<td>tissue or caused</td>
<td>damage</td>
<td>damage</td>
<td></td>
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</tr>
<tr>
<td>Time and motion</td>
<td>Many unnecessary</td>
<td>Efficient time/motion but some</td>
<td>Clear economy of movement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrument handling</td>
<td>moves</td>
<td>unnecessary moves</td>
<td>and maximum efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow of procedure</td>
<td>Frequently stopped</td>
<td>Demonstrated some forward planning with reasonable progression of procedure</td>
<td>Obviously planned course of procedure with effortless flow from one move to the next</td>
<td>Demonstrated familiarity with all aspects of procedure</td>
<td>Clearly superior</td>
</tr>
<tr>
<td>Knowledge of procedure</td>
<td>Deficient knowledge</td>
<td>Knew all important steps of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall performance</td>
<td>Very poor</td>
<td>procedure</td>
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