The Effect of Gowning on Labor Epidural Catheter Colonization Rate
A Randomized Controlled Trial

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Background: The need to gown for labor epidural catheter insertion is controversial. The American Society of Regional Anesthesia and Pain Medicine has identified a lack of randomized controlled trials investigating this issue. The purpose of this study was to examine the effect of gowning on colonization rates following epidural catheter insertion for labor analgesia.

Methods: Following research ethics board approval and informed written consent, parturients were randomized to undergo epidural analgesia with the anesthesiologist either ungowned or wearing a sterile gown. Cultures were obtained from each of the operator forearms, the work area under the insertion site, and from the epidural catheter tip as well as from the catheter segment adjacent to the insertion site. The primary outcome was growth of any microbial organisms from the cultured sites.

Results: Two hundred fourteen patients completed the study. There were no significant differences in catheter-tip colonization rates between the ungowned and gowned groups (9.2% vs 7.6%, respectively). The most common microorganism that was cultured was coagulase-negative *Staphylococcus*.

Conclusions: The use of gowns in the current study did not affect catheter colonization rate. Overall, there was a relatively high incidence of catheter-tip colonization in both groups, which underscores the need for strict aseptic technique.

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Infectious complications associated with epidural analgesia are exceedingly rare events that may result in devastating morbidity and mortality.[1,2]

The reported incidence of epidural catheter colonization varies from 0% to 28%[3–5] but has been reported to be as high as 53.1%.[6] Potential sources by which bacteria can be introduced into the epidural space include hematogenous migration from a remote infected site within the body, external contamination due to poor aseptic technique,[7,8] contaminated infusate solutions, disconnection of epidural catheter hubs and tubing, or local contamination from the patient's skin flora due to inadequate application of antiseptic solution.[9] Although breaches in sterility place patients at risk for preventable infections,[10] the standards of aseptic technique vary based on physicians' experience and on the local standards of practice especially when it comes to gowning for the procedure.[11] Gowning is considered standard practice in many parts of Europe, whereas in North America gowning for labor epidural catheter insertion is less common.[11] Recognizing this, the American Society of Regional Anesthesia and Pain Medicine created a task force to examine and suggest guidelines for aseptic practice.[12] Its findings emphasize the lack of randomized controlled trials to support specific recommendations. This is especially true in regard to the use of sterile gowns during the performance of neuraxial anesthesia. Similarly, the recommendations in the American Society of Anesthesiologists' practice advisory are equivocal, stating that "The literature is insufficient regarding the efficacy of aseptic techniques during neuraxial procedures in reducing infectious complications."[13]

The purpose of this study was to examine the effect of gowning on bacterial contamination and colonization rates during labor epidural catheter insertion. We hypothesized that there would be a decreased incidence of contamination of epidural equipment and colonization of epidural catheters in the gowned group.

METHODS

The study was approved by the local research ethics board (REB no. 09-0075-E) and registered with ClinicalTrials.gov (NCT01235858). Informed written consent was obtained from all participating patients and anesthesiologists. All members of the anesthesia team including residents, clinical fellows, and attending anesthesiologists participated in the study. Parturients with an American Society of Anesthesiologists physical status I or II in active labor and requesting epidural analgesia were enrolled. Using a sealed envelope randomization system, they were assigned to undergo epidural analgesia with the anesthesiologist either wearing a sterile gown or not wearing one. Parturients were excluded from participation if they were febrile, received antibiotics within the previous 48 hours, or had a preexisting skin infection or a history of immune deficiency state. Participation in the study was discontinued if parturients had more than 3 epidural insertion attempts (needle withdrawn to skin level and reinserted), or received antibiotics at any time before the removal of the epidural catheter.

To account for technical difficulties encountered during epidural catheterization, we collected information on patients' body mass index (BMI), total number of attempts, and time required for the procedure defined as time in minutes from the insertion of the epidural needle to the fixation of the epidural catheter. The duration of epidural catheterization was recorded before its removal.

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The current standard of practice for labor epidural catheter insertion at the study center includes several components.[14] After removal of jewelry, hand and forearm washing with an antimicrobial soap and water is performed prior to contact with the patient. A fresh mask and surgical hat are worn by the anesthesiologist and other support personnel present in the room. The patient's hair is also covered by a surgical hat. The epidural insertion site is prepared with sterile swabsticks containing 2% wt/vol chlorhexidine gluconate and 70% vol/vol isopropyl alcohol. Three prep sticks are applied in horizontal strokes, proceeding from a cephalad-to-caudad direction. The operator's hands and arms are disinfected up to the elbows using 70% alcohol gel and air dried. At this point in the gowned group, epidural practitioners wear sterile gowns and then put on sterile gloves. The patient's back is covered by a sterile drape. Required solutions (local anesthetics, saline) are poured into a sterile receptacle by an assistant away from the sterile field. Following completion of the procedure, the drape is removed; a sterile 3M Tegaderm transparent film dressing with border size of 4 × 4¾ inches (10 × 12 cm) (3M, St Paul, Minnesota) is applied to the epidural insertion site and then sealed by a clear plastic tape frame.

Parturients randomized into group 1 had an epidural catheter inserted by an anesthesiologist according to the current standard practice described above. Parturients in group 2 had an epidural catheter inserted by a gowned anesthesiologist. Other than gowning, all aseptic measures were identical in both groups. A sterile Arrow FlexTipPlus continuous epidural anesthesia tray (Arrow International, Reading, Pennsylvania) was used. All epidural catheterizations were performed with the patient in a sitting position. The insertion point at either the L3-L4 or L4-L5 vertebral interspace was identified by palpation using the Tuffier's line as the landmark that corresponds to the spinous process of the L4 vertebrae. Following a standard test dose, a loading dose of bupivacaine 0.125% 10 mL and 50 μg of fentanyl was given to all patients. Epidural catheters were connected to a continuous infusion system equipped with a 0.2-μm filter and infusing 0.0625% bupivacaine with 2 μg/mL fentanyl. The patient-controlled epidural analgesia settings were as follows: bolus dose of 5 mL with a lockout of 10 minutes and continuous infusion rate of 10 mL/h.

Cultures and Microbiology

A total of 5 cultures were obtained in each case. Two samples were taken from the operator's forearms after hand and arm washing was completed (either from the bare forearms or from the gown). Another sample was collected from the working area by placing sterile disposable 100 × 15-mm plastic Petri dishes immediately below the epidural insertion site under the operator's hands. All the Petri dishes were covered by sterile lids and handed over to the nurse as soon as the epidural was secured with a sterile dressing. Lastly, upon removal of the epidural catheter, it was cultured from 2 sites: the distal epidural catheter tip segment and the segment adjacent to the skin at the insertion site. All sample collections were performed using aseptic technique as follows.

A 10 × 10-cm area from the operator's bare forearms in the ungowned group and from the gown in the gowned group was swabbed following the hand and forearm washing. The swabs were obtained using transport medium premoistened sterile Dacron-tipped applicators (DuPont, Wilmington, Delaware). Swabs were coded, placed in 1.0 mL thioglycolate broth (BBL; Becton-Dickinson, Cockeysville, Maryland), and hand delivered to the microbiology laboratory. After 24 hours of incubation at 37°C, the broth was subbed to a single blood agar plate. At this time, a sweep of the plate was frozen in skim milk or glycerol, so that colonies of bacteria isolated from the practitioner's skin could be compared with catheter-tip colonies.

During the procedure, a sterile blood agar plate was placed inside the sterile field working area directly underneath the epidural insertion site. The plate was covered immediately following the procedure and hand delivered to the microbiology laboratory where it was incubated aerobically at 37°C for 24 hours. The microbiologist handling the specimens was blinded to the use of a gown during the procedure. All patients were followed up via a phone call for the possibility of clinical infection symptoms at 1 week, 1 month, and 3 months following catheter removal. The questions were standardized for all patients. The questions asked were as follows:

(1) Following your delivery, did you develop fever and back pain?
(2) Following your delivery, did you develop any bowel or bladder dysfunction?
(3) Following your delivery, did you develop any neurological symptoms?

Epidural catheter sampling was performed 1 hour after the delivery of the placenta during catheter removal. All catheters were removed aseptically by an anesthesiologist trained in aseptic sampling of the catheter and wearing sterile gloves and a mask. The segment adjacent to the insertion site was collected first. Then, in order to avoid contamination of the distal epidural catheter tip from the surrounding skin during its removal, the area surrounding the insertion site was disinfected with 70% isopropyl alcohol before the remainder of the catheter was removed after the alcohol had dried off. Each catheter was cut using sterile scissors and forceps. Two 3- to 5-cm segments from the distal tip and the insertion site were placed in sterile containers and immediately delivered to the microbiology laboratory. These specimens were cultured by a modification of the roll-plate technique. Colonies on each plate were counted, and all organisms were frozen, pending typing. Catheter colonization was defined as a positive semiquantitative tip culture of 15 colony-forming units/mL or more for the roll-plate method.[15]

Statistical Analysis

Our primary outcome was a comparison of the colonization rates of any microbial organism on the catheter tips between the 2 groups. The secondary outcome was the incidence of presence of the same pathogen on different cultured sites.

Descriptive statistics were calculated for patient and procedure characteristics. Means and SDs were used to summarize continuous measures that were not highly skewed (eg, BMI), and medians and interquartile ranges were used to summarize skewed continuous measures. Student *t* tests and Wilcoxon rank-sum tests were used to compare continuous measures across intervention groups for normally distributed and skewed measures, respectively. Frequencies and percentages were used to summarize the occurrence of colonization. To account for the clustered nature of the data (ie, multiple patients clustered within physician), unadjusted and adjusted comparisons of colonization across intervention groups were performed using generalized estimating equations analogous to logistic regression with a binomial distribution and logit link and exchangeable correlation matrix (PROC GENMOD, SAS Software, version 9.2; SAS Institute, Cary, North Carolina). All tests were 2-tailed. $P < 0.05$ was considered statistically significant.

The rate of catheter-tip colonization in the gowned arm of the trial was assumed to be small; therefore, sample size calculation was based on Fisher exact test using the method outlined by Walters.[16] Based on the initial data from our pilot cases (total, 50) and using a 2-sided type I error of 5%, a total of 192 patients

(96 per group) were needed in order to achieve 80% power to detect an absolute difference of 20%. To account for attrition and technical problems, we increased the desired sample size by 25% to 120 per group.

RESULTS

A total of 240 parturients were randomized and enrolled, and 214 completed the study (Fig. 1). Groups were similar with respect to parturients' BMI. All the epidural procedures that were included in the study were completed on the first or second attempt. There were no differences in the operator characteristics (staff/fellows/residents) between the 2 groups. The median epidural insertion time starting from the first contact of the epidural needle with patient's skin to securing the epidural catheter with a sterile dressing and the median duration of catheterization were similar in both groups (Table 1).

Physicians who were gowned had a significantly lower number of positive cultures from both forearms. However, there were no significant differences between the groups in the contamination rates of the catheter tip, the catheter's skin-adjacent segment, or the working area (Table 2).

The most common microorganism isolated in both groups was coagulase-negative *Staphylococcus* followed by the *Bacillus* species.

To test the hypothesis of bacterial fallout from operators' forearms leading to contamination of the working area, we performed a subanalysis of samples obtained from the working area only. In the ungowned group, we observed a higher incidence of colonization with coagulase-negative *Staphylococcus*, which is a part of normal skin flora, than *Bacillus* species, which is the most common environmental microorganism in hospitals compared with a much more balanced distribution of the organisms in the gowned group ($P = 0.014$). Fisher exact test for differences in organism distribution between the gowned and ungowned group is presented in Table 3.

None of the patients developed clinical signs or symptoms of infection as defined previously in the patient follow-up questionnaire.

DISCUSSION

The purpose of gowning is to prevent the passage of bacteria from the physician's skin to the sterile equipment or the insertion site, either through accidental direct contact or bacterial fallout, that is, bacteria from uncovered areas such as forearms "sloughing" or shedding onto the sterile field and equipment.

This study is the first randomized controlled trial to examine the effect of gowning on epidural catheter colonization rates in parturients. We did not find any association between gowning and catheter colonization. The most common microorganism isolated was coagulase-negative *Staphylococcus*. The incidence of catheter-tip colonization in our study in both groups was found to be greater than 7%. These results, although far from being conclusive, highlight the importance of strict aseptic technique. A larger sample size in future studies might help clarify the clinical significance of these findings.

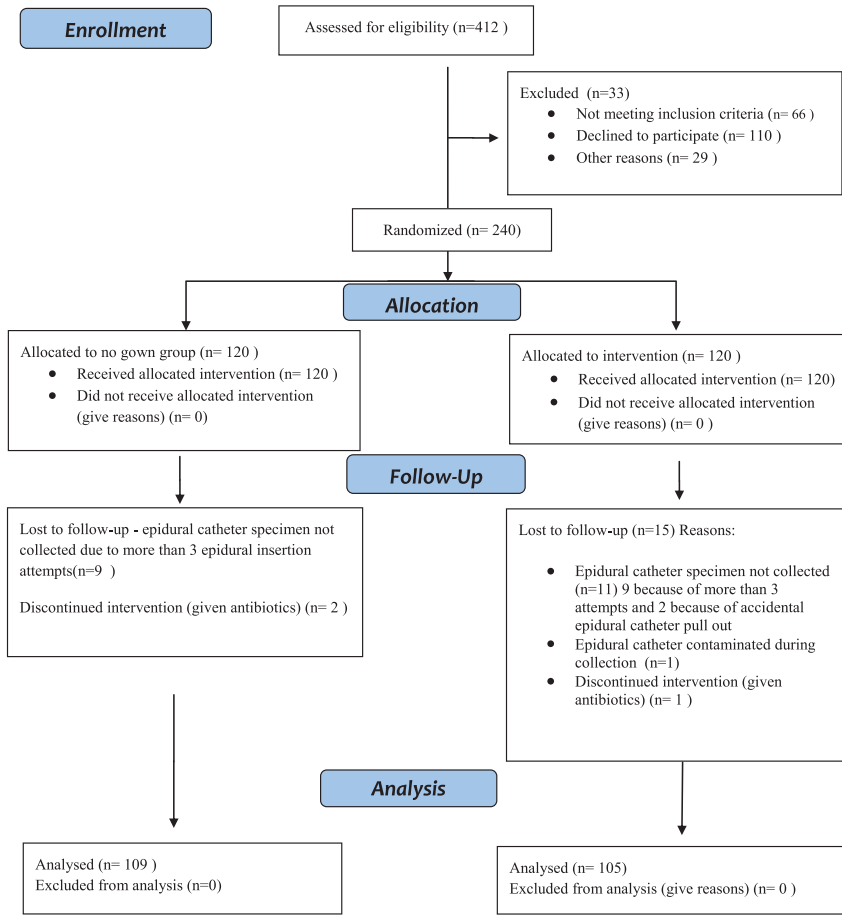

FIGURE 1. CONSORT flow diagram.

TABLE 1. Participant and Procedure Characteristics by Intervention Group

	No Gown (n = 109)	Gown (n = 105)	*P*
BMI, mean (SD), kg/m^2	29.35 (4.65)	29.95 (4.73)	0.35
No. attempts, median (IQR)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	0.94*
Duration of procedure in minutes, median (IQR)	9.0 (6.0–11.0)	8.0 (5.0–12.0)	0.53*
Duration of epidural catheterization, median (IQR), h:min	8:48 (6:40–11:54)	9:31 (6:26–13:01)	0.43*
Staff/fellow/resident, n	14/31/64	19/35/51	0.302

*Medians presented and Wilcoxon Wilk rank-sum test performed because of skewness in data. Student *t* tests used for all other comparisons.
IQR indicates interquartile range.

Asepsis is an essential component of any invasive procedure. The importance of understanding and maintaining sterility during these procedures is highlighted by several reports in the literature in which anesthesiologists' inadequate aseptic technique has been implicated as the direct cause of infectious complications.[7,8] Unfortunately, what constitutes "aseptic technique" is not well defined and often depends on the individual's interpretation of the fundamental principles of asepsis as well as the standards of practice in their region.[11] For instance, gowning for epidural catheter placement is common in England, but not in France or the United States.[8] Expert opinion from England suggested "It is expensive and unsupported by good evidence, but it can only be safer to do so."[17]

The current study did not demonstrate a clear advantage to gowning in an obstetric population. One of the reasons might be the typically short period of epidural catheterization in this population. Previous studies in nonobstetric patients have demonstrated a correlation between the duration of epidural catheterization and infection. Rates of 0.8% to 6% of overt infections of the skin at the epidural insertion site have been reported after a few days of catheterization.[18] This observation is consistent with the fact that when epidural catheters are kept in for a longer duration the risk of deep tissue infection is increased.[19,20]

Coagulase-negative *Staphylococcus*, a part of normal skin flora, was the most common microorganism found in our study. This finding is consistent with previous studies examining colonization of indwelling catheters where coagulase-negative *Staphylococcus* is the main culprit in epidural abscesses.[21,22] It supports the assumption that the most common sources of colonization and infection are bacteria from the patients' or the operator's skin gaining access to deeper tissue through the catheter insertion track. In a previous study, bacteria from epidural abscesses have been traced to *Staphylococcus aureus* strains from the patient's skin flora.[23]

The most common environmental microorganism in hospitals is the *Bacillus* species.[24] We expected that the cultures obtained from the working area under the epidural insertion site would grow mostly *Bacillus* species. However, we found a higher incidence of growth of coagulase-negative microorganisms (normal skin flora) than *Bacillus* species on the working area in the ungowned group, where coagulase-negative bacteria constituted the majority of cultures. Although based on a limited result, this could support the assumption that the operators' skin is the source of equipment contamination in the ungowned group. Unfortunately, we were not able to determine the exact typing of the organism because of storage error in our microbiology laboratory and therefore could not track the origin of the organisms to patient versus operator.

These findings illustrate the mechanisms by which colonization leading to infection may occur. Contamination from both the operator and the patient can be minimized with meticulous aseptic technique. Most practitioners appreciate the obvious requirements of sterile gloves, masks, and skin preparation for sterility.[11] However, the less tangible principles are not well taught and probably not strictly observed. Examples for such breaches include movement of bare forearms over the sterile field (either by the operator or the assistant pouring the solutions) or inadvertent contact with the patient's skin or the edges of the sterile drape, which are considered unsterile. Another possible source of colonization of the insertion site despite skin preparation may happen during and after the removal of the sterile drape, when the procedure is complete and attention to asepsis may be reduced. This could happen from exposure to patients' sweat dripping onto the insertion site or during the dressing process. Strict attention to these factors that are under our control may minimize the risk for infection.

There are several limitations to this study. We defined colonization to be positive when more than 15 colony-forming units of the same pathogen were identified on the cultured sites in keeping with definitions of previous studies.[15] This definition of colonization may not be a predictive precursor of infection. However, positive colonization is a necessary precursor to infection, and there is strong evidence that superficial colonization may ultimately transfer into deeper infections.[23]

TABLE 2. Number and Percentage of Positive Cultures in the Studied Groups

	No Gown (n = 109) n,%	Gown (n = 105) n,%	*P*
Right forearm	23 (21.1)	2 (1.9)	<0.001
Left forearm	22 (20.2)	1 (1.0)	<0.001
Working area	23 (21.1)	14 (13.3)	0.151
Tip of catheter	10 (9.2)	8 (7.6)	0.807
Skin adjacent section of catheter	16 (14.7)	14 (13.3)	0.845

TABLE 3. Colonization

	No Gown (n = 109) n, %		Gown (n = 105) n,%		
	Bacillus	CN *Staph*	*Bacillus*	CN *Staph*	*P**
Right forearm	8 (7.3)	14 (12.8)	2 (1.9)	0 (0.0)	0.16
Left forearm	8 (7.3)	16 (14.7)	1 (1.0)	0 (0.0)	0.36
Working area	2 (1.8)	21 (19.3)	7 (6.7)	7 (6.7)	0.014

*Fisher exact test for difference in colonization distribution across groups among those with positive cultures.
CN *Staph* indicates coagulase-negative *Staphylococcus*.

Our sample size calculation was based on our pilot 50 cases that showed 20% absolute difference between the catheter-tip colonization rate in each group. The actual incidence of colonization was much lower in both study groups, which might have resulted in an underpowered study. However, according to previous nonobstetric studies, rates of colonization for epidural catheters have been reported to be as high as 53%,[6] which leads us to believe that a 20% difference may be reasonable to power this prospective study.

The incidence of catheter-tip colonization in our study was fairly low in comparison to some reports in the literature. One of the reasons for this could be that the aseptic protocol was strictly observed during the study. Perhaps in "real" clinical practice, we may have seen a higher rate of colonization.

As mentioned, because of a storage error in our microbiology laboratory, we were not able to perform type analysis for all the samples. This prevented us from making definitive conclusions regarding the exact source of the microorganisms. Also, we cultured only a segment of the forearm, a small area at the insertion site, and a small collection plate under the work area. We have no data about environmental contaminants or late contamination during the catheterization period. These are all potential contamination sources that we have not examined.

Although standardized, the arm-washing technique was not initially documented. The problem was rectified when this design flaw was identified. We confirmed hand washing by contacting all the participants who were not observed; however, this remains a limitation of the study.

Prolonged rupture of membranes could potentially increase the risk of infection and is a potential confounder. We did not exclude these patients as this is not a contraindication to neuraxial anesthesia, and these parturients would receive epidural anesthesia in the "real world."

This study highlights an important issue pertaining to the practice of regional anesthesia. The outcomes associated with epidural infection can lead to major morbidity and mortality. One of the important contributing factors to infection may be lack of adherence to strict aseptic measures by physicians during the placement of epidural catheters. The use of sterile gowns for labor epidural procedures is not a standard practice, and there is not enough evidence to support any specific recommendation. The results of this study suggest that although gowning could potentially decrease the role of the forearms as a source of bacterial colonization, it did not significantly affect the overall colonization rates. However, the high incidence of catheter-tip colonization in both groups accentuates the need for meticulous aseptic measures. Emphasis should therefore be put on all aspects of aseptic techniques whether gowning is performed.

REFERENCES

1. Phillips JM, Stedeford JC, Hartsilver E, Roberts C. Epidural abscess complicating insertion of epidural catheters. *Br J Anaesth*. 2002;89:778–782.
2. Moen V, Dahlgren N, Irestedt L. Severe neurological complications after central neuraxial blockades in Sweden 1990–1999. *Anesthesiology*. 2004;101:950–959.
3. Barreto RS. Bacteriological culture of indwelling epidural catheters. *Anesthesiology*. 1962;23:643–646.
4. Simpson RS, Macintyre PE, Shaw D, Norton A, McCann JR, Tham EJ. Epidural catheter tip cultures: results of a 4-year audit and implications for clinical practice. *Reg Anesth Pain Med*. 2000;25:360–367.
5. Steffen P, Seeling W, Essig A, Stiepan E, Rockemann MG. Bacterial contamination of epidural catheters: microbiological examination of 502 epidural catheters used for postoperative analgesia. *J Clin Anesth*. 2004;16:92–927.
6. Holt HM, Andersen SS, Andersen O. Infections following epidural catheterization. *J Hosp Infect*. 1995;30:253–260.
7. Gregory A. Syringe misuse threat to 600. New Zealand Herald 2000;3. Available at: http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=135884. Accessed March 4, 2013.
8. Benhamou D, Mercier FJ, Dounas M. Hospital policy for prevention of infection after neuraxial blocks in obstetrics. *Int J Obstet Anesth*. 2002;11:265–269.
9. Yuan HB, Zuo Z, Yu KW, Lin WM, Lee HC, Chan KH. Bacterial colonization of epidural catheters used for short-term postoperative analgesia: microbiological examination and risk factor analysis. *Anesthesiology*. 2008;1:130–137.
10. Kidd-Ljunggren K, Broman E, Ekvall H, Gustavsson O. Nosocomial transmission of hepatitis B virus infection through multiple-dose vials. *J Hosp Infect*. 1999;43:57–62.
11. Sellors JE, Cyna AM, Simmons SW. Aseptic precautions for inserting an epidural catheter: a survey of obstetric anaesthetists. *Anaesthesia*. 2002;57:593–596.
12. Hebl JR. The importance and implications of aseptic techniques during regional anesthesia. *Reg Anesth Pain Med*. 2006;31:311–323.
13. American Society of Anesthesiologists Task Force on infectious complications associated with neuraxial techniques. *Anesthesiology*. 2010;112:530–545.
14. Friedman Z, Siddiqui N, Katznelson R, Devito I, Davies S. Experience is not enough: repeated breaches in epidural anesthesia aseptic technique by novice operators despite improved skill. *Anesthesiology*. 2008;108:914–920.
15. Maki DG, Weise CE, Sarafin HW. A semi quantitative culture method for identifying intravenous-catheter–related infection. *N Engl J Med*. 1977;296:1305–1309.
16. Walters DE. Walters Fischer exact test. In defence of the arc sine approximation. In: *The Statistician*. 28th ed. 1979, 219–232
17. Reynolds F. Infection as a complication of neuraxial blockade [editorial]. *Int J Obstet Anesth*. 2005;14:183–188.
18. Green LK, Paech MJ. Obstetric epidural catheter-related infections at a major teaching hospital: a retrospective case series. *Int J Obstet Anesth*. 2010;19:38–43.
19. Du Pen SL, Peterson DG, Williams A, Bogosian AJ. Infection during chronic epidural catheterization: diagnosis and treatment. *Anesthesiology*. 1990;73:905–909.
20. Nickels JH, Poulos JG, Chaouki K. Risks of infection from short-term epidural catheter use. *Reg Anesth*. 1989;14:88–89.
21. Orlikowski C, Majedi PM, Keil AD. Bacterial contamination of epidural needles after multiple skin passes. *Br J Anaesth*. 2002;89:922–924.
22. Scott DA, Beilby DS, McClymont C. Postoperative analgesia using epidural infusions of fentanyl with bupivacaine: a prospective analysis of 1,014 patients. *Anesthesiology*. 1995;53:727–737.
23. Sato S, Sakuragi T, Dan K. Human skin flora as a potential source of epidural abscess. *Anesthesiology*. 1996;85:1276–1282.
24. Bryce EA, Smith JA, Tweeddale M, Andruschak BJ, Maxwell MR. Dissemination of *Bacillus cereus* in an intensive care unit. *Infect Control Hosp Epidemiol*. 1993;14:459–462.