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SCIENTIFIC ARTICLE

Frequency of colonization and isolated bacteria from the tip of epidural catheter implanted for postoperative analgesia☆

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Abstract
Background and objective: The increased use of epidural analgesia with catheter leads to the need to demonstrate the safety of this method and know the incidence of catheter colonization, inserted postoperatively for epidural analgesia, and the bacteria responsible for this colonization.
Methods: From November 2011 to April 2012, patients electively operated and maintained under epidural catheter for postoperative analgesia were evaluated. The catheter tip was collected for semiquantitative and qualitative microbiological analysis.
Results: Of 68 cultured catheters, six tips (8.8%) had positive cultures. No patient had superficial or deep infection. The mean duration of catheter use was 43.45 h (18–118) ($p = 0.0894$). The type of surgery (contaminated or uncontaminated), physical status of patients, and surgical time showed no relation with the colonization of catheters. Microorganisms isolated from the catheter tip were *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Sphingomonas paucimobilis*.

☆ Study conducted at Hospital de Clínicas da Universidade Federal de Uberlândia, Uberlândia, MG, Brazil.

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Conclusion: Postoperative epidural catheter analgesia, under these study conditions, was found to be low risk for bacterial colonization in patients at surgical wards.

PALAVRAS-CHAVE
Anestesia epidural;
Infecção;
Bactérias

Frequência de colonização e bactérias isoladas de ponta de cateter de peridural implantado para analgesia pós-operatória

Resumo
Objetivos: O aumento do uso de analgesia pela via peridural com uso de cateteres leva à necessidade de se demonstrar a segurança do método. O presente estudo teve como objetivo conhecer a incidência de colonização de cateteres inseridos para analgesia peridural no pós-operatório e as bactérias responsáveis por estas colonizações.
Métodos: No período de novembro de 2011 a abril de 2012 foram avaliados pacientes operados eletivamente mantidos sob analgesia por cateter peridural no pós-operatório. A ponta do cateter foi coletada para análise microbiológica semi-quantitativa e qualitativa.
Resultados: Seis (8,8%) pontas dos 68 cateteres cultivados apresentaram culturas positivas. Nenhum paciente apresentou infecção superficial ou profunda. O tempo médio de permanência do cateter foi de 43,45 horas (18-118 horas) (p = 0,0894). O tipo de cirurgia (contaminada ou não contaminada), estado físico dos pacientes e tempo cirúrgico não mostraram relação com a colonização dos cateteres. Os micro-organismos isolados da ponta de cateter foram *Staphylococcus aureus, Pseudomonas aeruginosa* e *Sphingomonas paucimobilis*.
Conclusão: Conclui-se que, a analgesia por cateter peridural no pós-operatório, nas condições do presente estudo, revelou-se procedimento com baixo risco de colonização bacteriana em pacientes de enfermarias cirúrgicas.

Introduction

Epidural anesthesia has been used mainly not only for pain relief, for hours or a few days in surgical patients, trauma victims, and those admitted in intensive care units, but also for longer periods in patients with chronic pain, such as those undergoing cancer treatment.[1,2]

Evidence shows that association of general and epidural analgesia facilitates early recovery and improves patient outcome by reducing the incidence of thromboembolic, pulmonary, and gastrointestinal events.[1,3–5]

Besides the advantages mentioned, the complications associated with epidural catheters include total spinal anesthesia; post-dural puncture headache; spinal cord and nerve root trauma; hematoma; and infections such as epidural abscesses, meningitis, and superficial skin infection.[1,6,7] Epidural catheter colonization is defined as the growth of at least one microorganism in quantitative culture regardless of the number of units forming colony without local inflammation or infection in the spinal space.[7]

Studies of the use of epidural catheter for analgesia have shown rates of colonization or infection of 0–28.8%.[6,8–10] The incidence of infection associated with epidural catheter ranges from 0.06% to 5.3% in studies with surgical patients and the rate of site-specific infections (meningitis, paraspinal and epidural abscess) ranges from 0 to 0.7%.[1,6,10,11]

There are several mechanisms by which epidural catheter causes infection. First, infection may occur by contamination of the catheter emergence site or its lumen and spreads along its duct. The second mechanism is by organisms that are introduced during puncture or catheter insertion. Infection may occur via blood from blood stream or from a distant focal infection. A fourth mechanism described is intraluminal via a contaminated infuser.[1,12]

For intravascular catheters, Maki et al. reported that catheter growth of more than 15 colonies correlates with increased risk of infection.[13] However, the quantitative value of the results of epidural catheter cultures was not determined.[1]

The vast majority of epidural catheter infections are caused by *Staphylococcus aureus* (57–93% of cases), *Streptococcus* spp. (18%), and a variety of Gram-negative bacilli (13%), but mycobacteria, fungi, and parasites may also be found in the abscesses. The microbiological spectrum of infection depends on the population studied.[12,14–18]

The microorganisms most frequently isolated at the tip and at the site of epidural catheter insertion are: coagulase-negative *Staphylococcus*, especially *Staphylococcus epidermidis*, *S. aureus*, and *Pseudomonas aeruginosa*.[14–18]

Infections have always been a matter of debate for epidural analgesia, but studies have been limited to case reports and retrospective reviews. The considerable increase in the use of analgesia delivered through epidural catheter shows the need to demonstrate the advantages and safety of this method. Although a rare event, the impact of an epidural catheter infection on a healthy patient can be harmful, both economically and biologically; therefore, the objective of the study was to perform a prospectively and epidemiological analysis of patients admitted to medical wards undergoing epidural analgesia postoperatively as well as discover the frequency of colonization and the microorganisms involved in short-term catheters in these patients.

Methods

Prospective and epidemiological study carried out from November 2011 to April 2012 at the Hospital de Clínicas da Universidade Federal de Uberlândia. The project was approved by the Human Research Ethics Committee, number 280/11, and included all patients undergoing elective surgical procedures, requiring postoperative epidural catheter analgesia during that period.

All patients agreed to participate in the study and gave written informed consent. Data collection was performed using the anesthetic records made at the time of anesthesia and during the postoperative period at the surgical and gynecological wards. All patients were subjected to antisepsis with 70% alcohol for epidural catheter insertion. Patients were followed-up for analgesia and evaluation of the inflammatory and/or infectious aspect at the site of epidural catheter insertion, and other symptoms that may be present during hospitalization (such as fever, paresthesia, postoperative pain). The catheter used was Smiths Medical Portex, 16G, with analgesic solution infusion by infusion or intermittent pump bolus with syringe.

The data collection instrument included sociodemographic records and information such as hospital stay, comorbidities, surgical procedure, antimicrobials used, date of insertion and dwell time of epidural catheter, insertion level (thoracic or lumbar), local anesthetic used, management complications, signs of inflammation (redness, discharge) at the insertion site.

After the epidural catheter indwelling period, considered as sufficient by the anesthesiology team, the epidural catheter tip was harvested under strict aseptic and antiseptic techniques (mask, sterile gloves, and 70% alcohol).

Using sterile blades, the distal end of the catheter, at a distance of 3–4 cm, was sectioned, placed in a sterile container, and transported within 2 h for cultivation in microbiology laboratory of the Hospital de Clínicas da Universidade Federal de Uberlândia. Epidural catheter was semi-quantitatively and qualitatively cultivated. The laboratory culture methodology used was recommended by Maki et al., and colonization was considered as a semiquantitative culture with growth of more than 15 colony forming units, and bacterial identification was performed by the VITEK 2 system.

The catheters were grouped according to presence (group A) or absence (group B) of colonization and a dwell time shorter (group 1) and equal or greater (group 2) than 48 h. Groups A and B and 1–2 were compared according to the surgery classification, considering uncontaminated (clean and potentially contaminated) and contaminated (contaminated, dirty and infected); physical condition of patients, classified as ASA I–V, according to the American Society of Anesthesiologists (ASA), and duration of the surgical procedure.

Mann–Whitney nonparametric test was used for comparing quantitative variables between groups, and chi-square test for qualitative variables. The significance level used for these tests was 5%. Calculations were made using the software BioEstat 5.0.

Results

Seventy-four patients were initially included in the study. After excluding eight patients, one by death, two by accidental exit of catheter, and five by external end disconnection, 68 patients were effectively assessed. All patients were admitted to general surgery (23), urology (16), proctology (14), thoracic surgery (7), trauma (4), and gynecology (4) wards.

No patient had any sign of inflammation at the insertion site, epidural abscess, CNS infection or systemic infection.

Culture was positive in six catheters (8.8%) (group A) and negative in 62 (91.2%) (group B). There was no statistical significance in the comparison between the two groups. Prophylactic antibiotic was used in more than half the patients in both groups. More than one type of local anesthetic was used in some patients. The variables related to each group are shown in Table 1.

There was *Sphingomonas paucimobilis* isolation of one catheter, *S. aureus* of another, and *P. aeruginosa* of a third catheter. Three others had bacterial growth without predominance of some kind of colony, which led to no isolation of any bacteria.

The mean time of all catheters permanence was 43.45 h; in 37 patients, it was less than 48 h (group 1) and more than 48 h in 31 patients of group 2.

There was no statistically significant differences in the comparison of group 1 with group 2 and group A with group regarding the degree of surgery contamination, physical condition of patients (ASA I, II or III), and duration of surgical procedure (Table 2).

Discussion

Literature shows that conditions leading to immune impairment (diabetes mellitus, use of corticosteroids or other immunosuppressive therapies, malignancy, alcoholism, chronic renal failure), spinal cord injury (degenerative diseases, trauma injuries, surgery or instrumentation) and sources of infection (respiratory, urinary) are risk factors for epidural catheter colonization.[12,19–24]

In surgical site infection, studies show that blood glucose levels are important in case of diabetes. Levels over 200 mg dL^{-1} in early postoperative period are associated with increased surgical site infection.[25] Studies show

Table 1 Comparison of colonized (group A) and not colonized (group B) catheters according to patient characteristics.

	Group A ($n = 6$) n (%)	Group B ($n = 62$) n (%)	p
Sex			
Male	1 (16.7%)	29 (46.8%)	0.2177
Female	5 (83.3%)	33 (53.2%)	
Skin color			
Black	1 (16.7%)	6 (9.6%)	0.4927
White	4 (66.6%)	45 (72.7%)	1.0000
Brown	1 (16.7%)	11(17.7%)	1.0000
Mean age (years) ± SD	53.64 ± 16.44	48.00 ± 19.15	0.4311
ASA			
ASA I (23)	2 (33.3%)	21 (33.9%)	0.8294
ASA II (38)	3 (50%)	35 (56.4%)	
ASA III (7)	1 (16.7%)	6 (9.7%)	
Associated comorbidities			
Hypertenion	2 (33.3%)	26 (41.9%)	1.0000
Diabetes	0	7 (11.3%)	0.8685
IRC	0	2 (3.2%)	0.1510
Smoking	3 (50%)	19 (30.6%)	1.0000
Alcohol drinking	1 (16.7%)	5 (8.06%)	0.4383
Neoplasia	3 (50%)	30 (48.4%)	1.0000
Corticoterapy	1 (16.7%)	1(1.6%)	0.1699
Catheter insertion level			
Toracic ($n = 31$; 45.6%)	2 (33.3%)	29 (46.8%)	0.6809
Lumbar ($n = 37$; 54.4%)	4 (66.7%)	33 (53.2%)	
Antimicrobials			
No (4/5.9%)	1 (16.7%)	3 (4.8%)	0.3150
Yes (64/94.1%)	5 (83.3%)	59 (95.2%)	
Antimicrobials agents			
Only cephalosporin	3 (50%)	37 (59.7%)	0.6844
Cephalosporin and metronidazol	1 (16.7%)	18 (29.0%)	1.0000
Mean time for catheter dwelling (hours) ± DP	51.10 ± 12.11	42.71 ± 19.76	0.0894
Local anesthetic used for analgesia			
Ropivacaine	6 (100%)	56 (90.3%)	1.0000
Lidocaine	0	3 (4.83%)	1.0000
Bupivacaine	0	4 (6.45%)	1.0000
Surgery duration			
<1 h	0	2 (3.22%)	1.0000
1–3	3 (50%)	16 (25.8%)	0.3380
>3 h	3 (50%)	44 (71%)	0.3635

ASA, American Society of Anaesthesiologists; CRF, chronic renal failure; SD, standard deviation.
The use of other antimicrobial was not considered in the comparison.

that diabetes is the most important risk factor for the occurrence of epidural abscesses.[12] Patients under corticosteroids or other immunosuppressive drugs may be more likely to develop surgical site infection[25–27] and epidural abscesses.[28]

Only patients classified as ASA I–III were enrolled in the study. There was no statistical significance between them regarding colonization. Regarding surgical site infection, patients classified as ASA I and II have zero risk, while patients ASA III, IV, and V have favorable scores to develop surgical site infection.[25–27]

The proximity of the anal region with the caudal epidural catheter insertion may facilitate infection. Thus, caudal epidural analgesia is currently used less than lumbar due to the high risk of contamination by enterobacteria.[1] In our study there was no statistical significance regarding the level of insertion of epidural, lumbar or thoracic catheter. However, it is also known that patients undergoing thoracic or

Table 2 Comparison of epidural catheter colonization and dwelling time regarding surgical procedure degree of contamination, physical status, and surgical time.

	Group 1 ($n=37$)			Group 2 ($n=31$)		
	Group A ($n=1$) *n* (%)	Group B ($n=36$) *n* (%)	*p*	Group A ($n=5$) *n* (%)	Group B ($n=26$) *n* (%)	*p*
Surgical procedure degree of contamination						
Uncontaminated (clean and potentially contaminated)	1 (100%)	26 (72.2%)	1.0000	1 (20%)	17 (65.4%)	0.1337
Contaminated (contaminated and infected)	0	10 (27.8%)		4 (80%)	9 (34.6%)	
ASA						
I	1 (100%)	12(33.3%)	0.3514	1 (20%)	9 (34.6%)	1.0000
II	0	20 (55.6%)	0.4595	3 (60%)	15 (57.7%)	1.0000
III	0	4 (11.1%)	1.0000	1 (20%)	2 (7.7%)	0.4216
Surgical time						
<1 h	0	1(2.8%)	1.0000	0	0	1.0000
1–3 h	1	12 (33.3%)	0.3514	2 (40%)	7 (26.9%)	0.6125
>3 h	0	23 (63.9%)	0.3784	3 (60%)	19 (73.1%)	0.6125

ASA, American Society of Anaesthesiologists.

upper abdominal surgeries remain bedridden more time and have a higher growth of skin commensals, which could facilitate colonization.[2,19,29]

In our study, a high percentage of patients (94.1%) received a dose of antimicrobial during induction of anesthesia, and it is difficult to demonstrate whether it provided a protective effect. It is known in literature that the use of antimicrobials up to 1 h before surgery or during anesthesia minimizes the incidence of infection at the surgical site.[25,30–33] Studies with surgical patients and epidural analgesia for 2–3 days show that catheter colonization is not associated with invasive infection and is not prevented by the antimicrobial prophylaxis of surgery.[34] However, Aldrete et al.[35] reported that when using prophylactic antibiotics for prolonged use of catheters, the rate of infection decreases. Although there were positive catheter tips, there were no cases of infection, demonstrating that the routine culture of catheters may not be indicated. In our study, the use of antimicrobials may have contributed to the low incidence of catheter colonization, but it was not statistically proven.

Most studies recommend a limited number of days for epidural analgesia.[7,21,31] The epidural catheter dwell time is considered a risk factor for infection in some studies,[28] but not in others.[34] Catheterizations lasting two days or less have a low incidence of epidural infection, but longer durations are associated with higher incidence.[21] There is a considerable risk for catheterization with more than 7 days.[11] Scott et al.[36] and Bevacqua et al.[37] also found no association between this dwelling time and local infection. It is estimated that 1 in 35 cancer patients and prolonged epidural analgesia will have deep epidural infection and that 1 in 500 will die from related causes.[11]

Anesthetics such as lidocaine and bupivacaine have bactericidal activity due to the solution acidity, particularly at high concentrations;[19,28,35,38] thus, it may be able to inhibit bacterial growth. This may explain the low occurrence of epidural catheter colonization, as almost all of them received these drugs.

The incidence of epidural catheter colonization found in this study is in agreement with findings by other authors.[7,19,22,23,37] *S. aureus* and Gram-negative bacilli isolated in catheters are the most cited in the literatura.[1,2,6,7,19] The finding of *P. aeruginosa* emphasizes the possibility of nosocomial microorganisms contaminate the catheter and reach the spinal space.[7]

There are no comparisons between infected and uninfected catheters and even between colonized and not colonized catheters, as in the present study, regarding catheter dwelling time, type and duration of surgery, and physical status of patients in the literature. However, this knowledge is important to assess the degree of risk to which each patient will be submitted when a catheter is used. Although in our study none of these factors was found to be predictive of colonization, the number of cases evaluated was small, which led to a low statistical test power to detect existing risk factors among these variables.

For the same reason, this study was not intended to assess the safety of postoperative epidural analgesia in surgical patients with regard to spinal space infection, as it is a rare occurrence. There are less than 0.01% of patients when the technique is used for short-term surgical and obstetrical procedures.[7] The integrity of patient's immunity, the rich vascularization of the epidural space, insertion site poor microbiota, and

concomitant use of antimicrobials may contribute to the low incidence.[39]

Our study has some limitations. Epidural analgesia had a short duration, with a mean of 43 h. Although the short duration may speak against colonization, the use of prophylactic antibiotics, the small number of cases, and the clinical factors of the study patients may have influenced the culture results.

Despite uncertainties about the relationship between contamination and clinical infection, all efforts should be directed to minimize the potential risk of infection, as the impact of a possible infection caused by epidural catheter could result in irreversible consequences for the patient, such as permanent neurological deficits.

The use of postoperative epidural analgesia in surgical ward patients, under strict aseptic and antiseptic care proved to be a procedure with low risk of bacterial colonization.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Dawson SJ. Epidural catheter infections. J Hosp Infect. 2001;47:3–8.
2. Mishra S, Ishira S, Bhatnagar S, et al. Clinical implication of routine bacterial culture from epidural catheter tips in postoperative cancer patients: a prospective study. Anaesthesia. 2006;61:878–82.
3. Yeager MP, Glass DD, Neff RK, et al. Epidural anesthesia and analgesia in high-risk surgical patients. Anesthesiology. 1987;66:729–36.
4. Buggy DJ, Smith G. Epidural anaesthesia and analgesia: better outcome after major surgery? Br Med J. 1999;319:530–1.
5. Kost-byerly S, Tobin JR, Greenberg RS, et al. Bacterial colonization and infection rate of continuous epidural catheters in children. Anesth Analg. 1998;86:712–6.
6. Holt HM, Andersen SS, Andersen O, et al. Infections following epidural catheterization. J Hosp Infect. 1995;30:253–60.
7. Darchy B, Forceville X, Bavoux E, et al. Clinical and bacteriologic survey of epidural analgesia in patients in the intensive care unit. Anesthesiology. 1996;85:988–98.
8. Strafford MA, Wilder RT, Berde CR. The risk of infection from epidural analgesia in children: a review of 1620 cases. Anesth Analg. 1995;80:234–8.
9. Burstal R, Wegner F, Hayes C, et al. Epidural analgesia: prospective audit of 1062 patients. Anaesth Intensive Care. 1998;26:165–72.
10. Brooks K, Pasero C, Hubbard L, et al. The risk of infection associated with epidural analgesia. Infect Control Hosp Epidemiol. 1995;16:725–6.
11. Ruppen W, Derry S, Mcquay HJ, et al. Infection rates associated with epidural indwelling catheters for seven days or longer: systematic review and meta-analysis. BMC Palliat Care. 2007;6:1–8.
12. Grewal S, Hocking G, Wildsmith JAW. Epidural abscesses. Br J Anaesth. 2006;96:292–302.
13. Maki DG, Weise CE, Sarafin HW. A semiquantitative culture method for identifying intravenous-catheter-related infection. N Engl J Med. 1977;296:1305–9.
14. Baker AS, OJemann RG, Swartz MN, et al. Spinal epidural abscess. N Engl J Med. 1975;293:463–8.
15. Khanna RK, Malik GM, Rock JP, et al. Spinal epidural abscess: evaluation of factors influencing outcome. Neurosurgery. 1996;39:958–64.
16. Maslen DR, Jones SR, Crislip MA, et al. Spinal epidural abscess. Optimizing patient care. Arch Intern Med. 1993;153:1713–21.
17. McGee-Collett M, Johnston IH. Spinal epidural abscess: presentation and treatment. A report of 21 cases. Med J Aust. 1991;155:14–7.
18. McLaurin RL. Spinal suppuration. Clin Neurosurg. 1966;14:314–36.
19. Simpson RS, Macyntire PE, Shaw D, et al. Epidural catheter tip cultures: results of a 4-year audit and implications for clinical practice. Reg Anesth Pain Med. 2000;25:360–7.
20. Birnbach DJ, Meadows W, Stein DJ, et al. Comparison of povidone iodine and duraprep, an iodophor-in-isopropyl alcohol solution, for skin disinfection prior to epidural catheter insertion in parturients. Anesthesiology. 2003;98:164–9.
21. Morin AM, Kerwat KM, Klotz M, et al. Risk factors for bacterial catheter colonization in regional anaesthesia. BMC Anesthesiol. 2005;5:1–9.
22. Steffen P, Seeling W, Essig A, et al. Bacterial contamination of epidural catheters: microbiological examination of 502 epidural catheters used for postoperative analgesia. J Clin Anesth. 2004;16:92–7.
23. Darouiche RO, Hamill RJ, Greenberg SB, et al. Bacterial spinal epidural abscess. Review of 43 cases and literature survey. Medicine (Baltimore). 1992;71:369–85.
24. Reihsaus E, Waldbaur H, Seeling W. Spinal epidural abscess: a meta-analysis of 915 patients. Neurosurg Rev. 2000;23:175–204.
25. Mangram AJ, Horan TC, Pearson ML, et al. Guideline for prevention of surgical site infection, 1999. Am J Infect Control. 1999;27:97–134.
26. Giacometti A, Cirioni O, Schimizzi AM, et al. Epidemiology and microbiology of surgical wound infections. J Clin Microbial. 2000;38:918–22.
27. Weigelt JA, Lipsky BA, Tabak YP, et al. Surgical site infections causative pathogens and associated outcomes. Am J Infect Control. 2010;38:112–20.
28. Du Pen SL, Peterson DG, Williams A, et al. Infection during chronic epidural catheterization: diagnosis and treatment. Anesthesiology. 1990;73:905–9.
29. Mcneely JK, Trentadue NC, Rusy LM, et al. Culture of bacteria from lumbar and caudal epidural catheters used for postoperative analgesia in children. Reg Anaesth. 1997;22:428–31.
30. Kasuda H, Fukuda H, Togashi H, et al. Skin disinfection before epidural catheterization: comparative study of povidone-iodine versus chlorhexidine ethanol. Dermatology. 2002;204:42–6.
31. Sethna NF, Clendenin D, Umeshkumar A, et al. Incidence of Epidural Catheter-associated Infections after continuous epidural analgesia in children. Anesthesiology. 2010;113:324–32.
32. Raedler C, Lass-florl C, Puhringer F, et al. Bacterial contamination of needles used for espinal and epidural anaesthesia. Br J Anaesth. 1999;83:657–8.
33. Dipiro JT, Cheung RPF, Bowden TA, et al. Single Dose systemic antibiotic prophylaxis of surgical wound infections. Surg Pharmacol Am J Surg. 1986;152:552–9.
34. Kostopanagiotou G, Kyroudi S, Panidis D, et al. Epidural catheter colonization is not associated with infection. Surg Infect. 2002;3:359–65.
35. Aldrete JA, Williams SK. Infections from extended epidural catheterization in ambulatory patients. Reg Anesth Pain Med. 1998;23:491–5.

36. Scott DA, Beilby DSN, McClymont C. Postoperative analgesia using epidural infusions of fentanyl with bupivacaine. A prospective analysis of 1,014 patients. Anesthesiology. 1995;83:727–37.
37. Bevacqua BK, Slucky AV, Cleary WF. Is postoperative intrathecal catheter use associated with central nervous system infection? Anesthesiology. 1994;80:1234–40.
38. Feldman JM, Chapin-Robertson K, Turner J. Do agents for epidural analgesia have antimicrobial properties? Reg Anaesth. 1994;19:43–7.
39. Yentur AE, Luleci N, Topcu I, et al. Is skin disinfection with 10% povidone iodine sufficient to prevent epidural needle and catheter contamination? Reg Anesth Pain Med. 2003;28:389–93.