ORIGINAL ARTICLE

UDC: 617-089.5
DOI: 10.2298/VSP1310953S

Combined spinal-epidural technique: single-space *vs* double distant space technique

Kombinovana spinalno-epiduralna tehnika: izvođenje u jednom prostoru i u dva udaljena prostora

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Abstract

Background/Aim. Several combined spinal-epidural (CSE) anesthesia techniques have been described. This study was designed to compare the single space ("needle-through-needle") technique (SST) and the double distant space technique (DDS) with regards to the time needed for the procedure, patient discomfort during the procedure and patient's preference technique. **Methods.** This prospective, randomized single-blind study included 156 patients undergoing colorectal surgery under general anesthesia and CSE. All neuraxial blocks were performed before general anesthesia induction. DDS group of patients had thoracic epidural catheter placed at T6–7 or T7–8, followed by subarachnoid injection at the L2–3 interspace. The SST group of patients had a single injection using the needle-through-needle technique (Espocan® needle) at L2–3. The epidural catheter was used for postoperative analgesia for 72 hours. Body habitus, spinal anatomy and spinal landmarks were assessed preoperatively. The number of epidural and spinal punctures, the feeling that the dura is perforated (dural perforation click) and the time needed to perform CSE were also recorded. Complications during epidural catheter placement and perioperative and postoperative epidural catheter function and patient preference for the anesthetic procedure were recorded. **Results.** Epidural and subarachnoid spaces were successfully identified in all the patients. Duration of CSE procedure, the number of spinal punctures, dural click feeling and the effects of test dose did not differ between the groups. The patients in both groups (90% of DDS and 87% of SST) would choose CSE as preferred method in the future. The CSE procedure was painful for 16% of DDS *vs* 20% of SST patients. A significant correlation between time needed for CSE technique performance and body habitus ($r = 0.338$, $p < 0.01$), spinal landmarks ($r = 0.452$, $p < 0.001$) and anatomy ($r = 0.265$, $p < 0.05$) was found in the SST group. There was no correlation between the number of epidural/spinal punctures and epidural bacteriological findings. There was no correlation between the patients' choice of the CSE technique and the number of spinal punctures, duration of CSE procedure and epidural catheter stay. **Conclusion.** The two CSE techniques did not differ with regards to the procedure time and patient's preference. Procedure time correlated with body habitus, spinal landmarks and the anatomy in the SST group.

Key words:
anesthesia, epidural; anesthesia, spinal; colorectal surgery; anesthesia, general.

Apstrakt

Uvod/Cilj. Opisano je više tehnika izvođenja kombinovane spinalno-epiduralne anestezije (KSE). Ova studija je sprovedena sa ciljem da se uporede tehnike u jednom prostoru „igla-kroz-iglu" (SST) i tehnika dva udaljena prostora (DDS) u smislu dužine trajanja procedure, bolnosti i izbora tehnike od strane bolesnika. **Metode.** Ova prospektivna, randomizovana, jednostruko slepa studija obuhvatila je 156 bolesnika koji su planirani za kolorektalnu hirurgiju. Svi neuroaksijalni blokovi su izvođeni pre uvoda u anesteziju. Ukoliko je izvođena DDS tehnika, prvo je postavljan epiduralni kateter (T6–7 ili T7–8), a nakon toga izvedena subarahnoidna punkcija na nivou L2–3 (spinalna igla 25G). SST je izvođena upotrebom Espocan® igle specijalno konstruisane za izvođenje KSE u nivou L2–3. Nakon identifikacije epiduralnog prostora, vršena je subarahnoidana punkcija. Epiduralni kateter korišćen je za terapiju postoperativnog bola u periodu od 72 časa. Preoperativno, ispitana je telesna građa bolesnika, spinalna anatomija i spinalni anatomski znaci. Beleženi su broj spinalnih i epiduralnih punkcija, postojanje osećaja probijanja dure i vreme neophodno za izvođenje KSE, pojava parestezija kao i problemi tumačenja epiduralne test doze. Beležene su komplikacije u toku postavljanja epiduralnog katetera, perio-

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perativno i postoperativno funkcionisanje epiduralnog katetera i mišljenje bolesnika da li bi prihvatio korišćenje iste tehnike za sledeći hirurški zahvat. **Rezultati.** Epiduralni i subarahnoidni prostori su uspešno indentifikovani kod svih bolesnika. Nije bilo razlika između grupa u pogledu dužine trajanja KSE procedure, broja spinalnih punkcija, osećaja probijanja dure i tumačenja test doze. KSE tehnika bi bila procedura izbora za terapiju bola u obe grupe (DDS 90.4%, SST 87%). Izvođenje KSE tehnike bilo je bolno kod 16% DDS i 20% SST bolesnika. U SST grupi ustanovljena je značajna korelacija u vremenu neophodnom za izvođenje KSE, telesnoj građi ($r = 0.338$, $p < 0.01$), spinalnim znacima ($r = 0.452$, $p < 0.001$) i anatomiji ($r = 0.265$, $p < 0.05$). Nije nađena korelacija između broja epiduralnih/spinalnih punkcija i pozitivnih bakterioloških kultura. Nije nađena korelacija između odluke za ponovni izbor tehnike i broja spinalnih punkcija, trajanja izvođenja KSE i dužine stajanja epiduralnog katetera. **Zaključak.** Nije nađena razlika u dužini trajanja između dve tehnike izvođenja KSE. U tehnici izvođenja KSE u jednom interspinalnom prostoru, dužina izvođenja procedure KSE bila je u korelaciji sa telesnom građom, spinalnim znacima i spinalnom anatomijom.

Ključne reči:
anestezija, epiduralna; anestezija, spinalna; hirurgija, kolorektalna, procedure; anestezija, opšta.

Introduction

Combined spinal-epidural-general anesthesia (CSE-GA) offers several advantages over general anesthesia alone [1]. Several CSE techniques are described [2], and several technical improvements have been proposed as attempts to improve the technique, and reduce the incidence of complications. According to previous studies, the separate needle technique is superior compared to the "needle-through-needle" techniques with regards to complications and effectiveness [2].

Single space "needle-through-needle" technique (SST) is performed using a modified Touhy needle that has a back eye, *ie* a hole at the Touhy needle bevel for spinal needle guidance. The lower number of skin punctures with the SST technique may decrease pain during the procedure, and may also reduce the risk of infection at the puncture site, especially skin-borne infections and hematomas [3].

Since special CSE kits became commercially available, the single space CSE technique has been the preferred technique, whereas the double space technique is rarely used, because it requires puncture at two different interspaces (one space for epidural catheter placement and a lower space for subarachnoid puncture). In this study we used the technique described in earlier publications, which includes epidural puncture for epidural catheter placement in the thoracic region, combined with spinal puncture and a single subarachnoid injection at a lumbar level (double distant space – DDS) [4, 5].

The aim of a study was to compare the single space "needle-through-needle" technique (SST) with the double distant space technique (DDS). Our hypothesis was that the SST could offer shorter procedural time, less patient discomfort and better patient satisfaction as compared to the DDS. The time needed to perform the CSE procedure was the primary study outcome. Patient discomfort during the procedure and patient preference for the CSE as the technique of choice for postoperative pain management were designated as secondary outcomes.

Methods

This prospective, randomized, single blinded clinical trial was approved by the University Expert Council for Medical Science, and written informed consent was obtained from all patients before they entered the study. In total, 160 the American Society of Anesthesiology (ASA) physical status 1–3 adult patients requiring rectal surgery for malignancy were recruited. Inclusion criteria were scheduled surgery for resection of rectal carcinoma, absence of metastatic disease, and the need for intraoperative and postoperative epidural analgesia. Exclusion criteria were: patient refusal to participate, significant cardiac, pulmonary, hepatic or renal comorbidity, preoperative opioid or non- steroidal antiinflammatory drugs (NSAID) use, drug addiction, psychiatric disorders, spinal problems, neurological problems, allergy to medications used in the study, and any contraindication to neuraxial anesthesia. Preoperative preparation included patient education, in order to explain the goals of the study, and familiarize patients with the anesthesia technique. A computer-generated randomization schedule was provided to two independent investigators who preformed all blocks: the investigator one performed all DDS procedures, while the investigator two performed all SST procedures. The patients were blinded to the group assignment.

All the patients received pre-medication with midazolam 2.5 mg *iv*, fluid preload with Hartman's solution 1 L, and antibiotic prophylaxis with ceftriaxone 2 g and metronidazole 500 mg. All neuraxial blocks were performed in the operating room with the patients awake, in the right lateral decubitus position. Strict aseptic technique was maintained during all procedures. In the DDS technique (Figure 1), an epidural catheter was inserted at the T6–7 or T7–8 interspace *via* a paramedian approach [Perifix (18G Tuohy needle and 20G standard epidural catheter); B. Braun, Melsungen AG, Germany]. Lidocaine 2% combined with epinephrine 1 : 200,000, 3 mL total, were administered *via* the epidural catheter as test dose. In addition, all the patients received a subarachnoid injection of morphine 200 μg, fentanyl 25 μg and bupivacaine 2 mg (0.8 mL of 0.25% solution) at the L2–3 interspace *via* a 25 G spinal needle [Pencan (B. Braun, Melsungen AG, Germany)].

The SST was performed at the L2–3 interspace using an Espocan® needle (B. Braun Medical Inc., Bethlehem, PA, 18 Ga-Espocan Tuohy needle, Perifix epidural catheter 0.85 × 0.45 mm, length 100 mm, 27–Ga Pancan Pencil Point spinal needle) (Figure 2). After epidural space identification, the spinal needle was advanced, and medications (morphine

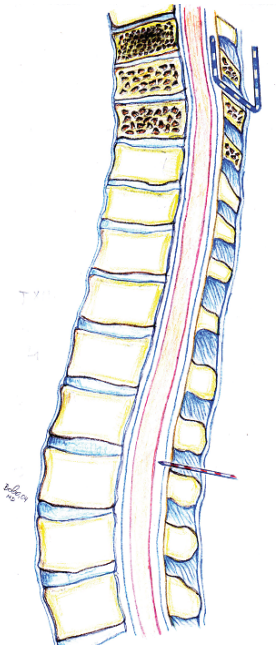

Fig. 1 – Double distant space combined spinal-epidural technique.

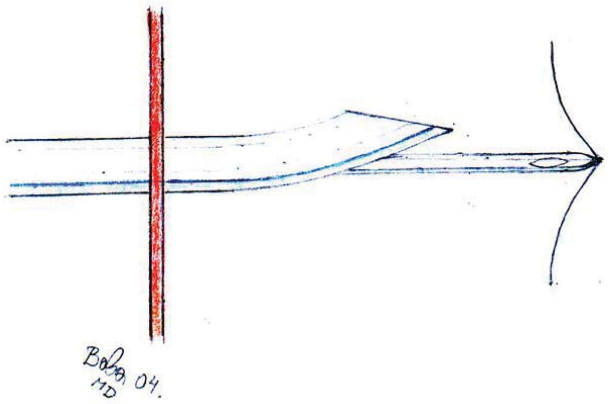

Fig. 2 – Single space technique using the needle-through-needle technique.

200 μg, fentanyl 25 μg and bupivacaine 2 mg (0.8 mL of 0.25% solution) were injected in the subarachnoid space. After the subarachnoid injection was completed, the spinal needle was withdrawn, and the epidural catheter was advanced. Lidocaine 2% with epinephrine 1 : 200,000 3 mL total was given *via* the epidural catheter as test dose to confirm appropriate catheter placement. After the subarachnoid injection, bupivacaine 0.25% 10 mL was administered through the epidural catheter, and sensory blockade level was measured by pinprick at the midclavicular line approximately 20 minutes later. At a minimum, sensory blockade from T6 to L1 was required before inducing general anesthesia. The epidural catheter was used for postoperative pain treatment for 72 hours.

Preoperatively, the patients' body habitus was assessed and classified as: 1 – normal, 2 – slim, 3 – muscular, 4 – obese. Spinal landmarks were classified as: 1 – good (processus spinosus easy to find), 2 – bad (it is difficult to palpate processus spinosus), 3 – extremely bad (impossible to identify processus spinossus). Spinal anatomy was recorded as 1 – normal, 2 – deformity exists. We also recorded the number of epidural and spinal punctures, dura perforation click feeling, time needed for CSE procedure, paresthesias and problems with epidural test dose interpretation. The time needed for the CSE procedure was defined as the time from skin preparation until succesful epidural catheter placement.

Complications during epidural catheter placement were recorded as:1 – none, 2 – dural puncture (cerebrospinal fluid appearance in the hub of needle), 3 – blood vessel puncture (blood appearance in the hub of needle), 4 – epidural catheter placed in the subdural space, 5 – epidural catheter placed in the subarachnoid space, 6 – epidural catheter placed in epidural vein,7 – paresthesias, 8 – impossible epidural catheter placement, 9 – other complications.

Perioperative and postoperative epidural catheter function was recorded as: 1-no problems, 2 – difficult flow, 3 – epidural catheter kinking, 4 – epidural catheter fell out. Time of epidural catheter removal was recorded and reasons for epidural catheter removal were recorded as: 1 – finished treatment, 2 – long duration of therapy, 3 – epidural catheter fell out, 4 – complications, 5 – other reasons.

The patients were assessed daily and complications related to neuraxial anesthesia were recorded as follows: 1 – postdural puncture headache, 2 – catheter migration, 3 – neurologic complications, 4 – epidural hematoma, 5 – infection at skin puncture site, 6 – fistula, 7 – meningitis, 8 – epidural abscess, 9 – other complications. Following catheter removal, all epidural catheter tips were assessed for the presence of bacteria.

Patient's satisfaction regarding the anesthetic procedure was recorded seven days after the surgery using a two-point scale: 1 – good, if necessary I would choose this technique again, or 2 – bad, if necessary I would prefer a different technique [6].

To ensure that sample size for the study is adequate, power analysis was conducted before the study started, using the sample size calculation described in the Norman and Streiner Statistics Book [7], based on the following assumptions [6]: we wanted to detect a 5-minute difference in procedure times between the two groups, with a significance level (alpha) of 0.05 (two-tailed) and power 80%, when the Standard Deviation of observed procedure times is 10 minutes. Sample size calculation based on these assumptions showed that the study would need 64 patients per group, but we decided to increase the number of patients to 80 per group, in order to allow for possible patient attrition or missing data.

Depending on data distribution, data are presented as mean (± standard deviation) or median (range). Parametric and non-parametric statistical tests were applied as appropriate. Data were analyzed using *t*-test or χ^2 test as appropriate. Nominal data were analyzed using χ^2. Correlation was assessed with Spearman's rho. The *p* values of the < 0.05 were considered significant for all tests. Data analysis was performed using the SPSS statistical software package, version 12.0 (SPSS Inc., Chicago, Illinois, USA).

Results

A total of 156 patients were enrolled in the study. Patient characteristics did not differ significantly between the groups, except for body habitus: more patients in the SST group had normal body habitus (Table 1).

Complications during epidural catheter placement were sporadic, and included dural puncture, blood vessel puncture, paresthesia and dural puncture (SST *vs* DDT, $p > 0.05$; Table 4). The epidural catheter functioned well, without problems, in 95% of the patients in each group, and in most cases it was removed after 72 hours, at the completion of the study (Table 4). Overall, the epidural catheter stayed longer than 72 hours in the DDS group, but this was a random, not a planned event, and was not associated with any complication, but correlated with more frequent positive bacteriological cultures ($r = 0.285$; $p < 0.05$) (Table 4). Three months after the procedure, three patients in each group reported lumbar pain (Table 4).

Table 1

Patient characteristics

Patient characteristics	Double space (n = 78)	Single space (n=78)	*p*
Age (years), $\bar{x} \pm SD$	58.55 ± 10.02	61.21 ± 10.03	ns
Weight (kg) , $\bar{x} \pm SD$	69.01 ± 14.20	72.49 ± 14.00	ns
Height (cm) , $\bar{x} \pm SD$	170.15 ± 8.91	171.95 ± 11.38	ns
ASA 1/2/3 (n)	15/54/9	15/54/9	ns
Body habitus, n (%)			
normal	21 (27)	37 (47)	
slim	24 (31)	10 (13)	
muscular	12 (15)	4 (5)	$p < 0.001$
obese	21 (27)	27 (35)	
Spinal signs, n (%)			
good	60 (77)	56 (72)	ns
bad	17 (22)	20 (26)	
extremly bad	1 (1)	2 (2)	
Spinal anatomy, n (%)			
normal	57 (73)	57 (73)	ns
deformity	21 (27)	21 (27)	

ASA – American Society of Anesthesiologists Physical Status Classification (1 – normal healthy patient; 2 – patient with mild systemic disease; 3 – patient with severe systemic disease);
ns – no statistically significant difference.

The epidural and subarachnoid spaces were successfully identified in all the patients. There were no differences between the groups with regards to the duration of the CSE procedure, the number of spinal punctures, dural click feeling and test dose interpretation (Table 2).

The majority of patients clearly understood the explanation regarding the CSE technique, and most of them in both groups stated that the CSE technique would be the preferred procedure for pain management, if they ever need surgery again in the future (Table 3). The CSE technique was uncomfortable for 16% and 20% of the patients when DDS technique and SST technique were used, respectively (Table 3).

In the SST group, a significant correlation was observed between the number of epidural punctures and body habitus ($r = 0.431$, $p < 0.001$), spinal landmarks ($r = 0.431$, $p < 0.001$) and the anatomy ($r = 0.310$, $p < 0.01$). Similarly, there was a significant correlation between the number of spinal punctures and body habitus ($r = 0.243$, $p < 0.05$) and spinal

Table 2

Technical problems related to the combined spinal-epidural anesthesia techniques

Parameters	Double space (n=78)	Single space (n=78)	*p*
Number of epidural punctures, (%)	2.5(1.7)	1.7(1.2)	< 0.01
Number of spinal punctures, (%)	1.2(0.6)	1.1(0.5)	ns
CSE procedure duration (min), $\bar{x} \pm SD$	15.03±6.64	13.14±5.80	< 0.001
Dural click, n (%)	72(92)	64(82)	< 0.001
Difficulties in test dose, n (%)	1(1.3)	3(3.8)	ns

CSE – combined spinal epidural technique; ns –no statistically significant difference.

Table 3

Patients opinion on combined spinal-epidural techniques

Patients opinion	Double space (n = 78)	Single space (n = 78)	*p*
Explanation of CSE technique was clear, n (%)	37 (86)	30 (83)	ns
CSE technique was painfull, n (%)	12 (16)	15 (20)	ns
CSE technique will be procedure of choice for pain management, n (%)	66 (90.4)	64 (87)	ns

ns – no statistically significant difference; CSE – combined spinal-epidural.

Table 4

Epidural catheter complications

Parameters	Double space (n = 78)	Single space (n = 78)	*p*
Epidural catheter placement complications, n (%)			
no complications	68 (87.2)	64 (82.1)	
dural puncture	7 (9)	7 (9)	
blood vessel puncture	2 (2.6)	4 (5.1)	ns
paresthesias	1 (1.3)	0	
dural puncture	0	2 (2.6)	
others	0	1 (1.3)	
Epidural catheter function, n (%)			
functional	74 (94.9)	74 (94.9)	
flow difficulties	3 (3.8)	0	ns
epidural catheter kinking	0	3 (3.8)	
epidural catheter accidenatly removed	1 (1.3)	1 (1.3)	
Epidural catheter removal, n (%)			
treatment completed	70 (89.7)	68 (87.2)	
epidural catheter accidental removal	8 (10.3)	6 (7.7)	ns
complications	0	3 (3.8)	
others	0	1 (1.3)	
Epidural catheter stay (days), n (%)	4.5 (1.29)	3.56 (0.93)	$p < 0.001$
Complications, n (%)			
present	1 (1.3)	2 (2.6)	
absent	77 (98.7)	76 (97.4)	ns
Positive bacteriological culture, n (%)	17/76 (22.4)	19/64 (29.7)	ns
Lumbar pain, n (%)			
preoperative	0	1 (1.3)	ns
3 months after CSE	3(3.8)	3 (3.9)	
6 months after CSE	1 (1.4)	0	

CSE – combined spinal-epidural; ns – no statistically significant difference.

landmarks ($r = 0.268$, $p < 0.05$). In addition, in the SST group there was a significant correlation between the time needed for the CSE procedure and body habitus ($r = 0.338$, $p < 0.01$), spinal landmarks ($r = 0.452$, $p < 0.001$) and anatomy ($r = 0.265$, $p < 0.05$). However, there was no significant correlation between CSE complications and body habitus, spinal signs or spinal anatomy in either group.

In the DDS group, a significant correlation was observed between paresthesias and spinal landmarks ($r = 0.418$, $p < 0.001$), but there was no correlation between the number of epidural punctures and paresthesias. In both groups the number of spinal punctures correlated with the appearance of parethesias (DDS: $r = 0.234$, $p < 0.05$; SST: $r = 0.235$, $p < 0.05$).

There was no correlation between epidural catheter stay and complications or a patient's choice of the CSE technique. In addition, there was no correlation between the number of epidural/spinal punctures and epidural bacteriological findings. Last, there was no correlation between patients' choice of the CSE technique and the number of spinal punctures, procedure time or duration of epidural catheter stay.

Discussion

The study was designed to evaluate the potential benefits of double space *vs* single space (needle-through-needle) CSE technique, and the time needed to perform the CSE procedure was the primary outcome. Both techniques were successful. In the SST group, body habitus, spinal landmarks and the anatomy influenced the number of epidural punctures. However, the time needed for the CSE procedure did not differ between the two techniques. In the SST group, body habitus, spinal signs and anatomy influenced the time needed for the CSE procedure.

The single space "needle-through-needle" technique is the most frequently used CSE technique [2]. After identification of the epidural space, the spinal needle is passed through the epidural needle and beyond its tip until it punctures the dura. Then, after the subarachnoid injection is completed, the epidural catheter is inserted. The CSE kit used in this study includes an epidural needle with a small hole in the greater curvature of the tip, the so called "back-eye", which provides a straight route for the spinal needle. In the SST group, body habitus, spinal landmarks and anatomy influenced the time needed to perform the CSE procedure. Compared to the DDS group, the time needed to perform the CSE procedure was shorter in the SST group, but the difference was not statistically significant. This observed difference can be explained by the need for only one site puncture, and the greater number of patients with normal body anatomy in this group. Similarly, an earlier study comparing three different techniques (CSE set with an interlocking device between the spinal and epidural needle *vs* CSE set with a "back eye" at the epidural needle curve *vs* a double-segment technique) found no difference in the time needed to perform the block [8]. Moreover, one study found greater success with the double space technique [9]. Time to "readiness for surgery" is not as important when CSE is used in combination with general anesthesia, but becomes very important when CSE is used as the sole anesthetic method for surgical anesthesia.

The higher number of epidural punctures observed with the DDS technique can be explained by technically more challenging thoracic approach. However, in the DDS group, the number of epidural punctures, the number of spinal punc-

tures and the mean time to perform DDS was not affected by body habitus, spinal landmarks or the anatomy. We opted for thoracic epidural catheter placement because the thoracic epidural space is the most appropriate space for placing an epidural catheter when the surgery involves a longitudinal abdominal incision. To our knowledge, this is the first study to directly compare the SST and DDT CSE techniques.

In both patient groups, complications were rare and independent on body habitus, spinal landmarks or the anatomy, and we did not observe any serious complications from use of the CSE technique. This finding is in accordance with the current literature which states that "severe complications of central neuraxial blocks are rare" [8, 10].

In agreement with previous studies [6, 11] paresthesias during epidural and spinal puncture were rare in our study, and there was no difference between the two CSE techniques. Based on literature data, the incidence of paresthesia is 0.9–11% [11].

Although we would expect that patients would prefer the SST method because it involves only one puncture site, this was not the case. The patients in both groups were asked what their choice would be, if they would undergo another surgical procedure in future, and their choice was independent of the number of spinal or epidural punctures, duration of CSE procedure or epidural catheter stay. In contrast, patients preferred the SST over the DDT in the Casati study [6].

Because back pain is a serious public health problem, we recorded the incidence of back pain in our patients. Six months after the procedure, only one patient in the DDS group had back pain, and this is in agreement with published data: Persistent back pain after spinal anesthesia in non-obstetric patients has been reported to be 0.8% three months after spinal puncture [12].

The epidural catheter stayed longer in DDS group, but this was a random, not a planned event, and was associated with higher incidence of positive bacteriological cultures (Table 4). We could not find any relevant literature regarding the incidence of epidural catheter colonization and infection after CSE technique in non-obstetric patients. Positive cultures have been reported in 28–28.8% of patients with epidural catheters [13, 14]. However, the significance of these positive cultures is questionable. Results of the study underwent by Simpson et al. [14] suggested that a significant proportion of epidural catheter tips may be culture positive, but this finding represents colonization of the skin at the puncture site with subsequent contamination of the catheter tip on catheter removal, rather than infection, as well as that in most cases routine culture of epidural catheter tips is clinically irrelevant. In our study there was no correlation between the number of epidural or spinal punctures and epidural tip positive bacteriological findings. This is in agreement with an earlier study on bacterial contamination of epidural needles with multiple (two or more) skin passes [15].

Conclusion

Our results suggest that there is no significant difference between the DDS and SST regarding the time needed to perform the CSE procedure. In the SST group, body habitus, spinal landmarks and the anatomy influenced the number of epidural punctures.

Acknowledgement

This study was supported solely by departmental funds. All the authors stated no conflicts of interest.

REFERENCES

1. *Eldor J.* Combined spinal-epidural-general anesthesia. Med Hypotheses 1995; 45(1): 86−90.
2. *Cook TM.* Combined spinal-epidural techniques. Anaesthesia 2000; 55(1): 42−64.
3. *Felsby S, Juelsgaard P.* Combined spinal and epidural anesthesia. Anesth Analg 1995; 80(4): 821−6.
4. *Scott NB, James K, Murphy M, Kehlet H.* Continuous thoracic epidural analgesia versus combined spinal/thoracic epidural analgesia on pain, pulmonary function and the metabolic response following colonic resection. Acta Anaesthesiol Scand 1996; 40(6): 691−6.
5. *Stamenkovic DM, Geric V, Slavkovic Z, Raskovic J, Djordjevic M.* Combined spinal-epidural analgesia vs. intermittent bolus epidural analgesia for pain relief after major abdominal surgery. A prospective, randomised, double-blind clinical trial. Int J Clin Pract 2008; 62(2): 255−62.
6. *Casati A, D'Ambrosio A, De NP, Fanelli G, Tagariello V, Tarantino F.* A clinical comparison between needle-through-needle and double-segment techniques for combined spinal and epidural anesthesia. Reg Anesth Pain Med 1998; 23(4): 390−4.
7. *Norman GR, Streiner DL.* Biostatistics: the bare essentials. 2nd ed. Hamilton: B.C. Decker; 2000.
8. *Puolakka R, Pitkanen MT, Rosenberg PH.* Comparison of technical and block characteristics of different combined spinal and epidural anesthesia techniques. Reg Anesth Pain Med 2001; 26(1): 17-23.
9. *Backe SK, Sheikh Z, Wilson R, Lyons GR.* Combined epidural/spinal anaesthesia: needle-through-needle or separate spaces? Eur J Anaesthesiol 2004; 21(11): 854−7.
10. *De TO, Caporuscio A, Tagariello V.* Neurological complications following central neuraxial blocks: are there predictive factors? Eur J Anaesthesiol 2002; 19(10): 705−16.
11. *Hoffmann VL, Vercauteren MP, Buczkowski PW, Vanspringel GL.* A new combined spinal-epidural apparatus: measurement of the distance to the epidural and subarachnoid spaces. Anaesthesia 1997; 52(3): 350−5.
12. *Schwabe K, Hopf HB.* Persistent back pain after spinal anaesthesia in the non-obstetric setting: incidence and predisposing factors. Br J Anaesth 2001; 86(4): 535−9.
13. *Kostopanagiotou G, Kyroudi S, Panidis D, Relia P, Danalatos A, Smyrniotis V,* et al. Epidural catheter colonization is not associated with infection. Surg Infect (Larchmt) 2002; 3(4): 359−65.
14. *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(4): 360−7.
15. *Orlikowski C, Majedi PM, Keil AD.* Bacterial contamination of epidural needles after multiple skin passes. Br J Anaesth 2002; 89(6): 922−4.

Received on February 5, 2012.
Accepted on March 14, 2012.