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Dural puncture epidural versus conventional epidural block for labor analgesia: a systematic review of randomized controlled trials

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ABSTRACT

Introduction: Dural puncture epidural (DPE) analgesia is a modification of conventional epidural analgesia that involves the intentional puncture of the dura with a spinal needle through the needle placed in the epidural space, without a medication being injected intrathecally. There have been contradictory findings regarding better analgesia and better block quality.

Methods: A systematic literature search was done to identify randomized controlled trials (RCT) comparing DPE with epidural analgesia. The risk of bias was assessed with the Cochrane tool. Risk ratio and 95% confidence intervals were calculated.

Results: Five RCTs including 581 patients were identified. One RCT on caesarean section was excluded. Single studies suggested slightly better analgesia by finding a median time to achieve sufficient analgesia of two minutes less in the DPE group, a higher number of women having a pain score <10/100 at 20 min, a reduction in the number of epidural top-ups and better sacral spread. The studies did not show a difference between DPE and epidural analgesia for catheter replacement or manipulation rates, the incidence of intravascular placement or unilateral block.

Conclusion: There is a lack of clear evidence on either the benefits or the risks of the DPE technique, such that a recommendation for or against its routine use is premature. Two of the three studies showing a beneficial effect of DPE came from the same institution and replication of the findings by other groups is warranted.

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Keywords: Epidural, dural puncture; Analgesia, labor; Randomized trial

Introduction

Dural puncture epidural (DPE) is a modification of the epidural technique that involves firstly the identification of the epidural space with a Tuohy needle, secondly the creation of a dural hole with a spinal needle inserted through the Tuohy needle, and thirdly the epidural insertion of a catheter. The dural hole allows the epidurally administered medication to pass into the subarachnoid space, which can result in a faster onset of analgesia¹ and better sacral spread.² The flow of cerebrospinal fluid through the spinal needle is an endpoint of dural puncture that is postulated to reflect not only correct positioning of the spinal needle, but also correct positioning of the Tuohy needle in the epidural space, thereby leading to a lower rate of poorly functioning or malfunctioning catheters. The rationale of the DPE

technique is that no medication is directly administered intrathecally, in contrast to the combined spinal-epidural (CSE) technique. This is postulated to reduce the side-effects associated with the latter technique.

So far, there have been contradictory results with data showing better block qualities after DPE compared to epidural analgesia² and another study not corroborating a significant difference between these two neuraxial techniques.³ To resolve this discrepancy, we performed a systematic literature search to identify all relevant randomized controlled trials in obstetric patients and we analyzed all available data.

Methods

We registered our systematic review with PROSPERO: (www.crd.york.ac.uk/PROSPERO/#index.php, registration number CRD 42017068621). The PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was applied.⁴ We

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systematically searched several databases (Medline, Epub, Embase.com (Embase plus Medline), Cochrane Central, Web of Science, and Google Scholar) in order to identify trials comparing DPE with the conventional epidural technique. Details of our search strategy are given in supplemental digital content 1.

The studies retrieved by our search were entered into the program EndNote (Clarivate Analytics), duplicate citations were removed, and then two authors (MH, MK) independently screened the search results for eligible trials. Moreover, we performed searches of the clinical trials registry, www.clinicaltrials.gov, and we hand-searched the bibliographies of the eligible articles.

We defined inclusion and exclusion criteria a priori. Studies with these characteristics, specified according

to the PICO acronym, were included. Patients: obstetric patients receiving neuraxial analgesia; Intervention: dural puncture epidural; Comparator: conventional epidural technique; Outcomes: Catheter replacement rate, catheter manipulation rate, unilateral block rate, intravascular catheter placement rate, other measures of quality of analgesia, accidental dural puncture, post-dural puncture headache (PDPH)/headaches.

Exclusion criteria were: patient age <18 years, non-randomized studies. Two investigators (MH, MK) independently extracted the data. The Cochrane Risk of Bias tool⁵ served to assess the risks of selection bias (random sequence generation, allocation concealment), performance bias (blinding of participant and personnel), detection bias (blinding of assessor) and attrition bias.

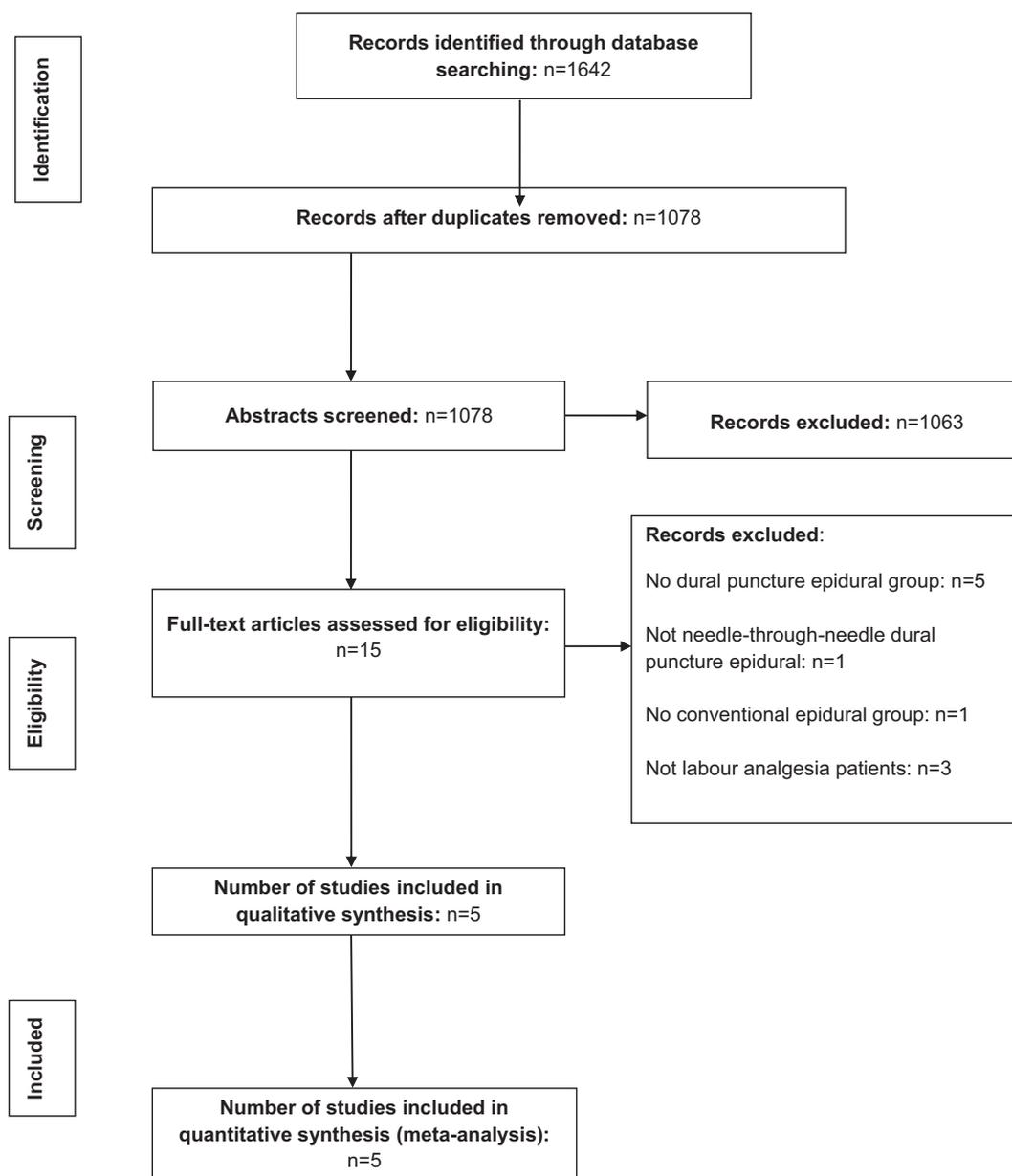


Fig. 1 Flow-chart of the selection of the included trials

Again, two researchers performed this analysis independently (MH, MK). According to our study protocol, disagreements between the two authors (MH, MK) should be resolved by a third author (RR).

We calculated risk ratios and 95% confidence intervals (95%CI). When the 95%CI spans 1 then the difference is statistically not significant.

Results

The systematic literature search identified 1642 hits of which finally five trials^{1-3,7,8} reporting on 581 obstetric patients were analyzed (Fig. 1). Suzuki et al.⁹ studied lower abdominal surgery and Beaubien and co-workers¹⁰ included patients undergoing major abdominal surgery who received a neuraxial technique in addition to general anaesthesia, so these two studies were excluded from further analysis. Another study⁶ that reported on cesarean section was also excluded. Fig. 2 gives the risk of bias assessment. Details of the studies are given in Table 1. Two studies came from the same group.^{2,7}

All studies reported failure of the dural puncture. The dura could not be punctured in 3/52 patients (5.8%) in the study by Wilson et al.;¹ in 1/40 patients (2.5%) in the study by Cappiello et al.;⁷ and 2/40 patients in the study by Chau et al. (5%),² all using 25- or 26-gauge (G) needles. The highest failure rates were 23.4% reported by Gupta et al.⁸ (15/64 patients) using a 25-G needle followed by Thomas et al.³ who had 14.2% of failures (18/127 patients) with a 27-G needle. The overall failure rate in these five studies was 12% (39/323).

Deviating from our initial intention, we did not perform meta-analytical calculations for a variety of reasons. One of them was the high and varying rates of failure to puncture the dura. Other reasons were the

heterogeneity in the needle size which we discuss in more detail in the discussion section. Moreover, the number of studies per outcome was quite low and for some outcomes the number of events was low.

The outcomes are given in Table 2. Catheter replacement and intravascular placement rates were assessed in four studies each but only two studies had events for each of these two outcomes; the differences were not statistically significant in any study. Catheter manipulation and unilateral block rates were reported in three studies, with no significant differences.

For epidural top-ups, one of five studies² reported a greater than 50% reduction in the DPE group, which was statistically significant.

Labor outcome as reflected by the incidence of spontaneous and instrumental vaginal delivery, as well as of cesarean section, did not differ between the two groups.

Headache/PDPH was assessed in five studies: the reported number of events was low (zero in three studies). Accidental dural puncture tap was reported by Gupta et al.⁸ with no significant difference between the arms (0/49 patients in the DPE and in 1/63 patients in the epidural group).

Hypotension, nausea, and pruritus were also evaluated. The 95%CIs were wide and no significant difference was observed. Fetal heart rate tracings were very low or absent in two studies but Chau et al.² observed a rate of more than 40% of fetal decelerations with no differences between the groups.

Analgesia was the primary outcome in the studies led by Chau et al.^{1,2,7} Chau et al.² did not observe a difference in the time to achieve a score $\leq 1/10$ on the verbal numeric pain rating scale (hazard ratio 1.4, 95%CI 0.83 to 2.4, $P=0.21$) with median times of 11 min in the dural puncture epidural group and 18 min in the conventional epidural group. Wilson et al.¹ did not find a difference in the number of patients having a visual analogue score $< 10/100$ at 10 min (55.3% in the DPE versus 44.7% in the epidural group, $P=0.256$). The median times to achieve sufficient analgesia were 8 min in the DPE and 10 min in the epidural group, with this difference being statistically significant ($P=0.042$). Cappiello et al.⁷ reported a significantly ($P=0.04$) higher percentage of women having a visual analogue score $< 10/100$ at 20 min in the DPE (85%) compared with the epidural group (65%). For their other primary outcome, the rate of patients having unilateral or bilateral sensory block of the S1 dermatome at 20 min after puncture, there was no statistically significant difference.⁷ However, the percentage of women having a S1 block at any time was significantly higher ($P=0.01$) in the DPE group (92%) compared with in the conventional epidural group (70%). No difference was found when analysing the block height at S2 ($P=0.24$).⁷ A higher likelihood for a bilateral S2 blockade at 10 min (risk ratio 2.13; 95%CI 1.39 to 3.28; $P < 0.001$), 20 min (risk ratio 1.60;

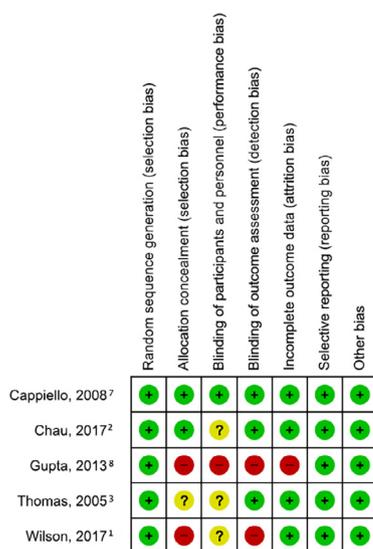


Fig. 2 Risk of bias-assessment

Table 1 Details of the included studies

Study	Number of patients		Type of intervention	Inclusion criteria	Exclusion criteria	DPE technique	EDA technique	Primary outcome	
	DPE	EDA							
Thomas, 2005 ³	107	123	Labor analgesia	Healthy laboring parturients with uncomplicated pregnancies and with cervical dilation <6 cm	n.d.	27-G Whitacre needle	Sitting position, L3-4 or L4-5, loss of resistance to air, 17-G Tuohy needle, 19-G closed-tip, multiport epidural catheter inserted 4–6 cm	Epidural catheter manipulation rate	27-G Whitacre needle, 5 mL plain lidocaine 2%, given 5 min later as an intravenous test dose. After initial negative subarachnoid and intravenous test doses, an additional 3 mL plain lidocaine 2% followed by PCEA with 0.11% bupivacaine, 2 µg/mL fentanyl (initiated at 10 mL/h, with a 5 mL demand dose, a 10-min lockout time and an hourly limit of 30 mL
Cappiello, 2008 ⁷	39	40	Labor analgesia	Nulliparous parturients with singleton, vertex presentation fetuses at 38–42 weeks' gestation and in active labor with cervical dilation <5 cm	Clinically significant diseases of pregnancy (i.e., preeclampsia, gestational diabetes), contraindications to neuraxial analgesia, conditions associated with an increased risk of a cesarean delivery (i.e., history of uterine anomaly or surgery; morbid obesity), and known fetal anomalies	25-G Whitacre needle	Sitting position, 17-G Tuohy needle, loss-of-resistance to air, 20-G multiport catheter inserted 5 cm	The presence of sacral dermatome (S1) block (either unilateral or bilateral) and an analgesia score of 10 within 20 min of initiation of epidural analgesia	25-G Whitacre needle, 12 mL of bupivacaine 2.5 mg/mL given over 5 min followed by the immediate initiation of PCEA: bupivacaine 1.25 mg/mL with fentanyl 0.2 µg/mL, background infusion at 6 mL/h, demand dose of 6 mL, lockout interval of 15 min and no hourly limits
Gupta, 2013 ⁸	49	63	Labor analgesia	ASA 1–3 patients requesting labor epidural analgesia	ASA 2–3 patients, patients with history of back surgery or central nervous system disease; and patients' who refused to have dural puncture	25-G Pencan needle	L2-3 or L3-4, 17-G Tuohy needle, loss-of-resistance to air, 19-G catheter inserted 5 cm	Initial 2 h after procedure: incidence of failure of epidural analgesia	25-G Pencan needle, loading epidural dose of 0.125% bupivacaine with 10 µg/mL fentanyl administered in two incremental doses of 5 mL each

Table 1 (continued)

Study	Number of patients		Type of intervention	Inclusion criteria	Exclusion criteria	DPE technique	EDA technique	Primary outcome	
	DPE	EDA							
Chau, 2017 ²	40	40	Labor analgesia	Healthy pregnant women with singleton, vertex presentation fetuses at 38 to 42 weeks' gestation in active labor with cervical dilatation <5 cm and desiring epidural labor analgesia	Diseases of pregnancy (eg, gestational hypertension, preeclampsia, or gestational diabetes), contraindications to neuraxial analgesia techniques, known fetal anomalies, or conditions associated with an increased risk of cesarean delivery (eg, vaginal birth after cesarean delivery, history of uterine rupture)	25-G Whitacre needle	Sitting position, L2-L3 or L3-L4, midline approach, 17-G epidural needle, loss-of-resistance to saline, 19-G single open end catheter, inserted 5 cm	Time to numerical pain score ≤ 1	25-G Whitacre needle 20 mL of 0.125% bupivacaine with fentanyl 2 $\mu\text{g}/\text{mL}$, given in 4 5 mL boluses over 5 min
Wilson, 2017 ¹	40	40	Labor analgesia	Parturients admitted to the labor and delivery unit planning to request neuraxial labor analgesia	Contraindication to neuraxial anesthesia, non-English speaking, body mass index $>50 \text{ kg}/\text{m}^2$, patient refusal and visual analogue pain score $<50 \text{ mm}$ during an active contraction at the time of request for neuraxial analgesia	26-G Whitacre needle	L3-L4 or L4-L5, 17-G Tuohy needle, 19-G catheter inserted 4-5 cm	Percentage of parturients with adequate analgesia 10 min after epidural bolus initiation defined as visual analogue pain score $\leq 10 \text{ mm}$ in the presence of contraction or a score $\leq 10 \text{ mm}$ in the absence of contraction provided that the score was still $\leq 10 \text{ mm}$ during the next contraction	26-G Whitacre needle, 12 mL bolus (0.125% bupivacaine with 50 μg fentanyl), in 4 mL boluses given every minute over 3 min

DPE: dural puncture epidural. EDA: epidural analgesia.

Table 2 Outcomes

Outcome	Studies	DPE group Events/participants	Epidural group Events/participants	RR, 95%CI
Catheter replacement rate	Wilson ¹	0/40	0/40	Not estimable
	Chau ²	0/40	0/40	Not estimable
	Thomas ³	10/107	10/123	1.15, 0.50 to 2.66
	Cappiello ⁷	1/39	5/40	0.21, 0.03 to 1.68
Catheter manipulation rate	Chau ²	2/40	4/40	0.50; 0.10 to 2.58
	Thomas ³	40/107	34/123	1.35; 0.93 to 1.97
	Cappiello ⁷	5/39	11/40	0.47, 0.18 to 1.22
Unilateral block rate	Chau ²	17/40	27/40	0.63, 0.41 to 0.96
	Thomas ³	27/107	28/123	1.11, 0.70 to 1.76
	Cappiello ⁷	3/39	10/40	0.31, 0.09 to 1.03
Intravascular placement rate	Chau ²	0/40	0/40	Not estimable
	Thomas ³	11/107	7/123	1.81, 0.73 to 4.49
	Cappiello ⁷	0/39	0/40	Not estimable
	Gupta ⁸	5/49	2/63	3.21, 0.65 to 15.87
Epidural top-ups	Wilson ¹	7/40	3/40	2.33, 0.65 to 8.39
	Chau ²	9/40	20/40	0.45, 0.23 to 0.86
	Thomas ³	63/107	75/123	0.97, 0.78 to 1.19
	Cappiello ⁷	21/39	20/40	1.08, 0.70 to 1.65
	Gupta ⁸	5/49	10/63	0.64, 0.23 to 1.76
Spontaneous vaginal delivery	Wilson ¹	34/40	31/40	1.10, 0.89 to 1.36
	Chau ²	31/40	28/40	1.11, 0.85 to 1.44
	Thomas ³	83/107	101/123	0.94, 0.83 to 1.08
	Cappiello ⁷	15/39	25/40	0.62, 0.39 to 0.98
Instrumental vaginal delivery	Wilson ¹	0/40	1/40	0.33, 0.01 to 7.95
	Chau ²	5/40	1/40	5.00, 0.61 to 40.91
	Thomas ³	10/107	9/123	1.28, 0.54 to 3.03
	Cappiello ⁷	12/39	5/40	2.46, 0.96 to 6.34
Cesarean section	Wilson ¹	6/40	8/40	0.75, 0.29 to 1.97
	Chau ²	4/40	11/40	0.36, 0.13 to 1.05
	Thomas ³	14/107	13/123	1.24, 0.61 to 2.52
	Cappiello ⁷	12/39	10/40	1.23, 0.60 to 2.51
Post-dural puncture headache /Headaches	Gupta ⁸	10/49	10/63	1.29, 0.58 to 2.84
	Wilson ¹	0/40	1/40	0.33, 0.01 to 7.95
	headache within 48 h			
	Chau ²	0/40	0/40	Not estimable
	Cappiello ⁷	0/39	0/40	Not estimable
	Choi ⁶	0/20	0/20	Not estimable
	Gupta ⁸	0/49	1/63	0.43, 0.02 to 10.25
	headache immediately after epidural placement			
Gupta ⁸	4/49	2/63	2.57, 0.49 to 13.47	
Hypotension	postpartum headaches			
	Chau ²	5/40	5/40	1.00, 0.31 to 3.19
	Thomas ³	34/107	38/123	1.03, 0.70 to 1.51
	Choi ⁶	4/20	7/20	0.57, 0.20 to 1.65
	Cappiello ⁷	1/39	0/40	3.08, 0.13 to 73.27
	Wilson ¹	2/40	3/40	0.67, 0.12 to 3.78
	hypotension within 20 min			
Gupta ⁸	4/49	5/63	1.03, 0.29 to 3.63	
hypotension within 2h				

Table 2 (continued)

Outcome	Studies	DPE group Events/participants	Epidural group Events/participants	RR, 95%CI
Nausea	Chau ²	1/40	4/40	0.25, 0.03 to 2.14
	Choi ⁶	1/20	7/20	0.14, 0.02 to 1.06
Pruritus	Nausea and vomiting Cappiello ⁷	2/40	0/39	4.88, 0.24 to 98.47
	Wilson ¹ pruritus within 48 h	1/40	5/40	0.20, 0.02 to 1.64
	Chau ²	4/40	4/40	1.00, 0.27 to 3.72
Fetal heart rate tracings	Cappiello ⁷	1/39	0/40	3.08, 0.13 to 73.27
	Wilson ¹ fetal bradycardia within 20 min	0/40	3/40	0.14, 0.01 to 2.68
	Chau ² fetal decelerations after neuraxial analgesia	18/40	17/40	1.06, 0.64 to 1.74
	Cappiello ⁷	0/39	0/40	Not estimable

PDPH: post-dural puncture headache. DPE: dural puncture epidural.

95%CI 1.26 to 2.03; $P < 0.001$), and 30 min (risk ratio 1.18; 95%CI 1.01 to 1.30; $P = 0.034$) in the DPE group was found by Chau et al.²

Discussion

We identified five studies on DPE compared to conventional epidural analgesia in parturients, spanning a period from 2000 to 2017. The quality of block was not significantly better with the modified technique, as reflected by the lack of significant differences for catheter replacement, catheter manipulation, unilateral block or intravascular catheter placement rates.

The significant findings were (1) a 2 min shorter median time to achieve sufficient analgesia (8 min versus 10 min)¹ which could be argued is not clinically meaningful, (2) a larger number of women having a VAS score $< 10/100$ at 20 min,⁷ (3) a reduction in the number of epidural top-ups,² and (4) better sacral analgesia, as indicated by a higher percentage of patients having a S1 (but not S2) block in one study⁷ and a S2 block in another study.²

Dural puncture epidural involves the epidural placement of a Tuohy needle, through which a spinal needle is introduced to puncture the dura. The rationale that the flow of cerebrospinal fluid secondary to the dural puncture reflects correct positioning of the Tuohy needle in the epidural space has been made before for the CSE technique.¹¹ In another meta-analysis,¹¹ the CSE block was associated with a significantly reduced risk for unilateral block compared with an epidural only block, but no differences were observed for the catheter replacement or the intravascular cannulation rates.

In the present study of the DPE technique, five studies reported a failure to perform the dural puncture, the rate varying from 2.5% to 23.4%. Factors that might influence the failure rate include epidural needle design (e.g. back channel for the spinal needle), operator experience and the approach (median or paramedian). The two studies with the highest rates^{3,8} had excluded the patients with failed dural puncture from further analysis, so that the failure rate cannot account for the lack of effect of dural puncture epidural on the variables under investigation.

In obstetric studies analgesia is a relevant outcome, but the respective results differed among the studies.^{1,2,7} No differences between the DPE and the epidural analgesia groups were found in the study by Thomas et al.³ A possible reason for this discrepancy is the needle size, which was higher (25- and 26-G) than the 27-G needle used in the study by Thomas et al.³ A study that is often quoted in this context¹² investigated the in vitro drug flow through monkey meninges after puncture with a 27-G, a 24-G and an 18-G needle. The flow of morphine was increased with all needles whereas an increased flow of lidocaine was observed only with the 24-G and the 18-G needles. The effect of the needle size therefore seems to vary for different agents. Another factor that could account for an effect of DPE is the volume of the epidural drug mixture. In studies reporting a difference between DPE and epidural analgesia, 12 to 20 mL were given over one to five minutes.^{1,2,7} By contrast, Thomas et al.³ applied only 3 mL lidocaine 2% (after a test dose of 5 mL, injection time not reported). Therefore a transfer of the medication through the dural hole is probably facilitated when higher epidural volumes and/or shorter injection times are used.

In summary, our systematic review showed substantial heterogeneity in the results obtained with DPE compared with epidural analgesia. Three studies, of which two were from the same institution, suggest inconsistently a somewhat better analgesic outcome and enhanced sacral spread with DPE. No differences were observed for catheter replacement, manipulation or unilateral block rates. Too few events to draw a conclusion were reported for PDPH/headaches and fetal heart rate tracings. A recommendation for DPE cannot be made unless more sufficiently powered evidence is published. Also, the additional costs of the needle for DPE have to be taken into account.

Disclosure of interests

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