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ORIGINAL ARTICLE

Intrathecal catheterization after unintentional dural puncture during orthopedic surgery

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Abstract
Purpose We investigated whether inserting an intrathecal catheter and leaving it in place for 24 h after an unintentional dural puncture in orthopedic patients reduced the incidence of post-dural puncture headache (PDPH).
Methods The study consisted of 427 patients in whom a total of 21 unintentional dural punctures had occurred during orthopedic surgery performed between 2002 and 2006. Seven patients (phase I; evaluated retrospectively) each underwent placement of an epidural catheter at another level after dural puncture during the period January 2002 to February 2004. Fourteen patients (phase II; evaluated prospectively) received an epidural catheter through the dural tear after an unintentional dural puncture during the period February 2004–March 2006
Results In phase I, 5 of the 7 patients experienced PDPH, and one required an epidural blood patch. In phase II, only one of the 14 patients complained of PDPH, which resolved after 48 h of medical therapy. No patient experienced paresthesia, neurologic or hemorrhagic complication, or infection.
Conclusion Inserting an epidural catheter through the dural tear following an unintentional dural puncture and leaving it in place for 24 h significantly reduces the incidence of PDPH.

Keywords Unintentional dural puncture · Intrathecal catheter · Postoperative 24 h

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Introduction

Total hip and knee replacements are common orthopedic surgeries. A combination spinal epidural technique is still a reasonable choice for use in patients treated with this type of surgery because it provides adequate analgesia, causes minimal adverse effects, and facilitates rehabilitation postoperatively. However, postdural puncture headache (PDPH) after unintentional dural puncture during induction of epidural anesthesia has limited the use of the technique. PDPH that occurs during the postoperative period negatively affects the patient's well-being. More than 50% of patients with an unintentional dural puncture experience an epidural needle-induced or catheter-induced PDPH [1, 2]. A conservative approach should be used to treat this complication, and if conservative treatment fails, an epidural blood patch may be used with 93–95% effectiveness [2, 3]. However, placement of an autologous epidural blood patch may result in both a potential blood infection of the central nervous system [4, 5] and a second unintentional dural puncture during attempts to reposition the epidural needle. That concern has compelled anesthesiologists to search for therapeutic modalities that involve less risk [2, 6–9].

The ideal technique must be as effective as the blood patch technique in preventing or treating PDPH but be less

invasive. It has been suggested that after unintentional dural puncture with a Tuohy needle, immediate placement of an intrathecal catheter through the perforation produces thecal compression and may provoke an inflammatory reaction and reduce the incidence of PDPH as effectively as an epidural blood patch [10–13]. However, some studies have reported that this technique is ineffective in reducing the incidence of PDPH [14, 15]. In these studies, however, the catheter was not left in place long enough to facilitate closure of the dural puncture. Speculative mechanisms on leaving the catheter in place for 24 h may be related to the inflammatory process that facilitates closure of the dural puncture after catheter removal.

In our study, we investigated whether leaving the catheter in place for 24 h after insertion of an intrathecal catheter reduces the incidence of PDPH after an unintentional dural puncture in patients undergoing total hip or knee replacement surgery.

Methods

Our study consisted of two phases. Phase I was retrospective review of 146 consecutive epidural blocks performed for total hip or knee replacement surgery during the period January 2002–February 2004. Patients were identified from the hospital admissions database using the total hip or knee replacement surgery codes. It was found that 7 of 146 patients had sustained an unintentional dural puncture during the first attempt to induce an epidural block with an 18-gauge Tuohy needle, which was followed by successful placement of an epidural block at another level and placement of a 20-gauge closed-end multiorifice epidural catheter.

Intraoperative data were obtained by reviewing the medical records. The same staff anesthetist performed all epidural block inductions. Postoperative data were obtained by reviewing the medical charts recorded in the pain unit.

Following identification of patients' complaints of discomfort from PDPH after a dural puncture, in our department, we considered inserting epidural catheters intrathecally instead of resiting the epidural catheter. Subsequently, since 2004, intrathecal epidural catheter insertion has been routinely performed in patients following unintentional dural punctures. This approach constituted phase II of the study.

After the study had been approved by the ethics committee, all patients requesting hip or knee replacement surgery during the period February 2004–March 2006 were enrolled in the study. Fourteen of the 281 patients in this group had sustained an unintentional dural puncture during the first attempt to induce an epidural block with an 18-gauge Tuohy needle through which a 20-gauge catheter was inserted (Sims Portex, Hythe Kent, UK).

In the phase II periods the same staff anesthetist also performed all spinal epidural anesthetic inductions. Instead of the combination technique, a separate approach was preferred to reduce the incidence of failure in the management of spinal epidural anesthesia. After a patient had been placed in the sitting position, spinal epidural anesthesia was induced at the level of the lumbar vertebral interspaces 3–4 or 4–5. Patients younger than 40 years required a 27-gauge Whitacre needle and patients 40 years or older required a 27-gauge Quincke needle for induction of spinal anesthesia. The spinal anesthesia needle was directed parallel to the long axis of the spine, and at the same level an 18-gauge Tuohy needle was introduced. The loss-of-resistance-to-saline technique was then used. The Tuohy needle bevel was directed horizontally at the time of meningeal puncture. Bupivacaine (15 mg) and fentanyl (25 μg) were injected into the subarachnoid space to induce spinal anesthesia. In phase I patients, 0.5% plain bupivacaine (4 mL) was injected through epidural catheter, and in phase II patients, 0.5% plain bupivacaine (1 mL) was injected intraoperatively through an intrathecal catheter to provide additional anesthesia in case spinal anesthesia proved inadequate during the procedures. Postoperative continuous epidural analgesia was achieved with an 8–10-mL bolus of bupivacaine (0.125%) and 2 μg mL^{-1} fentanyl at an infusion rate of 10–12 μg mL^{-1} during a 24-h period [16]. Continuous intrathecal analgesia was achieved with a 2-mL bolus of bupivacaine (0.0625%) and fentanyl 2 μg mL^{-1} at an infusion rate of 2–3 mL h^{-1} during a 24-h period [11]. In the phase II of the study, paresthesia during catheter insertion and postoperative events such as numbness or dysesthesia, nausea, or vomiting, and urinary retention were also recorded.

In both phase I and phase II periods we defined PDPH as a frontal or generalized headache with a postural component. All patients were examined daily for the development of symptoms of PDPH until their discharge, and thereafter were followed by daily phone calls for 1 week, at which time they were asked about whether a postural headache had developed. We classified PDPH into three categories: mild (postural headache slightly restricting daily activity), moderate (headache confining the patient to bed for part of the day), and severe (headache where the patient is bedridden for the entire day and associated symptoms such as nausea, vomiting, dizziness, and hearing loss are always present) [17]. All patients complaining of PDPH were treated with a conservative regime for a period of 1 week, which included drinking at least 2.0 L of fluids a day, caffeinated beverages (three cups of coffee a day), analgesics orally every 4 h (Geralgine–K which contains paracetamol 500 mg, caffeine 30 mg, codeine phosphate

10 mg). If this conservative approach was not successful, an epidural blood patch was offered.

Statistical analyses were performed with SPSS software (Statistical Package for the Social Sciences, version 11.0, SSPS, Chicago, IL, USA). Sample size analysis indicated that 7 subjects were needed in each group to detect a 60% decrease in the incidence of PDPH from 70 to 10.0% with alpha of 0.05 and power of 0.80. The results are presented as the mean ± the standard deviation. Continuous variables were evaluated with the unpaired Student's *t* test. The ordinal data were analyzed using a contingency table analysis with the chi-squared test with the appropriate correction. A *P* value of less than 0.05 was considered significant.

Results

During the study, 491 patients received an anesthetic during total hip or knee replacement surgery. Sixty-four patients who received morphine in the postoperative period, administered as intravenous patient-controlled analgesia when epidural analgesia failed, were excluded from the study. In phase I 146 patients and in phase II 281 patients received spinal epidural anesthesia during total hip or knee replacement surgery. Seventy-five of those patients underwent surgery in two steps during bilateral total hip or knee replacement. The paramedian technique was performed in 14 patients who had intra-articular fibrosis or closed ossification.

Table 1 shows the characteristics of the patients who had unintentional dural puncture. As the table illustrates, these are orthopedic patients with high body mass index, articular fibrosis, or ossification that destroys the articular process. Inevitably, these cases increase the incidence of unintentional dural puncture (21 out of 491 patients (4.9%); 7 in phase I and 14 in phase II). In phase I, 5 of the 7 patients (71.4%) experienced PDPH as shown in Table 2. Only one out of 14 (7.1%) patients experienced PDPH in phase II (odds ratio for PDPH, 0.03; 95% CI, 0.00–0.42; $P = .003$).

In phase II, a 25-year-old woman with postpolio syndrome had a PDPH. She was discharged on the seventh postoperative day and complained of a mild headache on the second day after her discharge from the hospital. Her symptoms, frontal and occipital headache and neck pain, were typical for a PDPH patient; they intensified on standing and were improved by lying supine. The headache resolved after 48 h of the medical therapy in the study. The same patient also requested epidural anesthesia for her second operation, which was performed 4 months after the first operation. During the second surgery, an epidural catheter was placed into the epidural space, and neither complications nor a PDPH developed.

Table 1 Characteristics of the dural puncture patients

	Phase I ($n = 7$)	Phase II ($n = 14$)
Age (year)	60.5 ± 9.0	56.3 ± 8.7
Diagnosis		
Osteoarthritis	5	11
Rheumatoid arthritis	–	1
Avascular necrosis	1	1
Ankylosing spondylitis	1	–
Developmental dysplasia of the hip	–	1
Sex (F/M)	5/2	9/5
Height (cm)	159 ± 7	155 ± 9
Weight (kg)	77 ± 13	75 ± 10
Body mass index	29 ± 5	30 ± 5
Post-dural puncture headache	5	1*

*$p < 0.05$

No paresthesia occurred in patients during intrathecal catheter placement. In phase II, a patient with mild hypotension (88/49 mmHg) and nausea during the sixth postoperative hour was treated with ephedrine (5 mg) and hydration. The patients whose intrathecal or epidural catheters were removed after 24 h did not exhibit any neurologic, infectious, or hemorrhagic complications; sensorial loss; or weakness during infusion.

Discussion

In our study we found that leaving an intrathecal epidural catheter in situ for 24 h in patients with an unintentional dural puncture from an 18-gauge epidural needle reduced the incidence of PDPH by a factor of ten in comparison with phase I. Reported incidences of PDPH after unintentional dural puncture in the study of Puolakka et al. [1] and in phase I of our study closely match (around 70%). Although the frequency of PDPH is inversely correlated with age, its incidence increases in elderly patients when the dural tap is made with a large-bore needle [2].

Even though use of the intrathecal catheter insertion method has been performed increasingly in recent years, the anesthesiology community still widely accepts the efficacy of resiting the epidural catheter [6]. Resiting an epidural catheter is a time-consuming process, and may result in a second dural puncture. Resiting the catheter, especially in orthopedic patients with a high body mass index, articular fibrosis, or ossification that destroys the articular process, increases the already high incidence of unintentional dural puncture. Furthermore, diffusion of the epidural top-up dosage through the dural tear is unpredictable and may cause an unexpected episode of

Table 2 Characteristics of the patients who developed PDPH

	Age (year)	Sex	BMI	PDPH onset time	Symptoms	Severity	Duration (days)
1st patient (phase I)	65	F	28.2	1st day	Headache (postural) Neck pain	Mild	5
2nd patient (phase I)	47	F	27.7	3rd day	Headache (postural) Throbbing	Mild	7
3rd patient[a] (phase I)	59	F	29.7	0 day	Headache (postural) Vomiting	Moderate	8
4th patient (phase I)	63	F	27.5	4th day	Headache (postural) Photophobia	Moderate	8
5th patient (phase I)	65	M	25.8	3rd day	Headache (postural) Neck pain Vomiting	Mild	4
1st patient (phase II)	25	F	23	8th day	Headache (postural)	Mild	2

[a] Blood patch patient

hypotension during the postoperative continuous epidural analgesia period [18, 19].

Intrathecal epidural catheter placement, however, is relatively easy to perform. The onset of local anesthesia is rapid, and local anesthetic toxicity is minimal. However, the main factors that limit the routine use of intrathecal epidural catheter placement are the risk of neurologic sequela and infection, both of which are associated with catheter placement of 24 h duration [2].

Except for the previously discussed advantages and disadvantages, our results demonstrated that intrathecal epidural catheterization reduces the incidence of PDPH by a factor of ten. If our findings are supported by those of other studies, the benefits of that procedure will outweigh the disadvantages. Some studies have shown that leaving an epidural catheter in the dural tear for a certain duration reduces the incidence of PDPH [12, 13]. However, other researchers have failed to note a difference in the incidence or severity of PDPH when a subarachnoid catheter was used [14, 15]. Most of those studies were performed in obstetric patients who had a high risk of unintentional dural puncture and a high incidence of PDPH. Cohen et al. [12] conducted a retrospective study in which PDPH did not occur in 13 patients who had undergone a cesarean section, had received an intrathecal epidural catheter after unintentional dural puncture, and were treated with continuous spinal analgesia through that catheter for 24 h after surgery. Ayad et al. [13] reported 115 consecutive unintentional dural punctures during epidural catheter insertion to provide analgesia for patients in labor. In that study, 31 of 115 parturients received an intrathecal epidural catheter immediately, and catheter was kept in place for 24 h. PDPH was observed in only one patient among 31 parturients, so success was significant. The results from those two studies corroborate similar case reports [11, 20]. Dennehy and Rosaeg [20] reported that they left an intrathecal epidural catheter in place for 13–19 h in three parturients, none of whom experienced a PDPH. Kuczkowski and Benumof [11] reported that only one of 7 parturients had a PDPH after an intrathecal catheter had been left in place for 12–20 h to provide analgesia after an unintentional dural puncture that occurred during epidural anesthesia. However, Norris and Leighton [14] and Rutter et al. [15] in their studies found no advantage of inserting an epidural catheter into the intrathecal space after unintentional dural puncture, in terms of reducing PDPH. In their prospective study, Norris and Leighton [14] compared 35 patients who had undergone intrathecal catheterization and 21 patients who had a repositioned epidural catheter. All patients had received an anesthetic agent through the catheter for approximately 2 h during labor and delivery after unintentional dural puncture. Those authors found no difference in the incidence of PDPH between the two groups [14]. Rutter et al. [15] administered an epidural block to 15030 parturients during labor, and unintentional dural puncture occurred in 73 of those women. During labor, analgesia was provided via an intrathecal catheter in 34 parturients and via a repositioned epidural catheter in 37 parturients. The incidence of PDPH was not found to be significantly different between two groups in that study. However, in that retrospective study of 9 years there may be several reasons which might confound the results. The number of unsuccessful attempts before taking the decision to insert an intrathecal catheter and the relationship between epidural needle size and intrathecal catheter size are not clearly indicated. Also, time duration of catheter placement in the intrathecal space was not recorded during the study. Because these important factors which may

strongly affect the occurrence of PDPH are not mentioned in the study of Rutter et al., the results of this study should be taken into account with great caution.

Liu et al. [21] reported the results of their study, which was performed in 87 elderly orthopedic patients. After a lumbar puncture, an intrathecal catheter was removed immediately from 47 of those patients and left 24 h after insertion in the remaining 40 patients. There was no difference in the incidence of PDPH between the groups; however, the incidence of PDPH was 9.2% which is too low—even lower than the general population [1, 2]. From the evidence provided in this study, it is not possible to draw conclusions with certainty, but we can say that, because the patients were geriatric cases, they may have very limited mobility and significantly reduced neurocognitive functions which may lead to reporting a very low number of PDPH occurrences.

Theories of immediate and delayed effect have been developed to explain the effectiveness of lowering the incidence of PDPH via intrathecal catheter insertion after dural puncture [9]. The immediate effect induces the formation of a plug in the dural hole to prevent cerebrospinal fluid leakage in the early period by catheter placement. The delayed effect, according to the proposed theories, may lead to an inflammatory response, edema, and fibrin formation after keeping the catheter in the dural hole for 18–32 h to seal the dural hole permanently in the long term. Although the catheter is kept in place for 24 h, PDPH may persist because the catheter may not completely have prevented leakage from the dural hole or because much more time may be required to seal the dural hole permanently.

We had two atypical PDPH patients. One patient in phase I refused to be mobile until the 4th day, so diagnosis was delayed; the onset time of PDPH in a patient in phase II was approximately 1 week after the procedure, which was quite unusual also; for this patient, however, clinical symptoms were completely compatible with PDPH. Although 99% of PDPH patients present symptoms within 3 days of dural puncture [22], an authoritative 2003 metaanalysis acknowledges that the onset of PDPH occurs from 1 to 7 days after the procedure [23].

Lack of randomization, not blinding, and matching with a retrospective group can be regarded weaknesses of our design. However, results clearly demonstrate that our methodology would provide important contributions in clinical practice and might improve quality of a patient's life. For that reason, we think that prospective clinical studies in large series are required to confirm these results.

We conclude that after unintentional dural puncture, inserting the catheter through the dural tear, maintaining intrathecal analgesia, and leaving the catheter in place for 24 h is an attractive alternative to repositioning the epidural catheter at another level in patients who undergo orthopedic surgery.

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