Review Article

Intrathecal catheter use after accidental dural puncture in obstetric patients: literature review and clinical management recommendations

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Summary

If an accidental dural puncture occurs, one option is to insert a catheter and use it as an intrathecal catheter. This avoids the need for a further injection and can rapidly provide labour analgesia and anaesthesia for caesarean section. However, there are no recommendations for managing intrathecal catheters and, therefore, significant variation in clinical practice exists. Mismanagement of the intrathecal catheter can lead to increased motor block, high spinal anaesthesia, drug error, hypotension and fetal bradycardia. Care must be taken with an intrathecal catheter to adhere to strict aseptic technique, meticulous labelling, cautious administration of medications and good communication with the patient and other staff. Every institution considering the use of intrathecal catheters should establish a protocol. For labour analgesia, we recommend the use of dilute local anaesthetic agents and opioids. For caesarean section anaesthesia, gradual titration to the level of the fourth thoracic dermatome, with full monitoring, in a facility equipped to manage complications, should be performed using local anaesthetics combined with lipophilic opioids and morphine or diamorphine. Although evidence of the presence and duration of intrathecal catheters on the development of post-dural puncture headache and need for epidural blood patch is limited, we suggest considering leaving the intrathecal catheter in for 24 hours to reduce the chance of developing a post-dural puncture headache while maintaining precautions to avoid drug error and cerebrospinal fluid leakage. Injection of sterile normal saline into the intrathecal catheter may reduce post-dural puncture headache. The level of evidence for these recommendations was low.

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Introduction

Neuraxial analgesia techniques are among the most effective, commonly used and versatile methods of obstetric pain management in contemporary clinical practice [1]. A complication of these procedures is an accidental dural puncture, which can result in a post-dural puncture headache in approximately 52-60% of obstetric patients [2, 3]. Identified as a major quality indicator in obstetric anaesthesia care [4], accidental dural puncture still occurs in 0.4–1.5% of all attempted neuraxial blocks [2, 5]. When a witnessed accidental dural puncture occurs, there are two possible options. The first is to remove the Tuohy needle and re-site the epidural catheter at another interspace; whilst the second is to insert the epidural catheter intrathecally for use as a continuous spinal (intrathecal) catheter. In 1989, Cohen et al. suggested that an intrathecal catheter was an effective method that could produce rapid labour analgesia and possibly reduce the incidence and severity of the post-dural puncture headache [3]. In 2003, a UK survey on the management of accidental dural puncture in labouring women found that the two most commonly cited reasons for intrathecal catheterisation were to avoid further dural puncture (76% of respondents) and to provide immediate analgesia for labour (75% of respondents) [6]. Another advantage of intrathecal catheter insertion is the ability to rapidly extend and deepen the blockade to enable caesarean section anaesthesia.

Whether an intrathecal catheter for labour analgesia reduces the incidence of post-dural puncture headache or need for an epidural blood patch has been questioned [7]. Moreover, there is limited information on the practical clinical management of an intrathecal catheter for labour analgesia, which can lead to variation in practices and an increased risk of adverse effects, including total spinal anaesthesia. Consequently, in this review, we will summarise the current literature on intrathecal catheters for labour and delivery, and discuss the management; the quality of analgesia and anaesthesia; the effect on post-dural puncture headache; complications; and the limitations in our existing knowledge.

Methods

We performed a literature search on 22 May 2020 and again on 5 October 2020 in PubMed, Google Scholar, the Cochrane Library, Embase and Web of Science databases with the following search terms: (spinal or intrathecal or subarachnoid) and (catheter or anaesthesia or analgesia) or continuous spinal and (spinal or unintentional intrathecal or subarachnoid) and (catheter or anaesthesia or analgesia) and (inadvertent or accidental) dural puncture and post-dural puncture headache or epidural blood patch.

The articles identified were entered into Endnote X9 (Clarivate AnalytiCD, New Jersey, USA) and duplicates were removed. The bibliographies of the retrieved articles were reviewed to identify additional references. We included randomised controlled trials, prospective observational, retrospective studies and case series and reports providing details of management of intrathecal catheters. Language restrictions were English, French, German and Hebrew.

Results

We included 35 articles identified by our literature search into the review. Most of the literature regarding intrathecal catheter use refers to an observed accidental dural puncture after attempted epidural catheterisation for labour analgesia. However, an accidental dural puncture can also occur during attempted combined spinal epidural for labour. In addition, an accidental dural puncture can also occur during attempted provision of anaesthesia for caesarean section in cases where an epidural or combined spinal epidural are used [8]. Moreover, a well-functioning epidural catheter may migrate into the spinal space and can subsequently be used as an intrathecal catheter. Therefore, we bring together current available information on intrathecal catheters, with their advantages and possible complications. At the end of the document, we summarise our recommendations; additional details such as dosages are given in Table 1, which sets out all our recommendations, and which the reader may use as the basis for a protocol. Figure 1 provides a visual summary of our guidelines.

There are a number of advantages for inserting an intrathecal catheter as opposed to re-siting the epidural. In a 2013 Obstetric Anaesthetists' Association survey sent to the leads of 210 UK obstetric anaesthesia units, 48% of the 158 respondents' institutional guidelines advocated intrathecal catheter insertion instead of epidural re-siting [9]. The stated advantages of intrathecal catheterisation included: rapid initiation of analgesia; the avoidance of need for further attempts to achieve epidural analgesia and possible repeat accidental dural puncture; and the potential reduction of post-dural puncture headache. Other reports have indicated potential disadvantages of intrathecal catheter insertion, including: accidental or iatrogenic effects of intrathecal drug administration (including high or total spinal); damage to the spinal cord; and creation of a conduit for infection [10–14]. In the only randomised controlled trial of intrathecal catheter vs. epidural catheter re-siting in the event of an

Table 1 Practice recommendations for intrathecal catheter management

Medication for labour analgesia through an intrathecal catheter
Initiation/test dose:
Bupivacaine 1.25–2.5 mg or ropivacaine 2–5 mg and fentanyl 12.5–25 μg or sufentanil 2–7 μg
Maintenance:
Bupivacaine 0.0417–0.1% or ropivacaine 0.1–0.2% and fentanyl 2–2.5 $\mu g.ml^{-1}$ or sufentanil 0.75–1 $\mu g.ml^{-1}$ at a rate of 1–3 $ml.h^{-1}$
Options: Patient controlled epidural analgesia with 0.5–1 ml of the maintenance solution every 20–30 min, or intermittent boluses by trained personnel
Breakthrough pain:
1–2 ml of maintenance solution
Respiratory/cardiovascular/fetal heart rate monitoring
Upon initiation of medication through an intrathecal catheter, perform frequent non-invasive blood pressure measurements, and continuous fetal heart rate monitoring for 30 min
Afterwards, monitoring according to hospital protocol as per standard epidural analgesia
Ambulation is not recommended during labour if medication is administered
Caesarean section anaesthesia
Titrate anaesthesia with incremental doses of bupivacaine/ropivacaine to achieve a sensory level of T4, with addition of fentanyl/sufentanil and morphine/diamorphine
Dosing of a functional intrathecal catheter should occur in the operating theatre with basic monitoring in place due to the need for backup equipment to manage a 'high spinal'.
Medication to prevent post-dural puncture headache
Intrathecal saline 10 ml may be injected
Optimal duration of catheterisation
Consider leaving an intrathecal catheter for 24 h. Precautions to prevent accidental drug administration or cerebrospinal fluid leakage should be instituted (taping)

accidental dural puncture, Russell reported successful intrathecal catheter use without complications in 50/57 (87.8%) cases [15]. Of the 58 women who were assigned to the repeat epidural group, 14 women required two or more attempts, and six women had a second accidental dural puncture [15]. This trial, however, was underpowered as it was halted prematurely.

Management of intrathecal catheters during labour

The use of a 'test dose' to assist in confirming the location of a neuraxial catheter is a common, albeit controversial practice, particularly in a pregnant woman, due to both a reduction in sensitivity and specificity and the presence of side-effects [16, 17]. Side-effects following a bolus of 3 ml of lidocaine 1.5% and epinephrine 1:200,000, the most commonly used test dose, via an intrathecal catheter, include hypotension, emergency caesarean section, fetal bradycardia and a high spinal block [18, 19]. It has been questioned whether the use of a lower test dose would reduce complications yet retain the ability to confirm intrathecal placement [19].

In a survey conducted among North American members of the Society of Obstetric Anaesthesia and Perinatology on the management of intrathecal catheters for labour analgesia, local anaesthetic agents with or without added opioids were administered as follows: 55% used a continuous infusion and no patient controlled analgesia; 33% used intermittent boluses; 9% used continuous infusion and patient controlled analgesia; and 3% used intermittent boluses of opioids alone [20].

We found 16 studies detailing labour analgesia through an intrathecal catheter after accidental dural puncture [2, 8, 15, 18, 19, 21–31] (Table 1 and online Supporting Information Table S1). Of these, 13 were retrospective [2, 8, 18, 19, 22, 23, 25–31], two were prospective observational [21, 24] and one was a randomised controlled trial [15]. All of these studies exclusively discussed only the management of accidental dural puncture occurring during labour [2, 15, 18, 19, 21–31], except that of Verstraete et al., which also discussed accidental dural punctures occurring during caesarean sections and fetal surgery [8]. All studies compared intrathecal catheters with re-sited epidurals [8, 15, 18, 19, 21–25, 27–30], except: Cohn et al., which had no comparator group [26]; Orbach-Zinger et al., who compared with a normal epidural [2]; and Brinser et al., who compared intrathecal/epidural morphine with no intrathecal/epidural morphine [31]. In the majority of studies that detailed intrathecal catheter medications, intrathecal analgesia was established with bupivacaine 1.25–5 mg combined either with fentanyl 12.5–25 μg or sufentanil 2–7.5 μg [2, 21, 23–28, 31].

Analgesia was maintained in almost all studies with a continuous infusion [2, 8, 18, 23–27, 31], except for two

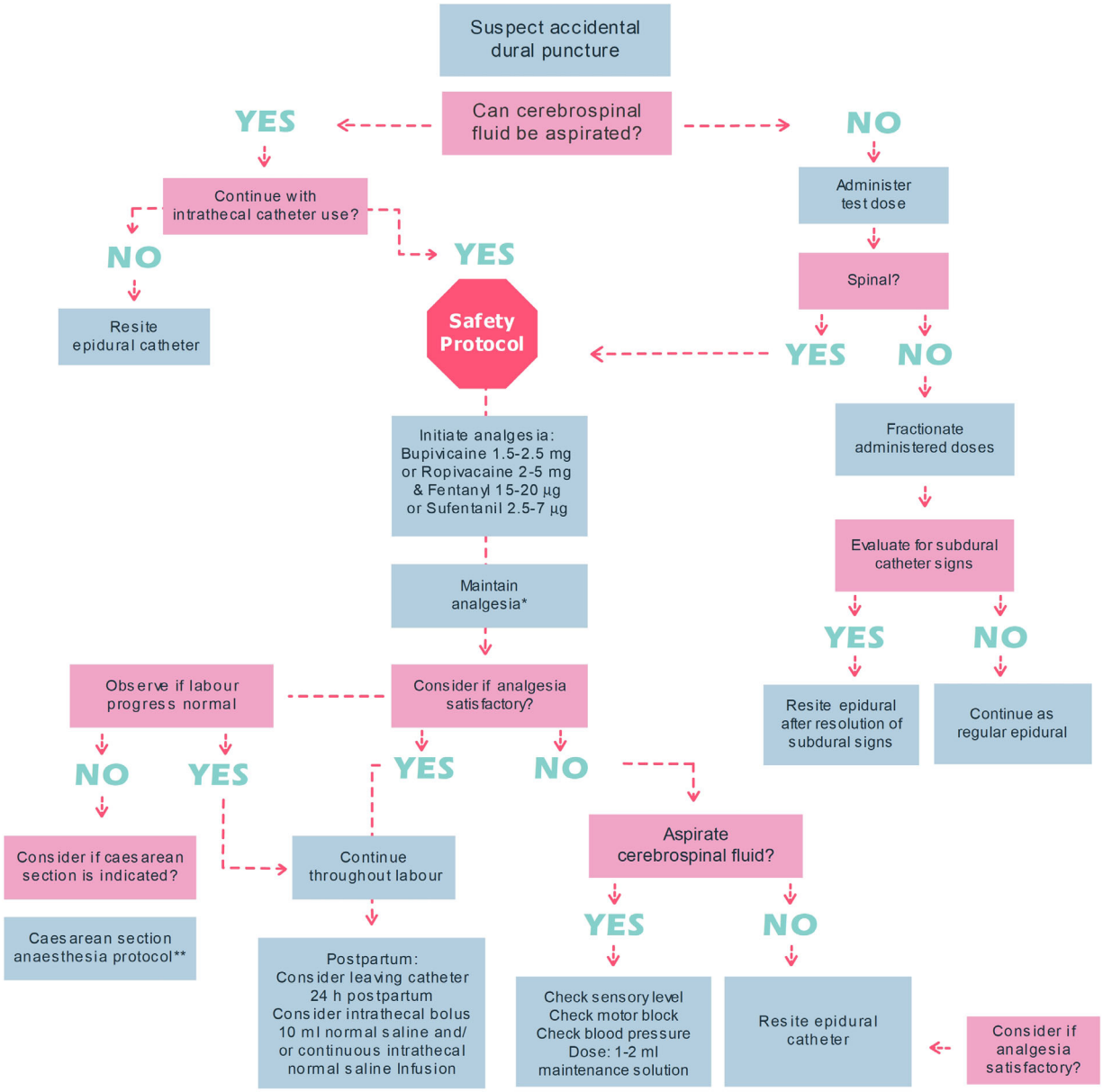

Figure 1 Algorithm for the management of accidental dural puncture and intrathecal catheter. *Maintenance: bupivacaine 0.0417–0.1% or ropivacaine 0.175–0.2% and fentanyl 2–2.5µg.ml^{-1} or sufentanil 0.75–1 µg.ml^{-1}, at a rate of 1–3 ml.h^{-1}, with patient-controlled epidural analgesia with 0.5–1 ml of the maintenance solution every 20–30 min, or intermittent boluses by trained personnel. **Caesarean section anaesthesia protocol: incremental doses of local anaesthetic to achieve a sensory level of T4, with addition of fentanyl or sufentanil and morphine or diamorphine. Injection of solution initiated only in operating room.

studies by Bolden et al., where details were not provided [19] and by Tien et al., where some patients were maintained with intermittent boluses only [28]. The continuous infusion consisted of low-dose bupivacaine 0.0417–0.1% or ropivacaine 0.175–0.2% combined with fentanyl 2–2.5 µg.mL^{-1} or sufentanil 0.75–1 µg.mL^{-1} at a rate of 1–3 ml.h^{-1} [2, 8, 19, 23–28, 31].

In two studies, a patient controlled analgesia bolus allowed labouring women to add 0.5–1 ml of a low-dose solution that consisted of local anaesthetic and fentanyl, every 20–30 min [8, 28]. In cases of breakthrough pain, 1-2 ml of the same solution was administered by a clinician [2, 18, 27]. Details of reported studies are provided in online Supporting Information Table S1. Two studies from the

same institution described the administration of low-dose epinephrine in their intrathecal catheter solutions [18, 19]; the addition of spinal epinephrine has been observed to prolong sensory block, increase analgesic efficacy and augment motor block [32].

Compared with an epidural catheter in labour, no study reported the use of more extensive cardiovascular or respiratory monitoring when an intrathecal catheter was in use [2, 18, 19, 23–25, 27]. One study reported greater vasopressor use in the intrathecal catheter group than in the re-sited epidural group (33/129 (25.6%) vs. 2/52 (3.8%), $p < 0.001$, OR (95%CI) 8.59 (1.98–37.28) [18]; the cause of this difference was presumed to be the effect of the lidocaine/epinephrine test dose in the intrathecal vs. epidural space. In a study using intrathecal morphine to diminish post-dural puncture headache, respiratory rate and sedation level were assessed clinically by the nursing staff every hour for 12 h initially postpartum, followed by every 2 h for the next 12 h [33]. In a study of intrathecal catheter side-effects by Izquierdo et al., women with intrathecal catheters received a post-procedure assessment at 24, 48 and 72 h [18]. No women in these two studies, however, had any respiratory or cardiovascular complications.

Most studies have indicated satisfactory labour analgesia with intrathecal catheters [2, 15, 18, 21–23, 26, 28]. In a recent meta-analysis, the overall relative risk (95% CI) for adequate analgesia after intrathecal catheter insertion compared with re-siting the epidural catheter was 1.05 (0.83–1.32), showing no difference between the two techniques [7]. Since this meta-analysis was published, a retrospective study found that women with accidental dural puncture managed by intrathecal catheter insertion had less pain throughout labour compared with women managed by re-siting the epidural [18].

Whereas the majority of intrathecal catheters provide adequate analgesia as detailed above, decreased effectiveness or failed analgesia have been reported [21, 27]. We therefore provide a 'troubleshooting' algorithm for correcting suboptimal to adequate labour analgesia (Figure 2).

Intrathecal catheter caesarean section anaesthesia

A suggested advantage of an intrathecal catheter is the ability to convert labour analgesia easily and rapidly to caesarean section anaesthesia. In the largest study, caesarean section anaesthesia was given by gradual titration of hyperbaric bupivacaine 0.75% to achieve a level of loss of sensation to pinprick to the fourth thoracic dermatome, preceded by intrathecal fentanyl 15–20 μg and morphine 0.25–0.3 mg [26]. Izquierdo et al. started with bupivacaine 5–7.5 mg and titrated to effective anaesthesia with an average dose of 8.8 mg (range 7.5–12 mg) [18]. In a study using continuous spinal microcatheters inserted intentionally (not an accidental dural puncture), the median (range) dose for caesarean section anaesthesia of isobaric bupivacaine was 15 (10–25) mg [34].

In spite of a theoretical ease of conversion, two studies have demonstrated a significant failure rate in conversion to caesarean section anaesthesia [18, 26]. One study found that of 20 intrathecal catheters, one intrathecal catheter was associated with inadequate anaesthesia intra-operatively, requiring conversion to general anaesthesia, and three required replacement during labour due to inadequate labour analgesia before the caesarean section [18]. Another study found that 16 out of 455 (3.5%) intrathecal catheters failed to provide adequate anaesthesia for caesarean section [26].

Management of post-dural puncture headache

Purported advantages of inserting an intrathecal catheter after an accidental dural puncture are the decreased incidence of post-dural puncture headache [8, 18, 24, 25], and the decreased need for an epidural blood patch [35]. In a recent meta-analysis and trial sequential analysis of 13 studies representing a total of 1653 patients, the relative risk (95% CI) of developing a post-dural puncture headache after intrathecal catheter insertion (compared with epidural catheter re-siting) was 0.82 (0.71-0.95) and the relative risk (95% CI) of requiring an epidural blood patch was 0.62 (0.49-0.79). However, the trial sequential analysis suggested that there was insufficient evidence to draw a firm conclusion [7]. A recent study that was not included in this 2020 meta-analysis was a retrospective study published with 129 women in the intrathecal catheter group and 52 in the re-sited epidural group; this study showed a significant decrease both in post-dural puncture headache (21.7% vs. 67.3%, $p < 0.001$) and the need for epidural blood patch (12.4% vs. 50.0%, $p < 0.001$) when an intrathecal catheter was inserted, compared with epidural catheter re-siting after an accidental dural puncture [18].

Cohen et al. suggested that leaving an intrathecal catheter for 24 h might reduce the rate of headache and decrease the need for an epidural blood patch [35]. In studies that left an intrathecal catheter indwelling for 24 h or more, only two found a decreased rate of post-dural puncture headache compared with re-sited epidural catheters [8, 25] and none found a decrease in the need for an epidural blood patch [8, 15, 23, 25]. In the study by Verstraete et al., where there was prolonged intrathecal catheterisation postpartum, the need for a therapeutic epidural blood patch showed a trend towards reduction, as

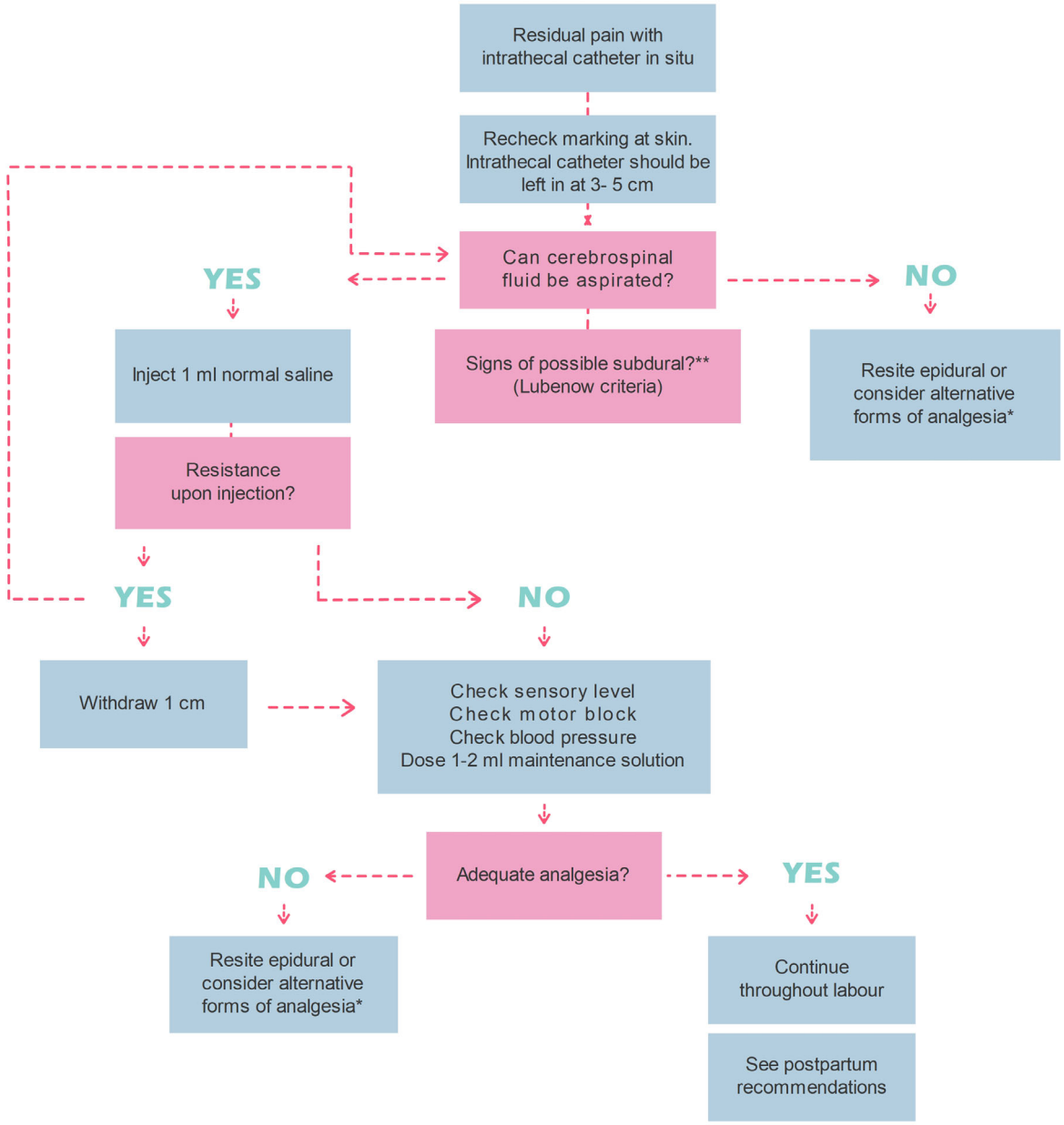

Figure 2 'Troubleshooting' an intrathecal catheter when it does not provide adequate analgesia. *Patient-controlled analgesia with fentanyl/remifentanil or nitrous oxide or non-pharmacological measures. **Lubenow criteria: Two major criteria: negative aspiration test; unexpected widespread sensory blockade. One minor criterion: delayed onset; variable motor blockade; extensive sympathetic blockade.

the incidence was lowered from 54% in the epidural re-site group to 36% in the prolonged intrathecal catheter group. The OR (95%CI) for this comparison was 2.1 (0.97–4.46), p = 0.06, but insufficient patient numbers might have been responsible for the comparison not reaching statistical significance [8]. In two small retrospective studies that compared an intrathecal catheter removed immediately after delivery with an intrathecal catheter left in for 24 h [19, 24], only one found a significant decrease in post-dural puncture headache and the need for an epidural blood patch in the group in which the intrathecal catheter was left in for 24 h [24]. Details on intrathecal catheter duration are listed in online Supporting Information Table S2. All studies [8, 15, 19, 21–23, 25, 27] compared intrathecal catheters with re-sited epidurals. Ayad et al. also compared intrathecal catheters left in place for varying durations [24].

Different intrathecal catheter medications have been evaluated to determine their ability to influence the rate of post-dural puncture headache. Recent interest in the use of intrathecal morphine to prevent post-dural puncture headache includes a small randomised controlled trial comparing 27 women who received intrathecal morphine 150 μg through the intrathecal catheter after delivery to a control group of 34 women who received 0.6–1 ml of intrathecal normal saline [33]. There was no difference in the incidence of post-dural puncture headache or the need for epidural blood patch.

Similarly, the administration of intrathecal saline to reduce the rate of post-dural puncture headache has been controversial. Two small retrospective studies observed an advantage in the administration of a bolus of saline intrathecally, postulating that the early saline administration would restore cerebrospinal fluid volume and thereby mitigate a sequence of cerebral hypotension, traction on dural structures, and eventual post-dural puncture headache [18, 19]. Bolden et al., evaluating the effect of a 10 ml intrathecal bolus of saline, found no difference between groups in the incidence of headache, but a significant difference in the need for an epidural blood patch (intrathecal catheter with saline 8.1% vs. intrathecal catheter without saline 25.9%, p = 0.03) [19]. In a subsequent retrospective study by the same investigators, the injection of sterile saline 10 ml at the time of intrathecal catheter insertion and removal significantly decreased post-dural puncture headache and the need for an epidural blood patch when compared with women who had their epidural catheter re-sited [18]. Verstraete et al. observed a significant decrease in post-dural puncture headache rates when saline was infused into the intrathecal catheter for the 24 h following delivery in 89 women [8]. These studies corroborated two case series where saline was injected intrathecally after an accidental dural puncture and the post-dural puncture headache was mitigated [36, 37].

Concerns and complications

Two studies have demonstrated no effect of an intrathecal catheter on labour progression [2, 27]. In a study comparing accidental dural puncture managed by intrathecal catheter insertion to primary functioning epidural catheters, there were no significant differences in time from neuraxial insertion until birth, rate of instrumental delivery, or caesarean section rate [2].

In a retrospective study designed to examine the effect of neuraxial technique after accidental dural puncture on obstetric outcomes, there was no difference between intrathecal catheter and re-sited epidural catheters in duration of the second stage of labour or caesarean section rate [27]. Recently, one study found that accidental dural puncture was associated with a prolonged second stage of labour after adjusting for confounders, the adjusted RR (95%CI) being 1.99 (1.04–3.82), p = 0.037 [38]; however, the accidental dural puncture was managed by intrathecal catheter in two-thirds of cases and re-sited epidural catheter in the remaining third of cases, and the effect could not be assigned to either technique [38].

The risk of drug error, such as the wrong drug or a large 'epidural dose' being given into an intrathecal catheter, is of particular concern. In the UK, Beckett et al. identified that one of the leading causes of maternal cardiac arrest was related to anaesthesia (local anaesthetic toxicity and high neuraxial block), although all women were successfully resuscitated [39]. A similar analysis, in the USA by Mhyre et al. also indicated that maternal cardiac arrest occurred from anaesthetic complications but the survival rate was high [40]. These studies, however, did not specifically evaluate intrathecal catheters. Of the 417 of 671 (62%) Australian obstetric anaesthetists who responded to an anonymous postal survey, 69.6% chose not to place an intrathecal catheter for fear that the catheter would be misused, and 59.2% feared a high block [41]. Cohn et al. reported one case of high spinal block due to an accidental dosage error of the intrathecal catheter during an emergency caesarean section [26]. Whereas the value of labelling the intrathecal catheter to prevent medication error has been suggested in most studies, only Rana et al. delineated labelling details and other safety elements, including: informing the midwife and parturient; writing a note in the patient record; and allowing only anaesthetists to administer medications through the intrathecal catheter [30].

In Australia and New Zealand, 90.7% of surveyed anaesthetists who did not use an intrathecal catheter following an accidental dural puncture cited lack of safety as the main concern [41]. In a retrospective study following accidental dural puncture, Tien et al. reported a 9% complication rate, with 6% experiencing hypotension, 1% having a high block level and 3% having fetal bradycardia; no differences were observed compared with those who were managed with a re-sited epidural catheter [28]. In a similar retrospective study of 761 intrathecal catheters in obstetric patients, Cohn et al. reported three high blocks and one case of respiratory depression after 2 mg of neuraxial morphine was given [26]. None of the studies comparing intrathecal catheters to re-sited epidural catheters reported adverse events such as meningitis, epidural or spinal abscess, haematoma, arachnoiditis or

cauda equina syndrome. Case reports, however, have described meningitis [42], neurological injury [42], tinnitus [43] and persistent cerebrospinal fluid leak [14]. The occurrence of a cerebrospinal fluid-cutaneous fistula has been reported both in non-obstetric patients and obstetric patients following an intrathecal catheter, as well as three cases following a combined spinal-epidural in obstetric patients [44, 45]. When a cerebrospinal fluid-cutaneous fistula is suspected, the cerebrospinal fluid should be differentiated from interstitial fluid [46]; the presence of glucose and low protein levels suggest cerebrospinal fluid, but this finding has low specificity [47]. Beta-2 transferrin electrophoresis can confirm the diagnosis [48], although the availability, report time and expense of this test may make it less feasible. Conservative treatment options for fistulae include bed-rest and fluids [46]; the use of antibiotic prophylaxis is controversial. Unresolved fistulas can be treated with an epidural blood patch or skin suture [46].

Due to the possibility of serious complications with the use of intrathecal catheters, every institution should decide according to their specific labour room anaesthesia coverage (24-h anaesthesia coverage, midwife administration of epidural medication) if the use of intrathecal catheters is applicable in their specific hospital. If so, clear institutional guidelines should be agreed stipulating labelling of intrathecal catheters; intrathecal catheter medications; management of complications; and duration of catheter insertion. The use of intrathecal catheters without a clear institutional protocol should be discouraged.

Discussion and recommendations

We have summarised the evidence for the insertion of an intrathecal catheter if the dura is accidentally punctured and derived recommendations for its use in routine clinical practice. Inserting the catheter intrathecally has the benefits of providing fast and reliable labour analgesia and rapid caesarean section anaesthesia if needed. In order to maximise benefits and minimise risks using intrathecal catheters, we recommend the following protocol. Further details and doses can be found in Table 1.

1. Following epidural catheter insertion, aspiration should be performed through the catheter. When clear fluid is aspirated, the aspirate should be tested for the presence of glucose. When the clear fluid contains glucose, the catheter is considered to be intrathecal. In cases where the epidural catheter is clearly intrathecally located, no test dose is required. When it is unclear if the catheter is intrathecally located, a test dose should be administered which contains a low dose of local anaesthetic.
2. Analgesia is initiated with a low-dose solution of local anaesthetic and lipophilic opioid. Maintenance of analgesia can be established with the use of a continuous infusion of dilute local anaesthetics and lipophilic opioids, with or without patient-controlled spinal anaesthesia. Alternatively, intermittent manual boluses can be used for maintenance. Bolus doses and manual 'top-ups' should always be given by a person trained to manage both spinal and epidural analgesia. Although not sufficiently discussed in the literature, we strongly discourage ambulation during labour (during intrathecal catheter local anaesthesia administration) because of the increased risk of motor weakness and falling.
3. Upon initiation of intrathecal catheter analgesia, frequent non-invasive blood pressure and fetal heart rate monitoring are needed for 30 min. During maintenance, the intrapartum monitoring needed for intrathecal catheter is identical to the monitoring in the hospital protocol for epidural catheter maintenance.
4. For caesarean section anaesthesia using an intrathecal catheter, gradual titration to the level of the fourth thoracic dermatome, with full monitoring, in a facility equipped to manage high or total spinal block, should be performed. Bupivacaine/ropivacaine combined with lipophilic opioids and morphine or diamorphine are suggested solutions.
5. After delivery, consider leaving the intrathecal catheter in for 24 h to decrease the chance of developing a post-dural puncture headache. However, since an intrathecal catheter carries the potential of serious complications such as high spinal block or toxic drug administration, adequate labelling is mandatory and precautions should be taken to avoid cerebrospinal fluid leakage from the catheter (taping).
6. It may be helpful to inject sterile saline into the intrathecal catheter; however, the evidence for this effect is not strong and dosage, timing and mode (single vs. continuous dose) of administration have not been established.
7. There should be clear labelling of an intrathecal catheter and proper documentation. During structured handover, the presence of an intrathecal catheter should be notified to all staff members.
8. When hospitals choose to use intrathecal catheters, clear institutional guidelines should be established.

Limitations

Our analysis identified substantial heterogeneity in the available studies of intrathecal catheters. Most studies were

retrospective, with only one prospective observational trial and one randomised controlled trial. Moreover, most studies were small and underpowered, including the only randomised controlled trial, which had aimed to recruit 500 women, but ultimately reported the findings from only 97 women [15]. The studies differed regarding: epidural needle size (17 vs. 18-G); intrathecal catheter size; whether the dural puncture was recognised or unrecognised; and whether the accidental dural puncture was caused by the needle or by the epidural catheter. Specific catheter details (i.e. tip design, single vs. multiple orifices, material) have been shown to be associated with specific outcomes during epidural anaesthesia; however, the attributes of the catheter and their influences on the rate of post-dural puncture when used intrathecally are not known [49]. Issues may exist in terms of blinding both the proceduralist as well as the assessor of the consequences of the accidental dural puncture. The literature is not uniform in the management of post-dural puncture headache, whether standardised protocols are followed, and when an epidural blood patch is performed. Finally, a number of confounders may influence the rate of post-dural puncture headache such as BMI, multiparity, history of migraines, and pushing during the second stage of labour [2,50]. Many studies were unable to control for these factors. Our degree of confidence in the evidence is low, and therefore we included our expert opinions in these practice management guidelines.

Future research

There is a need for a randomised controlled trial investigating the role of intrathecal catheter insertion after accidental dural puncture, evaluating outcomes including post-dural puncture headache and the need to perform an epidural blood patch. However, such a study would have multiple inherent problems; for example, difficulty with blinding, and would not be easy to perform. It would be difficult to undertake randomisation at the time of an accidental dural puncture, and one possibility for a study is to compare hospitals or units which use intrathecal catheters with those who do not. This type of study is known as a cluster randomised controlled trial, but runs the risk of bias from differences in parturients' baseline characteristics, as well as inconsistencies in intrapartum and postpartum management.

Another possibility is an impact study, as previously undertaken [15], where a period when the protocol was to insert an intrathecal catheter alternated with a period when the protocol was to re-site the epidural catheter. However, this sort of study may also be difficult to perform, and is affected by changes in patient care over time, other than those relating to the management of the accidental dural puncture.

Conclusions

Intrathecal catheter insertion after accidental dural puncture can provide effective and satisfactory labour analgesia and caesarean section anaesthesia in the parturient. Because of possible serious consequences, every institution should weigh the risks and benefits of use and should develop and promote institutional guidelines. There are a few complications with the intrathecal catheter technique, including possible hypotension, infection, drug-administration errors and cerebrospinal fluid-cutaneous fistula; although infrequent, these complications can be associated with serious morbidity. It is unclear if an intrathecal catheter prevents a post-dural puncture headache or mitigates the need for an epidural blood patch. Likewise, the optimal duration of intrathecal catheter isation and therapies to prevent post-dural puncture headache are unknown.

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Supporting Information

Additional supporting information may be found online via the journal website.

Table S1 Intrathecal catheter medication details for labour analgesia

Table S2 Intrathecal catheter duration details and effect on post-dural puncture headache and need for epidural blood patch

