Guidelines

Intrathecal catheter placement after inadvertent dural puncture in the obstetric population: management for labour and operative delivery. Guidelines from the Obstetric Anaesthetists' Association

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Summary

Background Anaesthetists of all grades who work on a labour ward are likely to be involved in the insertion or management of an intrathecal catheter after inadvertent dural puncture at some point in their careers. Although the use of intrathecal catheters after inadvertent dural puncture in labour has increased in popularity over recent decades, robust evidence on best practice has been lacking.

Methods The Obstetric Anaesthetists' Association set up an expert working party to review the literature. A modified Delphi approach was used to produce statements and recommendations on insertion and management of intrathecal catheters for labour and operative delivery following inadvertent dural puncture during attempted labour epidural insertion. Statements and recommendations were graded according to the US Preventive Services Task Force grading methodology.

Results A total of 296 articles were identified in the initial literature search. Further screening identified 111 full text papers of relevance. A structured narrative review was produced which covered insertion of an intrathecal catheter; initial dosing; maintenance of labour analgesia; topping-up for operative delivery; safety features; complications; and recommended follow-up. The working party agreed on 17 statements and 26 recommendations. These were generally assigned a low or moderate level of certainty. The safety of mother and baby were a key priority in producing these guidelines.

Conclusions With careful management, intrathecal catheters can provide excellent labour analgesia and may also be topped-up to provide anaesthesia for caesarean or operative vaginal delivery. The use of intrathecal catheters, however, also carries the risk of significant drug errors which may result in high- or total-spinal anaesthesia, or even cardiorespiratory arrest. It is vital that all labour wards have clear guidelines on the use of these catheters, and that staff are educated as to their potential complications.

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Recommendations

1 An intrathecal catheter may be inserted for the provision of analgesia and anaesthesia following inadvertent dural puncture during attempted epidural catheter placement. This decision must be made with consideration of potential risks and benefits (Grade C, moderate level of certainty).
2 Whether using intermittent boluses or a continuous infusion technique, use the same local anaesthetic solution throughout labour (Grade I, low level of certainty).
3 Maternal blood pressure should be checked every 5 min for 15 min following the first dose, and after every subsequent bolus given via an intrathecal catheter (Grade A, high level of certainty).
4 As with epidural analgesia, sensory and motor block should be checked every hour during intrathecal catheter analgesia (Grade B, moderate level of certainty).
5 Fetal heart rate should be continuously monitored during intrathecal analgesia (Grade B, moderate level of certainty).
6 Top-ups of local anaesthetic for caesarean delivery should be given incrementally, with each bolus limited to 2.5 mg bupivacaine (or equivalent) (Grade I, low level of certainty).
7 Extension of labour analgesia for caesarean delivery via an intrathecal catheter should be performed in an operating theatre (Grade B, moderate level of certainty).
8 Non-invasive blood pressure, ECG and oxygen saturations should be monitored throughout the duration of intrathecal anaesthesia (Grade A, high level of certainty).
9 All departments should have clear guidelines for the management of intrathecal catheters in labour and for delivery. These should highlight key risks, monitoring protocols and other safety measures (Grade A, low level of certainty).
10 Only anaesthetists should administer top-ups through an intrathecal catheter, and connect, disconnect or reconnect the catheter and tubing (Grade A, low level of certainty).
11 Anaesthetists should account for the dead space of the intrathecal catheter and filter when administering top-ups in labour or for operative delivery (Grade B, low level of certainty).
12 An intrathecal catheter should be clearly labelled adjacent to the filter and on the front of any infusion pump (Grade A, low level of certainty).
13 The multidisciplinary team (including any non-resident staff who may be called to attend the patient during labour or delivery), must be made aware of the intrathecal catheter through both verbal and written communication, including at every handover (Grade A, low level of certainty).
14 Intrathecal catheters should be removed at the earliest opportunity following delivery to reduce the risk of accidental overdose and infectious complications (Grade B, low level of certainty).
15 When patients who experience inadvertent dural puncture, with or without intrathecal catheter insertion, are discharged from hospital, follow-up should be in line with established guidance and include written information on headaches, `red flag´ symptoms, hospital contact information and communication with primary care (Grade B, low level of certainty).

Why were these guidelines developed?

Inadvertent dural puncture is a common complication of attempted labour epidural insertion, especially among novice anaesthetists. Surveys conducted over the last 30 years have shown that an increasing number of anaesthetists now choose to insert an intrathecal catheter after inadvertent dural puncture, rather than re-attempt insertion of the epidural in a different interspace. Despite the increase in popularity of using an intrathecal catheter in this situation, there has been a lack of guidance on the best practice management of these catheters for labour and operative delivery.

What guidelines currently exist?

Guidelines from the Obstetric Anaesthetists' Association (OAA) and, more recently, an international consensus report have been published on the management of postdural puncture headache. Several review articles cover aspects of

intrathecal catheter use after inadvertent dural puncture in the obstetric population and make some clinical management recommendations.

How do these guidelines differ from existing guidelines?

The OAA working party statements, recommendations and narrative review represent formal, evidence-based guidelines on the insertion and management of intrathecal catheters for labour analgesia and for operative delivery, together with a comprehensive discussion of potential complications and safety considerations pertinent to their use, and suggested follow-up for all obstetric patients who suffer inadvertent dural puncture.

Introduction

The incidence of inadvertent dural puncture, a recognised complication when attempting to locate the epidural space, is approximately 1.5% in obstetric patients [1]. Inadvertent dural puncture may be detected by the flow of cerebrospinal fluid (CSF) through the epidural needle, aspiration of CSF from a misplaced catheter, or from the unexpected rapid onset of analgesia and motor block, with or without haemodynamic changes. In these circumstances, the operator must decide whether to provide analgesia with an intrathecal catheter (threading the epidural catheter into the CSF) or abandon the procedure and attempt to position the epidural catheter correctly.

Continuing with an intrathecal catheter has the advantages of providing rapid analgesia without the risk of a further inadvertent dural puncture, which can be extended for operative delivery if required. However, the impact of intrathecal catheters on the incidence of postdural puncture headache (PDPH) and the requirement for an epidural blood patch when compared with subsequent epidural catheter insertion, continue to be debated [2, 3]. There are also concerns regarding the safety of intrathecal catheters, which include the risk of high- or total-spinal anaesthesia with inappropriate dosing, and the possibility of neurological complications. The use of intrathecal catheters for labour analgesia following inadvertent dural puncture has increased in popularity. A 2018 OAA-approved UK survey of practice reported their use in 59% of units [4]. Robust evidence on best practice is lacking, and recommendations for use are few [5–7]. Consequently, to assist clinicians who choose to provide labour analgesia or anaesthesia for operative delivery with an intrathecal catheter, the OAA set up a working party to undertake a systematic review of the evidence and produce guidelines on best practice.

Methods

All members of the working party were selected due to their obstetric anaesthetic experience and particular interest in the management of intrathecal catheters. In September 2023, a literature search of MEDLINE, Embase and Cochrane CENTRAL was undertaken by a public health librarian at NHS Scotland using various search terms including `intrathecal catheter´; `spinal catheter´; `subarachnoid catheter´; `inadvertent dural puncture´; `accidental dural puncture´; `unintentional dural puncture´; `postdural puncture headache´; `blood patch´ paired with `anaesthesia/obstetrical´; `pregnancy´; and `labour, obstetrical´. A publication date limit of 1 January 1993 onwards was set and the search limited to English-language papers. Independent screening of these results was carried out by two members of the working party to decide on the inclusion or exclusion of each article in the final list of results. A third member was asked to resolve any screening conflicts.

Results were imported into Covidence (www.covidence.org) following which members of the writing group screened references to eliminate irrelevant publications and check that important papers had not been overlooked. Structured narrative reviews on different aspects of the topic were then prepared by individual members of the working party.

The authors produced recommendations that were graded according to the US Preventive Services Task Force guidance [8]. Where recommendations were not possible due to the paucity of evidence, statements were presented instead. These statements were given a level of certainty without grading. The individual reviews were edited by two working party members (SG, RR) to prepare an interim draft guidance document. This was distributed to all members of the working party who were asked to vote anonymously (agree, disagree or abstain) on each statement and recommendation in a modified Delphi process. Where disagreements occurred, members were asked to document their reasons. The editors then clarified and revised the document before recirculating to the working party for further voting. The process was repeated until all statements and recommendations achieved > 75% agreement on content, wording and certainty/grading [9]. The guidance document was then revised and shared with all members of the working party for approval. Finally, the OAA Executive Committee, other experienced obstetric anaesthetists and a lay representative were asked to comment. Support for these guidelines from the Royal College of Obstetricians and Gynaecologists and from the Royal College of Midwives was also sought and obtained.

Results

The initial literature search produced 296 articles. After exclusions, a total of 111 full text papers of potential relevance to the topic were identified and these were made accessible to all members of the working party.

The structured narrative review produced is divided into six main sections: insertion of an intrathecal catheter after inadvertent dural puncture; management of an intrathecal catheter for labour analgesia; management of an intrathecal catheter for operative delivery; safety considerations for the use of intrathecal catheters; complications of intrathecal catheters; and recommended follow-up of obstetric patients after inadvertent dural puncture. After several rounds of anonymised voting, the working party agreed on the content, wording and grading of 17 statements and 26 recommendations using the US Preventive Services Task Force grading methodology [8]. The relevant statements and recommendations follow each section of the narrative review below.

Insertion of an intrathecal catheter after inadvertent dural puncture

Risk factors for inadvertent dural puncture with an epidural needle

Identification of risk factors for inadvertent dural puncture is often based on retrospective data following the onset of PDPH, a significant sequela of dural puncture, which may itself have specific independent risk factors.

Two studies used multivariate analysis to control for factors associated with inadvertent dural puncture. A study of 46,668 women of whom 177 (0.4%) had a documented inadvertent dural puncture, showed that a greater degree of cervical dilatation at the time of epidural insertion was positively associated with an increased risk (OR (95%CI) 1.23 (1.04–1.42); p = 0.01) [10]. Maternal age, parity, onset of labour and gestational age were not significant risk factors for inadvertent dural puncture. Although pre-gestational BMI was similar in those women who did and did not experience inadvertent dural puncture, the median depth of epidural needle insertion was greater in the inadvertent dural puncture group. Rates of inadvertent dural puncture did not differ with the choice of lumbar interspace or the medium (air vs. saline) used for loss of resistance. A retrospective cohort study of 7976 patients with a labour epidural or combined spinal-epidural, reported an inadvertent dural puncture rate of 0.6% (95%CI 0.4–0.9%) in high-case volume specialists (a mean annual number of obstetric procedures of 44) compared with 2.4% (95%CI 1.4–3.9) for low-case volume specialists (a mean annual number of obstetric procedures of 10) [11]. The odds of inadvertent dural puncture were 3.77 times greater (95%CI 1.72–8.28) for low-volume specialists. Among anaesthetists in training, inadvertent dural puncture rates decreased once trainees progressed past novice training.

The time of day may also influence the rate of inadvertent dural puncture. In a prospective study of 1489 epidural procedures performed in a single centre, the relative risk of inadvertent dural puncture was 6.33 times higher (95%CI 1.39–28.8) at night (19.00–08.00) [12]. This effect may in part be explained by the greater number of less experienced anaesthesia providers working out-of-hours and human factors such as fatigue and sleep deprivation.

Evidence suggests that the paramedian approach to the epidural space does not reduce the risk of inadvertent dural puncture or PDPH [9]. Meta-analysis has shown decreased rates of PDPH when spinal blocks are performed in the lateral decubitus position [13]. However, this does not prove that inadvertent dural puncture is more likely when blocks are performed with patients sitting, as CSF leak may be greater in the upright position.

In a randomised trial of 685 obstetric patients allocated to have their epidural block performed using either a 16- or 18-G Tuohy needle, there was no significant difference in the inadvertent dural puncture rate between the two needles [14].

- **A greater degree of cervical dilatation and operator inexperience increases the risk of inadvertent dural puncture (moderate level of certainty).**

Methods to confirm inadvertent dural puncture

Inadvertent dural puncture is most frequently recognised by persistent leak of CSF from an epidural needle. When using loss of resistance to saline for identification of the epidural space, it is common for a small amount of fluid to drip from the epidural needle when the syringe is removed. It may be difficult to distinguish between inadvertent dural puncture with leakage of CSF, and a small loss of saline following uncomplicated identification of the epidural space. Several techniques to distinguish CSF from saline have been suggested, including testing for protein or glucose, temperature, pH and changes in turbidity when mixed with thiopental [15–18]. In a prospective study undertaken to determine if anaesthetists could distinguish CSF from saline, the glucose test was most accurate at 97%, compared with 91% for pH, 84% for temperature and 50% when using thiopental [17].

It has been estimated that around a third of inadvertent dural punctures are unrecognised [19], and dural puncture may only be spotted following catheter insertion. If an

epidural dose of local anaesthetic is injected into the subarachnoid space, a higher and denser than expected neuraxial block is likely. Catheter aspiration is used widely to detect an intrathecal catheter. Studies suggest that direct intrathecal injection after negative aspiration through needle or catheter is rare, estimated to be between 1 in 1750 (0.06%) and 1 in 126,000 (0.0008%) [20–22]. While negative aspiration of fluid (or blood) via the epidural catheter is reassuring, it does not entirely preclude the possibility of catheter misplacement. Multi-orifice catheters are more likely to produce a reliable aspiration test [23].

The ideal test dose to exclude a misplaced catheter, be that intrathecal, subdural or intravascular, has yet to be identified [24]. In a systematic review of various epidural test doses and other strategies to detect catheter misplacement, Guay suggested that a combined sensitivity and a positive predictive value of ≥ 80%, shown by at least two randomised controlled trials was required [25]. The author could not, however, identify any randomised trial meeting these criteria for the intrathecal injection of lidocaine, bupivacaine, ropivacaine or levobupivacaine. Guay highlighted an observational trial of pregnant women using 8 mg bupivacaine by Prince et al. which showed a 95%CI ≥ 80% for both sensitivity and positive predictive values [26]. This is consistent with the findings of a clinical investigation of 10 ml intrathecal bupivacaine 0.1% and 2 $\mu g.ml^{-1}$ fentanyl in 15 women undergoing elective caesarean delivery [27]. A spinal block with a sensory level between T1 and T2 developed over 10–15 min in all women. No patient experienced respiratory depression, although two developed hypotension that responded rapidly to vasopressors. Motor block was not reported. Patients received 10 mg bupivacaine, which is within the range of the ED_{95} of isobaric and hyperbaric bupivacaine for caesarean delivery [28, 29].

In a double-blind randomised trial of women undergoing elective caesarean delivery, the sensitivity and specificity of 30 mg vs. 45 mg lidocaine were compared to distinguish between intrathecal and epidural injection [30]. The study was conducted using a combined spinal-epidural technique in which all women received both an intrathecal test dose and epidural saline placebo (or vice versa). Resulting sensory levels to cold and pinprick were variable, with overlap between intrathecal and epidural administration, regardless of lidocaine dose. Furthermore, subjective symptoms of warmth or leg heaviness, reported 3 min after lidocaine injection, had insufficient specificity in diagnosing such a rare outcome for those with a positive result: 30 mg had a specificity of 74% (95%CI 55–88%) compared with 45 mg with a specificity of 59% (95%CI 41–76%). Motor block appears to be more useful, but a 5-min delay may be necessary for accurate assessment. At the 3-min measurement, 30 mg had 83% sensitivity (95%CI 66–94%) while 45 mg had 100% sensitivity (95%CI 84–100%).

The Royal College of Anaesthetists' 7th National Audit Project investigating peri-operative cardiac arrest suggested that a test dose of 10 mg bupivacaine (or equivalent) allows recognition of an intrathecal catheter while minimising the risk of high- or total-spinal anaesthesia [31]. This dose should produce clinically evident sensory, motor or autonomic effects.

- **For labour epidural analgesia, to minimise the risk of high- or total-spinal anaesthesia, a test dose of local anaesthetic solution should not exceed the equivalent of 10 mg bupivacaine (Grade B, moderate level of certainty).**

The decision to place an intrathecal catheter or re-attempt epidural insertion

The decision to proceed with an intrathecal catheter or re-attempt epidural placement should consider factors related to the clinical situation and the perceived balance of risks vs. benefits. The stated advantages of an intrathecal catheter include rapid initiation of analgesia; avoidance of further attempts to achieve epidural analgesia and possible repeat inadvertent dural puncture; facilitation of rapid extension of a block for operative delivery while eliminating the requirement for a large epidural top-up in the presence of a breach in the dura; and a potential reduction in the incidence of PDPH and the need for an epidural blood patch. Adverse effects of intrathecal catheter placement, such as high blocks and neurological complications, are addressed later.

Surveys of practice among UK obstetric anaesthetists have shown that placement of an intrathecal catheter has become more widespread over the last 30 years. In 1993, only 1% of UK anaesthetists sited an intrathecal catheter following inadvertent dural puncture [32]. This figure climbed to 28% in 2003 [33] and to 48% in 2011 [34]. The most recent survey published in 2018 revealed that 59% of OAA members would thread an intrathecal catheter as first-line management of inadvertent dural puncture in labour [4].

Ultimately, the decision between continuing with an intrathecal catheter or re-siting an epidural catheter at another space depends on careful consideration of the specific clinical context. This may include, but is not limited to, the stage of labour; the difficulty in identifying the epidural space; the experience of the anaesthetist; the availability of other anaesthetists; and the suitability of other potential methods for analgesia in labour. The patient's preference should be considered. Whatever

technique is chosen, close monitoring and effective communication between the anaesthetist, midwife and patient are essential. The decision must be communicated to all staff involved in the patient's care.

- **An intrathecal catheter may be inserted for the provision of analgesia and anaesthesia following inadvertent dural puncture during attempted epidural catheter placement. This decision must be made with consideration of potential risks and benefits (Grade C, moderate level of certainty).**

Insertion of an intrathecal catheter

As with any neuraxial technique, aseptic precautions must be observed during intrathecal insertion of an epidural catheter [35]. As the dura has been breached and a foreign body is to be inserted, the risk of infection must not be overlooked.

Evidence from randomised studies on the optimal length of catheter insertion for labour analgesia is lacking. The position of an intrathecal catheter deliberately placed for long-term drug administration is usually checked fluoroscopically, which is impractical in labour. Studies using intentionally placed narrow-gauge spinal catheters and epidural catheters sited after inadvertent dural puncture have reported placing 2–4 cm of catheter into the subarachnoid space [36–38]. Extrapolation from studies on catheters placed in the epidural space suggest that shorter lengths are more likely to result in catheter dislodgement. Insertion of longer lengths of catheter may increase the risk of paraesthesia, but whether this is likely to result in neurological complications is unknown.

Intrathecal catheters may be attached to the skin using the same technique for epidural catheter fixation. It is, however, essential that they are clearly marked as being intrathecal and that this information is passed on to any member of staff who attends the patient. Insertion of an intrathecal catheter should be clearly documented and highlighted in the patient's record.

- **The ideal length of catheter insertion is not known, although most publications report advancement of 2–4 cm into the subarachnoid space (low level of certainty).**

Management of an intrathecal catheter for labour analgesia

Initial dose

Following recognised inadvertent dural puncture, initial intrathecal catheter dosing is usually with a bolus and should be given by an anaesthetist. Most studies and case reports describe an initial dose of local anaesthetic solution, with or without the addition of fentanyl or sufentanil [34, 38–48]. In two studies, a small dose of adrenaline was also added to the local anaesthetic/opioid bolus [49, 50]. Conditions of United States Food and Drug Administration approval for one randomised study prohibited the use of a mixture of intrathecal drugs, and therefore an initial dose of 5 μg sufentanil alone was administered [37]. In one large retrospective review and one case report, it is unclear whether initial intrathecal boluses were given, as only continuous intrathecal infusions were discussed [3, 51].

Evidence on the optimum initial intrathecal dose is predominantly from dose-finding studies using labour combined spinal-epidural analgesia. In these studies, injection was made through a spinal needle and not an epidural catheter. Consequently, caution is necessary with extrapolation of findings to intrathecal catheter use. Using up-down sequential analysis, Camorcia et al. investigated the minimum local analgesic dose (equivalent to the ED_{50}) for various intrathecal local anaesthetics in labour [52]. Ropivacaine was the least potent (3.64 mg), followed by levobupivacaine (2.94 mg) and bupivacaine (2.37 mg). These findings suggest that compared with bupivacaine, the intrathecal analgesic potency ratio for levobupivacaine is 0.8 and for ropivacaine is 0.65. Stocks et al. reported a slightly lower minimum local analgesic dose of bupivacaine for labour analgesia of 1.99 mg (95%CI 1.71–2.27). This value reduced to 0.69–0.85 mg when 5–25 μg fentanyl was added, although the reduction in minimum local analgesic dose was not dependent on fentanyl dose, leading the authors to suggest that a dose of fentanyl of < 5 μg may be effective [53]. Using varying doses of fentanyl (0–25 μg) combined with 2.5 mg bupivacaine, Wong et al. found that at least 15 μg was required to achieve reliable analgesia [54]. Comparison of outcomes between studies requires caution due to demographic differences in the study populations and variations in outcome measures, most notably the definition of effective analgesia.

Clinical assessment of the ED_{95} of plain local anaesthetic solutions is lacking, although data on local anaesthetic and opioid combinations, which are more likely to be used in clinical practice, have been published. In a study to determine the ED_{95} of bupivacaine and fentanyl, Whitty et al. found that 1.75 mg bupivacaine with 15 μg fentanyl produced reliable analgesia in labour [55]. The addition of sufentanil to local anaesthetics has also been investigated. The intrathecal potency ratio of sufentanil to fentanyl is 4.4:1 [56]. In a dose-finding study using bupivacaine, levobupivacaine or ropivacaine (1–3.5 mg)

with 1.5 μg sufentanil, Van de Velde et al. reported ED_{95} values of 3.3 mg for bupivacaine, 5.0 mg for levobupivacaine and 4.8 mg for ropivacaine [57].

Although initial dosing of intrathecal catheters with ropivacaine has been reported, levo- or racemic bupivacaine have been described more frequently. Reported concentrations of levobupivacaine and bupivacaine range from 0.1% to 0.75%. Most authors, however, describe an initial bolus of 1.0–2.5 mg (volume 1–2.5 ml) of 0.1%, 0.125% or 0.25% bupivacaine, with fentanyl (12.5–25 μg) or sufentanil (1–5 μg) [34, 38–40, 42–45].

The use of hyperbaric local anaesthetic solutions for intrathecal loading has not been studied, and the baricity of the initial dose is not described in the majority of publications. Most authors only state the dose and concentration of bupivacaine. From the dosing regimens described, it would appear that hyperbaric solutions are rarely used for initiating intrathecal catheter analgesia.

In their literature review and management recommendations, Orbach-Zinger et al. suggest an initial intrathecal dose of either 1.25–2.5 mg bupivacaine or 2–5 mg ropivacaine, with either 12.5–25 μg fentanyl or 2–7 μg sufentanil [7]. The review by Moaveni suggests a similar initial dosing strategy of 1.25–2.5 mg bupivacaine with 10–20 μg fentanyl [6]. These recommendations for bupivacaine appear reasonable, although larger doses of levobupivacaine and ropivacaine may be necessary to achieve satisfactory analgesia. The use of larger doses of opioids is more likely to produce adverse effects [53, 54]. With studies showing effective pain relief with smaller doses, a more cautious approach should be considered with doses limited to a maximum of 15 μg fentanyl [54] or 2.5 μg sufentanil [58].

If intrathecal placement is only recognised after administration of 10 mg bupivacaine (or equivalent) through the catheter, the extent of the sensory block should be assessed by the anaesthetist. Further incremental doses of up to 2.5 mg bupivacaine should only be administered when the sensory block has receded to a level of T10.

- **For initiation of labour analgesia via an intrathecal catheter, an initial bolus of 2.5 mg bupivacaine (or equivalent) may be used, with the addition of up to 15 μg fentanyl (or equivalent) (moderate level of certainty).**

Maintenance

A 2011 OAA survey indicated that intermittent top-ups were used for the maintenance of intrathecal labour analgesia in 98% of units, with anaesthetist administration of boluses in 100% of cases [34]. With the evolution of clinical practice over the last decade, the use of a continuous infusion for analgesia via an intrathecal catheter is now also reported. As well as reducing some of the risks associated with intrathecal catheters, a continuous infusion may help to ensure more consistent delivery of analgesia as there is no requirement for an anaesthetist to administer top-ups. This may be particularly advantageous on a busy labour ward when an anaesthetist is unable to attend immediately for this purpose.

The optimum continuous infusion regimen is unknown as comparative studies are lacking, and comparing outcomes between different studies is not recommended. Studies have not reported the frequency with which individual dosing regimens fail to provide effective analgesia requiring anaesthetic review.

Limited evidence suggests greater spread of intrathecal solutions may be achieved with bolus dosing [59]. In studies which have described the use of intermittent top-ups for maintenance analgesia via an intrathecal catheter, 1–5 ml boluses of 0.1% or 0.125% bupivacaine with 2 $\mu g.ml^{-1}$ fentanyl is the most commonly used regimen [34, 46, 48]. One study used 0.5–1 ml boluses of 0.25% bupivacaine alone; fentanyl (5–10 μg) was only added if analgesia remained inadequate [60].

Boluses may also be given by an anaesthetist through a pump, rather than via syringe. This technique has the advantages associated with the use of a closed-loop system. Anaesthetist-administered pump boluses eliminate the need to disconnect and reconnect the circuit to give top-ups. This reduces the likelihood of drug errors and may also help to reduce the risk of infectious complications.

For continuous intrathecal infusion, most studies report the use of the same local anaesthetic and opioid solution used for the initial bolus via an intrathecal catheter. The majority describe the use of ultra-low or low-dose levo- or racemic bupivacaine (0.04–0.125%), with fentanyl (1.5–5 $\mu g.ml^{-1}$) or sufentanil (1 $\mu g.ml^{-1}$), running between 1–4 $ml.h^{-1}$ [3, 38, 40, 41, 44, 45]. Two studies reported the addition of adrenaline to the local anaesthetic infusion with the intention of enhancing sensory block and analgesic effect [42, 49]. The addition of adrenaline is, however, associated with an increased intensity of motor block [61].

Patient-controlled intrathecal analgesia has been described using a solution of ropivacaine 0.175% with 0.75 $\mu g.ml^{-1}$ sufentanil at a continuous rate of 1 $ml.h^{-1}$ with a patient-controlled bolus 0.5–1 ml and a lock-out of 30 min [62]. However, review of the literature yielded insufficient evidence to make a recommendation on maintenance

techniques using continuous infusions supplemented with patient demand boluses to maintain analgesia via an intrathecal catheter in labour.

Breakthrough pain occurring in the context of a continuous infusion has been managed with anaesthetist boluses of 1–2 ml of the same solution, with or without adjustment in the infusion rate by 1 $ml.h^{-1}$ [3, 40, 49]. In these studies, ineffective analgesia after one or two boluses resulted in removal of the intrathecal catheter. There is no evidence to support either the safety or efficacy of using a more concentrated local anaesthetic solution in the management of breakthrough pain. Instead, consideration should be given to the re-siting of the catheter in the epidural space, or use of an alternative form of labour analgesia, if an additional bolus of the same solution is ineffective.

- **For maintenance of labour analgesia via an intrathecal catheter, bupivacaine 0.1–0.125% (or equivalent) with 2–2.5 $\mu g.ml^{-1}$ fentanyl (or equivalent) are suitable solutions (moderate level of certainty).**
- **Low-dose local anaesthetic solutions for maintenance of labour analgesia via an intrathecal catheter may be given either as intermittent boluses (up to 2.5 mg) by an anaesthetist, or as a continuous infusion (1–3 $ml.h^{-1}$) (low level of certainty).**
- **Whether using intermittent boluses or a continuous intrathecal infusion technique, use the same local anaesthetic solution throughout labour (Grade I, low level of certainty).**
- **For breakthrough pain during the use of a continuous intrathecal infusion, give up to 2 ml of the solution used to maintain labour analgesia (Grade I, low level of certainty).**
- **If analgesia remains inadequate after an additional 2 ml intrathecal bolus, remove the catheter and consider re-siting the epidural, or using an alternative form of labour analgesia (Grade I, low level of certainty).**

Monitoring during labour analgesia via an intrathecal catheter

Few studies discuss maternal and fetal monitoring during intrathecal catheter use for labour analgesia. Orbach-Zinger et al. suggest frequent non-invasive blood pressure monitoring and continuous fetal heart rate monitoring for 30 min after initiation of intrathecal analgesia [7]. They recommend that this should be followed by an identical monitoring protocol during maintenance analgesia as that which would be used with epidural analgesia. In practice, this guidance would equate to a non-invasive blood pressure measurement every 5 min for at least 15 min following the first dose of medication through an intrathecal catheter, and after any subsequent top-ups [63]. The attending midwife should remain in the room throughout this time. When intrathecal labour analgesia is established, blood pressure may be recorded hourly if this has remained stable and provided there are no other concerns. An anaesthetist should remain with the patient for at least 10 min after the initial bolus dose. Following National Institute for Health and Care Excellence guidance for neuraxial analgesia, the sensory level of the block should be checked hourly [63].

One advantage of intrathecal catheter use in obstetric practice is the rapid onset of analgesia and consistent coverage of sacral nerve roots afforded by the spinal block. Frequent top-ups or prolonged local anaesthetic administration through an intrathecal catheter may, however, result in a dense motor block. Motor block should be checked hourly by asking the woman to straight leg raise [63]. It is important that midwives encourage and assist women with changing position regularly in labour to avoid the development of skin pressure damage. Due to the risk of falls, ambulation is not recommended during or after intrathecal catheter use until the block has completely resolved [7].

Since the effects of intrathecal labour analgesia may be less predictable than that from an epidural and the risk of fetal bradycardia is increased by intrathecal opioids [64], continuous fetal heart rate monitoring throughout labour should be employed when using an intrathecal catheter, regardless of whether intermittent top-up or continuous infusion is used as a maintenance analgesic technique.

- **Maternal blood pressure should be checked every 5 min for 15 min following the first dose, and after every subsequent bolus given via an intrathecal catheter (Grade A, high level of certainty).**
- **Ambulation with an intrathecal catheter should be avoided. If dense motor block is present, assistance should be provided with regular positioning changes in labour to avoid skin pressure damage (Grade I, low level of certainty).**
- **As with epidural analgesia, sensory and motor block should be checked every hour during intrathecal catheter analgesia (Grade B, moderate level of certainty).**
- **Fetal heart rate should be continuously monitored during intrathecal analgesia (Grade B, moderate level of certainty).**

Management of an intrathecal catheter for operative delivery

Top-up solution, volume and adjuncts

Analgesia provided by a labour intrathecal catheter can be topped-up for caesarean or operative vaginal delivery. Supporting evidence for how best to extend the sensory block for operative delivery via an intrathecal catheter is, however, limited to observational studies [37, 38, 49, 65, 66], case reports [48, 67, 68] and expert opinion [5–7]. Furthermore, some of the literature relates to narrow-gauge intrathecal catheters intentionally placed for specific reasons such as obesity, cardiac disease and spinal surgery, with fewer studies reporting outcomes from wider-gauge intrathecal catheters placed following inadvertent dural puncture. The ideal top-up should produce a reliable block while minimising adverse effects. The choice of local anaesthetic, dose, baricity of the solution and mode of administration all need to be considered.

Cohn et al. reported outcomes of 761 women who had a 19- or 20-G labour intrathecal catheter; of these, 653 were placed after inadvertent dural puncture [38]. Labour analgesia was maintained with a continuous infusion of bupivacaine 0.1% with 2.5 $\mu g.ml^{-1}$ fentanyl at 2–3 $ml.h^{-1}$. When required, anaesthesia was provided by 15–20 µg fentanyl and 0.25–0.3 mg morphine, followed by incremental bupivacaine 0.75% (size of increment not stated) to achieve a pinprick sensory level of T4. Information on the total dose of bupivacaine used was not presented. From the cohort of 761 women, 455 required caesarean delivery. Of these 455 women, 16 intrathecal catheters (3.5%) failed to provide adequate anaesthesia. Looking specifically at the 653 women whose intrathecal catheter was placed in labour after inadvertent dural puncture, 140 women subsequently required an intrapartum caesarean delivery. Of these 140 cases, failure was reported in 10 (7.1%).

In another observational study of 129 labouring women, analgesia was provided with a continuous infusion of 0.04% bupivacaine with 5 $\mu g.ml^{-1}$ fentanyl and 0.033 $mg.ml^{-1}$ adrenaline through an 18- or 19-G intrathecal catheter following inadvertent dural puncture [49]. Of these 129 women, 20 required caesarean delivery. The block was titrated with intrathecal bupivacaine to the desired sensory level (not defined) with an initial dose of 5.0–7.5 mg (baricity not stated). The mean [range] top-up dose was 8.8 [7.5–12.0] mg. Of the 20 cases, 16 were successfully conducted using the intrathecal catheter. Of the remaining four, three were inadequate in labour requiring epidural replacement, and one failed to provide surgical anaesthesia requiring conversion to general anaesthesia. No details were provided on top-up doses for operative vaginal delivery.

Tao et al. reported the success rate when converting analgesia to anaesthesia for caesarean delivery using intentionally placed 23-G intrathecal catheters [65]. Labour analgesia was provided with patient-controlled intrathecal bupivacaine 0.0625% with 2 $\mu g.ml^{-1}$ fentanyl. For operative vaginal delivery, boluses of 2.5 mg bupivacaine were administered, although data on total doses were not presented. Sixteen women were receiving continuous spinal analgesia when the decision for caesarean delivery was made, of whom 15 had a successful top-up. Plain bupivacaine 0.5% up to 25 mg was given incrementally to achieve a T4 sensory level, but details on each incremental dose were not presented. Mean [range] bupivacaine dose was 15 [10–25] mg. The authors did not report block heights or incidence of intra-operative pain. For operative vaginal delivery, the protocol allowed 1 ml increments of bupivacaine 0.25%, but no additional boluses were required.

Arkoosh et al. allocated women randomly to receive labour analgesia via a 28-G single-orifice intrathecal catheter or a 20-G single-orifice epidural catheter [37]. In patients allocated to the intrathecal catheter group, analgesia was provided with a sufentanil infusion, with 2.5 mg bupivacaine (up to three doses) given only for rescue analgesia or operative vaginal delivery. If caesarean delivery was required, up to five doses of 5 mg bupivacaine (baricity not stated) were given. Of 322 women allocated to the intrathecal catheter group, 24 required an operative vaginal delivery and 43 a caesarean delivery. Details on top-ups and their complications were not presented. Two women requiring caesarean delivery needed conversion to general anaesthesia: one because of extreme urgency; the other because of catheter dislodgement during transfer to the operating theatre. No further details were presented.

A prospective case series by Dresner and Pinder described outcomes of intentionally placed 24-G intrathecal catheters for caesarean delivery in patients with cardiac conditions [66]. Successful anaesthesia was achieved in 33 out of 34 women. Hyperbaric bupivacaine 0.5% was administered in 1.25 mg increments every 3 min following an initial injection of 300 µg diamorphine. In contrast to other studies, Dresner and Pinder gave details on intra-operative analgesic supplementation which was required by 8/33 women, but no conversions to general anaesthesia were reported. Of note, due to the complex cardiac conditions, the authors reduced their required block height for surgery to T8.

Case reports have described successful extension of labour analgesia with an intrathecal catheter for caesarean delivery with hyperbaric 15 mg bupivacaine and 0.3 mg morphine [48], and with 6.5 mg isobaric bupivacaine [68].

In the UK, hyperbaric bupivacaine 0.5% is the local anaesthetic used most widely when performing spinal anaesthesia for operative delivery. The spread of hyperbaric solutions is considered to be more predictable, producing fewer high blocks when compared with isobaric solutions [69], although this has not been assessed when topping-up via an intrathecal catheter.

There is a lack of evidence to suggest whether it is better to top-up an intrathecal catheter for operative delivery with the patient in a supine or slightly Trendelenburg position (both with uterine displacement) to achieve an adequate sensory block to T4. In the review by Moaveni, both hyperbaric and isobaric solutions are described as having been used successfully at caesarean delivery with patients in a supine position for top-ups [6].

The total volume of the top-up solution is dependent on the spread of the existing block which should be assessed before extension for operative delivery. To minimise the risk of a high block, top-ups should be given incrementally. However, the ideal incremental dose is not known. Doses up to 2.5 mg have been suggested [5–7], but evidence to support their safety, or that of larger increments, is lacking, as is evidence on additional top-ups that may be required to maintain anaesthesia during surgery. It would appear prudent to limit these to increments of 2.5 mg bupivacaine.

Similarly, the addition of adjuncts to the top-up solution given through an intrathecal catheter has not been studied. Adding further drugs increases the risk of drug error and delays administration. Consequently, the potential benefit of additional medication must be balanced against risk. Short-acting opioids such as fentanyl may improve the intra-operative quality of the block. However, if intrathecal fentanyl has already been administered during labour, its benefit may be reduced and adverse effects are more common. Long-acting opioids such as morphine or diamorphine may be given to improve the quality of postoperative analgesia. In several studies opioids were given independently of a local anaesthetic top-up.

Evidence on topping-up an intrathecal catheter for operative vaginal delivery is also lacking. Supplementation with 1 ml boluses of bupivacaine 0.25% is reported in some studies [37, 65], but details are not included in others. If the success of operative vaginal delivery is in doubt, the catheter should be topped-up for a potential caesarean delivery.

- **Labour intrathecal analgesia may be extended to provide anaesthesia for caesarean delivery (high level of certainty).**
- **There is a lack of evidence to support the most appropriate local anaesthetic solution for extending labour analgesia with an intrathecal catheter for caesarean delivery or operative vaginal delivery (low level of certainty).**
- **Intrathecal long-acting opioid (300 μg diamorphine or 100 μg preservative-free morphine) may be given in addition to local anaesthetic for top-up for caesarean delivery (high level of certainty).**
- **Intrathecal top-ups of local anaesthetic for caesarean delivery should be given incrementally, with each bolus limited to 2.5 mg bupivacaine (or equivalent) (Grade I, low level of certainty).**

Location and monitoring during anaesthesia via an intrathecal catheter

The development of the sensory block for operative delivery when extended via an intrathecal catheter may be less predictable than that observed after a single-shot spinal injection or an epidural bolus. Therefore, it is advisable to perform all high-dose intrathecal injections in the operating theatre rather than the delivery room.

The time between each incremental top-up has not been subject to scientific evaluation, but it appears prudent to wait at least 3 min between each increment [5, 66]. The response to each dose should be assessed and recorded before additional top-ups are given. In situations where urgent operative delivery is required, the risks and benefits of a shorter time interval between top-ups may be considered, although this increases the possibility of a high block and associated consequences.

National standards of patient monitoring should apply [70], with vigilance paid to blood pressure control with vasopressor support. The anaesthetist should be alert to the possibility of a high block, and the sensory level should be checked regularly with the frequency dictated by the clinical response [7]. Monitoring of the fetal heart rate should be continued in the operating theatre.

- **Extension of labour analgesia for caesarean delivery via an intrathecal catheter should be performed in an operating theatre (Grade B, moderate level of certainty).**
- **Individual intrathecal top-ups should ideally be given no more frequently than every 3 min with assessment of the block before each dose (Grade I, low level of certainty).**

- **Non-invasive blood pressure, ECG and oxygen saturations should be monitored throughout the duration of intrathecal anaesthesia (Grade A, high level of certainty).**
- **During intrathecal anaesthesia, block height should be assessed at least every 5 min until no further extension is observed (Grade I, low level of certainty).**

Safety considerations for use of intrathecal catheters in labour and for operative delivery

Institutional guidelines

All obstetric units which advocate insertion of an intrathecal catheter after inadvertent dural puncture should have clear written guidelines on their use to support staff and reduce risks [6, 7, 34, 71]. Guidelines should cover labour analgesia protocols and management of top-ups for operative delivery, provide a standardised algorithm for the management of breakthrough pain, and highlight key complications of intrathecal catheter use including how these should be managed.

- **All departments should have clear guidelines for the management of intrathecal catheters in labour and for delivery. These should highlight key risks, monitoring protocols and other safety measures (Grade A, low level of certainty).**

Drug administration

Although any staff member may stop an intrathecal infusion if a safety concern or complication arises during labour, only an anaesthetist should give bolus medications through an intrathecal catheter, or connect, commence and disconnect intrathecal infusions.

After the initial bolus dose has been given by an anaesthetist, the use of a closed-loop infusion system for maintenance of analgesia should be considered. Boluses for breakthrough pain should be administered through the pump whenever possible. The use of closed-loop infusion systems may help to mitigate the small risk of infectious complications, as well as the much greater risk of drug errors occurring secondary to frequent disconnections and re-connections of the catheter [6, 71].

Evidence is lacking regarding whether full aseptic precautions should be used when handling an intrathecal catheter [34, 71]. Thorough hand washing and application of a sterile pair of gloves before touching the catheter or filter is, however, advisable. All intrathecal medications must be preservative-free and given through a filter connected to the catheter.

- **To minimise the risks of infection, accidental overdose and drug errors, consideration may be given to the use of closed-loop infusion systems for intrathecal analgesia (low level of certainty).**
- **Only anaesthetists should administer top-ups through an intrathecal catheter, and connect, disconnect or reconnect the catheter and tubing (Grade A, low level of certainty).**

Consideration of the dead space of the intrathecal catheter and filter

Anaesthetists must account for the dead space of the intrathecal catheter and filter (usually between 0.5 ml and 1 ml) when giving top-ups in labour [6, 34, 71] or for operative delivery. When administering the first dose through an intrathecal catheter in labour, the dead space of the catheter and filter may contain saline if this has been used for priming. This has implications for how much of the initial dose is delivered into the subarachnoid space. A further top-up of up to 2.5 mg bupivacaine (or equivalent) may be required to establish satisfactory labour analgesia if the first dose is only partially effective.

Similarly, when topping-up an intrathecal catheter for caesarean or operative vaginal delivery, anaesthetists should be mindful that the dead space will initially contain whichever local anaesthetic and opioid solution has been used to provide labour analgesia. This will enter the subarachnoid space before the anaesthetic top-up employed for operative delivery. Flushing the intrathecal catheter with saline after each top-up in labour or at operative delivery is not recommended by the working party, since this may have unquantifiable effects on the baricity and dose of drug delivered to the patient.

- **Anaesthetists should account for the dead space of the intrathecal catheter and filter when administering top-ups in labour or for operative delivery (Grade B, low level of certainty).**

Multidisciplinary communication and handovers

The key safety concern with the use of an intrathecal catheter is the risk of accidental administration of an epidural dose, resulting in a high- or total-spinal. To reduce this risk, it is imperative that intrathecal catheters are clearly labelled on both the infusion pump and on the tubing immediately adjacent to the filter [6, 7, 38].

The insertion of an intrathecal catheter must be communicated verbally to the patient, attending midwife, resident obstetric team, midwife in charge of the shift and other anaesthetists who may be called to be involved in the

patient's care during labour or at the time of delivery [7, 34, 38]. Consideration should be given to placing a notice on the door of the patient's room to indicate that an intrathecal catheter is in use. An alert must be placed on multidisciplinary handover boards [6]. Whenever possible, a single anaesthetist should review and manage an intrathecal catheter. If this anaesthetist finishes their shift, responsibility should be handed over to a suitably experienced colleague who will subsequently take on responsibility for the management of the intrathecal catheter until its removal.

It is important that insertion and use of an intrathecal catheter is also communicated clearly in the patient's written notes (in electronic or paper form depending on unit protocol). Each individual staff group handover should highlight that the catheter is intrathecal rather than epidural, and staff should remain vigilant to possible intrathecal catheter complications. Some units suggest use of specifically designed intrathecal catheter records, with integrated safety and management protocols, and bright and identifiable colours which are also matched to corresponding equipment labels [72].

- **An intrathecal catheter should be clearly labelled adjacent to the filter and on the front of any infusion pump (Grade A, low level of certainty).**
- **The multidisciplinary team (including any non-resident staff who may be called to attend the patient during labour or delivery), must be made aware of the intrathecal catheter through both verbal and written communication, including at every handover (Grade A, low level of certainty).**

Complications of intrathecal catheters

Catheter failure

Neuraxial catheter failure in labour may be defined as the inability of the catheter to provide satisfactory analgesia. This may require replacement of an epidural catheter or use of an alternative form of pain relief. Failure may occur due to catheter migration, complete dislodgement at the level of the skin, inadequate dosing or from uneven drug spread despite optimal catheter management.

In the study by Arkoosh et al. comparing intrathecal and epidural catheters in labour, patients in the intrathecal catheter group had better initial analgesia and maternal satisfaction, although intrathecal catheters were associated with a higher incidence of catheter failure [37]. Many intrathecal catheter failures were due to catheter migration and dislodgement, and there were increased technical difficulties with intrathecal catheter insertion, use and removal.

Subsequent retrospective studies compared outcomes following inadvertent dural puncture in women managed with either an intrathecal catheter or a re-sited epidural [39, 40]. Using 19-G catheters, Jagannathan et al. reported that catheter replacement due to inadequate analgesia was more frequent with intrathecal catheters compared with re-sited epidurals (14% vs. 2% replacement rate, $p = 0.05$). Tien et al., however, found no significant difference in failure rate (intrathecal catheter 22% vs. re-sited epidural 13%, $p = 0.33$). Both studies suggested that intrathecal catheter failure was likely multifactorial. In most cases, failure was attributed to inadequate spread of local anaesthetic within the CSF that may have been exacerbated by low flow rates of intrathecal infusion, the use of single-orifice catheters and inconsistency in maintenance labour analgesia regimens between patients. In some cases, failure was believed to be due to catheter migration.

In a large, single-centre retrospective review of 761 obstetric patients by Cohn et al., the intrathecal catheter failure rate was 5.7% [38]. The failure rate was 2.8% after intentional dural puncture (utilised for complex cases), and 6.1% after inadvertent dural puncture. In 16.3% of cases where the catheter failed, it was felt that it had migrated out of the subarachnoid space. Complete catheter dislodgement at the skin occurred in 0.53% of patients.

Overall, intrathecal catheter failure after inadvertent dural puncture is comparable with epidural failure, which is quoted in the literature at between 3.5–32% [38, 39, 73, 74]. Despite a relative lack of anaesthetist familiarity in managing intrathecal catheters, most studies indicate that they can provide reliable labour analgesia [7]. A meta-analysis has shown a summary relative risk for adequate analgesia with an intrathecal catheter vs. a re-sited epidural catheter after inadvertent dural puncture of 1.05 (95%CI 0.83–1.32), indicating no significant difference between techniques [2].

Although block height should be readily titratable when using an intrathecal catheter, failure to extend the sensory block for operative delivery via an intrathecal catheter has been reported. Cohn et al. reported an overall failure rate of 3.5%, but this figure rose to 7.1% when only assessing those catheters that had previously been used for labour analgesia following inadvertent dural puncture [38]. Izquierdo et al. reported one failure in 16 cases [49]. Failure was defined as the need for conversion to general anaesthesia and neither study commented on the use of intra-operative supplementation. From such limited information, comparison with failure rates from other neuraxial techniques is unwise. However, as intrathecal catheter failure may occur, it is important that alternative

methods of anaesthesia are planned should extension of the block not be possible. The choice of an alternative technique will depend on the spread of the intrathecal injectate, urgency of delivery, and anaesthetist and patient preferences.

- **Evidence does not suggest a difference in catheter failure and inadequate analgesia between an intrathecal catheter and a re-sited epidural catheter (moderate level of certainty).**

High- and total-spinal blocks

Inadvertent high neuraxial block requiring cardiovascular and/or respiratory support is a rare complication of obstetric neuraxial blocks. The incidence during spinal anaesthesia has been estimated to be approximately 1 in 4367 cases [75]. It is more common when spinal anaesthesia is attempted following a failed epidural top-up.

Intrathecal catheter use has the potential for accidental overdose of local anaesthetic solutions, either during labour or at operative delivery. This is more likely if the anaesthetist is unaware of subarachnoid catheter placement. Inadvertent administration of an epidural dose of local anaesthetic via an intrathecal catheter has resulted in high- or total-spinal blocks, hypotension and even respiratory or cardiac arrest [7, 31, 34, 38, 39, 76]. Cohn et al. reported three high blocks in 761 cases of intrathecal catheter use in obstetric patients [38]. Although one case followed an accidental top-up with an epidural dose of local anaesthetic, the other two developed after administration of much smaller doses (3 ml chloroprocaine 3% and 1.6 ml hyperbaric bupivacaine 0.75% with 15 μg fentanyl); all patients required respiratory support.

The risk of dosing errors during intrathecal catheter use highlights the importance of clear labelling of catheters, with good communication and handover between healthcare professionals. This is particularly important during patient transfer to the operating theatre, since cases of administration of epidural doses via an intrathecal catheter have occurred during top-up for operative delivery [38].

As cases of high- and total-spinal anaesthesia have been reported after smaller doses, the anaesthetist needs to be vigilant in monitoring the patient for signs of developing a high block. The block height should be assessed at least once every 5 min until no further extension is observed. Increasing agitation, significant hypotension, bradycardia, upper limb weakness, dyspnoea or difficulty in speaking may indicate the need for intervention. If this occurs, the circulation should be supported with vasopressors and fluids, supplemental oxygen should be given and tracheal intubation and ventilation may be required.

Hypotension is common when converting labour neuraxial analgesia to anaesthesia for operative delivery. Its management is familiar to obstetric anaesthetists with the use of vasoconstrictors and intravenous fluids. Several studies have reported approaches to blood pressure management when using intrathecal catheters for operative delivery in patients with cardiac disease. Extrapolation of their recommendations should be done with caution when approaching the use of intrathecal catheters following inadvertent dural puncture in otherwise healthy patients. Appropriate fluid loading and vasoconstrictor use should be tailored to individual requirement. Given the more unpredictable onset of anaesthesia, increased vigilance is necessary.

Post-delivery respiratory depression necessitating naloxone infusion and assisted manual ventilation has been described following the administration of an epidural dose of local anaesthetic and morphine via an intrathecal catheter after a recognised inadvertent dural puncture in labour [38]. The anaesthetist was unable to aspirate CSF and, believing the catheter to be in the epidural space, gave standard epidural drug doses for caesarean delivery and postnatal analgesia. This shows the unreliability of catheter aspiration in determining catheter position. Failure to aspirate CSF, even when this has previously been possible, should not lead to the assumption that the catheter is in the epidural space. Since there is potential for a catheter to migrate over time, slow and incremental dosing must always be used when giving any top-up.

- **Failure to aspirate CSF from a catheter does not exclude positioning within the subarachnoid space (high level of certainty).**
- **Anaesthetists must be aware of the risk of high- or total-spinal anaesthesia when topping-up an intrathecal catheter, particularly if an epidural dose is inadvertently given through the catheter (high level of certainty).**
- **Appropriate fluid loading and vasoconstrictor use should be used when topping-up an intrathecal catheter for operative delivery (Grade A, moderate level of certainty).**

Postdural puncture headaches

These occur in 50–85% of patients following inadvertent dural puncture and are often debilitating [62, 77, 78]. It has been hypothesised that insertion of an intrathecal catheter after inadvertent dural puncture and leaving an intrathecal

Table 1 Summary of systematic reviews and meta-analyses evaluating the role of intrathecal catheters in preventing postdural puncture headache (PDPH) and epidural blood patch (EBP) after observed inadvertent dural puncture.

Author	Number of studies included in review or meta-analysis	Findings
Apfel [82]	6 (5 full papers, 1 abstract)	No reduction in incidence of PDPH or need for EBP in patients who had received an intrathecal catheter
Heesen [80]	9 (6 full papers, 3 abstracts)	No difference in PDPH rates but reduced requirement for EBP
Heesen [2]	13 (12 full papers, 1 abstract)	Relative risk (RR) in PDPH 0.82 (95%CI 0.71–0.95); RR in EBP 0.62 (95%CI 0.49–0.79) Finding negated by trial sequential analysis, which suggested insufficient data to exclude a type 1 error of statistical analysis
Deng [83]	13	Intrathecal catheter significantly reduced the incidence of PDPH (pooled RR 0.82, 95%CI 0.70–0.97, p = 0.018) and requirement for EBP (pooled RR 0.62, 95%CI 0.44–0.86, p = 0.004)
Creazzola [84]	16	Intrathecal catheter significantly reduced incidence of PDPH compared with epidural catheter replacement (pooled RR 0.81, 95%CI 0.72–0.91, p < 0.001)

catheter in place for a prolonged period reduces the incidence of headache [44, 79]. The proposed mechanism is two-fold: through physical blockage of the dural tear reducing CSF loss; and/or through inducing a fibrous, inflammatory reaction promoting a seal of the dural tear [80, 81]. However, as catheters are inert and should not generate an inflammatory reaction, the first mechanism would appear to be the more likely explanation.

Several systematic reviews and meta-analyses have evaluated the role of intrathecal catheters in preventing PDPH after an observed inadvertent dural puncture [2, 80, 82–84] (Table 1). Data contributing to these reviews and analyses are mostly retrospective, comparing different populations and outcomes. Furthermore, trial sequential analysis has suggested that there are insufficient data within current meta-analyses to exclude a type 1 error [2].

A single prospective multicentre study investigated either repeating the epidural or converting to intrathecal analgesia following inadvertent dural puncture [85]. Units were randomised to either repeat the epidural or convert to intrathecal analgesia. Primary outcomes were the incidence of PDPH and need for an epidural blod patch. Although underpowered to detect a significant difference in outcomes, converting to intrathecal analgesia did not affect PDPH or epidural blood patch rates. Factors associated with an increase in headache included: anaesthetist experience (RR 1.02 per year difference in experience, 95%CI 1.001–1.05, p = 0.043); size of the epidural needle (16-G vs. 18-G needle RR 2.21, 95%CI 1.4–2.6, p = 0.005); and mode of delivery (spontaneous vaginal compared with caesarean delivery) (RR 1.58, 95%CI 1.14–1.79, p = 0.02).

With regards to PDPH and epidural blood patch, the 2023 International Consensus Practice Guidelines on PDPH stated that current evidence was insufficient to confirm that placement of an intrathecal catheter decreased the risk of PDPH and epidural blood patch [9]. More recent evidence from a retrospective study of 550 inadvertent dural punctures in labour, found no significant difference between intrathecal catheters and re-sited epidurals in the rate of PDPH [3]. However, fewer women in the intrathecal catheter group received an epidural blood patch (adjusted OR 0.82, 95%CI 0.73–0.91, p < 0.001). Further work is needed to clarify whether an intrathecal catheter reduces the need for an epidural blood patch.

- **Current evidence does not suggest a difference in the rate of PDPH between an intrathecal catheter and a re-sited epidural catheter, although evidence on the requirement for epidural blood patch is conflicting (moderate level of certainty).**

Neurological complications

Following reports of the use of micro-catheters (smaller than 24-G) for continuous spinal anaesthesia in 1990 [36], a cluster of cauda equina syndrome cases was reported in non-obstetric patients [86]. In three of the four cases reported, large doses of local anaesthetic (usually hyperbaric lidocaine 5%) had been administered via 28-G catheters, with repeated doses given due to inadequate block levels for surgery. Subsequent investigations revealed that intrathecal lidocaine is more likely to be associated with permanent nerve damage [87]. Poor flow through the micro-catheters results in pooling of concentrated local anaesthetic around the cauda equina, which on repeated dosing increases the risk of neurotoxicity. In 1992, spinal micro-catheters (smaller than 24-G) were removed from

clinical practice by the US Food and Drug Administration, although they have continued to be used elsewhere [88–90]. These cases increased awareness of the potential for neurological complications when using continuous spinal anaesthesia via both micro- and macro-catheter techniques.

In the review by Horlocker et al., which included a subset of 127 patients who had 28-G intrathecal catheters intentionally placed for labour analgesia or for caesarean delivery, no cases of cauda equina syndrome or persistent paraesthesia were reported [90]. Similarly, in the trial by Arkoosh et al., there were no cases of permanent neurological deficits (including cauda equina syndrome) [37]. In both studies, intrathecal catheters were intentionally inserted via a spinal needle, rather than after inadvertent dural puncture during epidural insertion.

In the obstetric population, there have been isolated case reports of lumbar and cervical radicular symptoms associated with injection through an intrathecal catheter after inadvertent dural puncture, all of which resolved in the early postnatal period [91, 92]. There have been no reports of damage to the conus medullaris from an intrathecal catheter, although such damage has been reported secondary to direct trauma from spinal needles [93]. Several large retrospective reviews in obstetric patients who had an intrathecal catheter placed after inadvertent dural puncture have failed to identify cases of neurological complications (cauda equina syndrome, spinal or epidural haematoma or other neurological injury) [38, 39].

Postdural puncture headache development following inadvertent dural puncture has been associated with the development of other serious neurological sequelae including subdural haematoma and cerebral venous sinus thrombosis [94]. In the 2009–2012 MBRRACE-UK report, there was one death from each of these complications following inadvertent dural puncture [95]. While subdural haematoma has been described as occurring while an intrathecal catheter was in place after delivery, the primary cause of the haematoma was considered to be the initial inadvertent dural puncture, rather than use of the intrathecal catheter. Insertion of an intrathecal catheter or epidural blood patch does not, however, eliminate the risk of such a complication subsequently developing [42, 43, 94].

- **There is insufficient evidence to determine differences in the incidence of neurological complications between those who have an intrathecal catheter and those who have a re-sited epidural catheter (low level of certainty).**

Infectious complications

Central neuraxial infection is a concern with intrathecal catheter use as the dura is breached and the catheter placed within the CSF adjacent to nerve roots and meninges. Micro-organisms may enter the central nervous system via several routes, most commonly from seeding of skin organisms along the catheter track. There may be contamination from the anaesthetist's nasopharynx at the time of inadvertent dural puncture. Less commonly, bacteria may enter from contaminated equipment or local anaesthetic solution or spread through the patient's bloodstream [96]. In a 2005 OAA survey, 60% of units cited anxiety regarding infection as one of the main reasons for removing an intrathecal catheter immediately after delivery [33].

The risk of infectious complications from intrathecal catheter use is likely related to both duration of catheter placement and the attention to asepsis during its insertion and subsequent management. As evidence suggests that leaving an intrathecal catheter in place after delivery does not reduce the likelihood of PDPH or epidural blood patch, the benefit of providing ongoing postnatal analgesia through an intrathecal catheter is likely outweighed by the small, but potentially serious, risk of infectious complications.

Fortunately, the risk of infectious complications after an obstetric neuraxial technique is extremely low [94, 97, 98]. Several reviews have not identified cases of meningitis, arachnoiditis or abscess after inadvertent dural puncture and use of intrathecal catheters in labour or at delivery [38, 39, 90]. However, the number of women in these studies was small. There has been one report of meningitis in an obstetric patient who had an intrathecal catheter sited after inadvertent dural puncture. The anaesthetist did not wear a face mask during insertion and the catheter was capped off but kept in place for 36 h after vaginal delivery [47]. The patient developed back pain, non-positional headache and worsening fever, and *Staph epidermidis* was identified in the CSF. After intravenous antibiotics and critical care admission, the woman made a full recovery with no neurological sequelae.

Both accidental disconnection of the intrathecal catheter with continued CSF leak and development of CSF-cutaneous fistulae have been reported after intrathecal catheter use following inadvertent dural puncture in the obstetric population [7, 51, 99]. These complications carry a potential route for micro-organisms to enter the CSF, either directly or as a result of an epidural blood patch to treat a resulting PDPH. Antibiotic prophylaxis and skin sutures may be required if a CSF-cutaneous fistula is confirmed by biochemical analysis of the leaking fluid.

An intrathecal catheter should be removed if an accidental and unwitnessed catheter disconnection occurs as this is likely to increase the risk of infectious complications. Care must be taken to ensure the integrity of connectors throughout the duration of intrathecal catheter placement, and consideration should be given to the use of closed-loop drug delivery systems to minimise infection risk.

- **The risk of infectious complications following obstetric neuraxial blockade is low (high level of certainty).**
- **An intrathecal catheter should be removed if an accidental and unwitnessed disconnection between catheter and bacterial filter occurs (Grade I, low level of certainty).**
- **Intrathecal catheters should be removed at the earliest opportunity following delivery to reduce the risk of accidental overdose and infectious complications (Grade B, low level of certainty).**

Effects on the fetus, labour and delivery

A meta-analysis has shown that the use of intrathecal opioids increases the risk of fetal bradycardia, although the risk of subsequent caesarean delivery is not increased [64]. One study of 79 women who had an intrathecal catheter inserted after inadvertent dural puncture reported fetal bradycardia as a complication [39]. This occurred in two patients (3%) who received bupivacaine and fentanyl (median initial doses 2.5 mg and 12.5 μg, respectively), followed by an infusion of bupivacaine 0.125% with 2 $\mu g.ml^{-1}$ fentanyl via patient-controlled infusion, continuous background infusion or a combination. It was not stated whether fetal bradycardia occurred on initiation of analgesia or during the maintenance infusion period.

In the study by Arkoosh et al. comparing continuous spinal with epidural analgesia, there was no difference in the rates of operative delivery, although a primarily opioid-based intrathecal analgesic regimen was used [37]. Similarly, in the retrospective study by Jagannathan et al. comparing obstetric outcomes between those women who had an intrathecal catheter after inadvertent dural puncture (n = 173) with those who had an epidural re-site (n = 63), there was no difference in the incidence of a prolonged second stage (13% vs. 16%, p = 0.57) or caesarean delivery rate (17% vs. 16%, p = 0.78) [40].

- **There is insufficient evidence to determine differences in fetal heart rate abnormalities between those who have an intrathecal catheter and those who have a re-sited epidural catheter (low level of certainty).**
- **There is insufficient evidence to determine differences in mode of delivery between those who have an intrathecal catheter and those who have a re-sited epidural catheter (low level of certainty).**

Follow-up after inadvertent dural puncture in obstetric patients

Complications of inadvertent dural puncture may arise in the hours following delivery or may take weeks to develop [77, 94]. Maternal deaths resulting from complications of inadvertent dural puncture show the importance of close follow-up and good multidisciplinary communication between maternity staff and primary care providers [100]. A proactive approach to patient follow-up has been further highlighted in several independent maternity investigations [101, 102].

Many units have written guidelines for the follow-up of women who develop a PDPH, including those who subsequently undergo an epidural blood patch. Information on postnatal headaches is available from the OAA [103]. Despite publication of national [104] and international guidance [9] on follow-up for PDPH patients, there is still considerable variation between units and between practitioners regarding how long follow-up should continue and what form it should take. Some units do not routinely follow up women who have had an inadvertent dural puncture if they do not develop a PDPH before hospital discharge.

Recommendations for obstetric patients who experience inadvertent dural puncture, regardless of whether this is managed with an intrathecal catheter, an attempted epidural re-site or an alternative strategy, should encourage standardised and consistent patient follow-up to ensure equity of care and to reduce the physical and psychological morbidity which may be associated with this iatrogenic complication.

- **Patients who experience inadvertent dural puncture, with or without intrathecal catheter insertion, should receive a full explanation of events and an apology. The explanation should include the intended management plan for provision of analgesia and anaesthesia for labour and delivery and post-delivery follow-up (Grade B, low level of certainty).**
- **All patients who experience inadvertent dural puncture, with or without intrathecal catheter insertion, should have a daily, in-person review by an anaesthetist while they remain in hospital (Grade B, low level of certainty).**

- **When patients who experience inadvertent dural puncture, with or without intrathecal catheter insertion, are discharged from hospital, follow-up should be in line with established guidance and include written information on headaches, `red flag´ symptoms, hospital contact information and communication with primary care (Grade B, low level of certainty).**
- **Patients who experience inadvertent dural puncture, with or without intrathecal catheter insertion, should be offered an anaesthetic debrief 6–8 weeks after delivery (Grade B, low level of certainty).**

Discussion

While the use of an intrathecal catheter after inadvertent dural puncture in the obstetric setting has gained increasing popularity over the last decade, there has been little formal guidance available in the literature on optimum management. Most anaesthetists will only have cause to insert an intrathecal catheter occasionally and a lack of familiarity with their use, coupled with a non-standardised approach to management, may result in suboptimal provision of analgesia and anaesthesia, as well as a greater propensity for complications. In response to these concerns, in 2023 the OAA convened the current authors to form a working party to review this topic. The working party was tasked with developing clear, useful and, as far as possible, evidence-based guidance on the use of intrathecal catheters for labour analgesia and operative delivery, with the aim of improving safety and standardising practice in intrathecal catheter management.

This guidance represents a comprehensive set of best practice guidelines and recommendations on the management of obstetric intrathecal catheters after inadvertent dural puncture. While the narrative review also discusses the use of local anaesthetics and opioids used more commonly overseas, the guidelines and final recommendations are predominantly aimed at those practicing obstetric anaesthesia in the UK. Indeed, the primary goal of the working party was to produce guidelines that would be of direct clinical use and relevance to any anaesthetist on a UK labour ward who may insert or manage an intrathecal catheter.

Particular detail has been included on drug selection and dosing for the initiation and maintenance of labour analgesia, management of breakthrough pain and top-up for operative delivery. In addition, there is extensive discussion of the potential complications of intrathecal catheter use in obstetric patients and the recommended safety precautions which should be implemented in order to mitigate these risks. Finally, since many complications of inadvertent dural puncture may not become apparent until some time has elapsed in the postpartum period, the guidelines provide practical recommendations on the follow-up of all patients who suffer inadvertent dural puncture, regardless of whether this is managed with an intrathecal catheter or a re-sited epidural catheter. The management of PDPH and the use of epidural blood patch fall outside the scope of this guidance but has been discussed extensively in other reviews in the literature.

There are some limitations to our guidelines. Despite the use of a broad range of search terms and a methodical, structured approach to the literature search, it is possible that other studies of relevance (particularly those before 1993, or those published in other languages) may have been overlooked. A lack of existing evidence on what constitutes best practice in the management of obstetric intrathecal catheters was one of the main drivers to the development of these guidelines. At the same time, however, this lack of high-quality evidence in the literature constitutes one of the main limitations of the guidelines we have produced. Due to better quality evidence being unavailable, many of the recommendations have been based on evidence from case reports and small studies, or on expert opinion and consensus only. Some of the statements and recommendations therefore necessarily have only a low level of certainty when applying the established US Preventive Services Task Force grading methodology.

We found few prospective studies on intrathecal catheter use. Most large studies were retrospective reviews looking at intrathecal catheter complications which occurred in one or two centres, and where local practices (catheter size/design, needle gauge and intrathecal drug regimens) also changed over the studied time period. The working party found no studies which directly compared different initiation or management techniques for intrathecal catheter labour analgesia or operative delivery. Many studies from the literature review related to intentional intrathecal catheter insertion following planned dural puncture with a spinal needle in the non-obstetric population, rather than intrathecal catheter insertion after inadvertent dural puncture on a labour ward. Consequently, the production of these guidelines has necessitated some extrapolation of practice from the non-obstetric population, and from the use of intrathecal catheters in situations other than after inadvertent dural puncture. We have also not specifically discussed the management of an intrathecal catheter for emergency caesarean or operative vaginal

delivery when there has been no time to use the catheter for prior labour analgesia.

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