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Neuraxial labor analgesia: Initiation techniques

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The ideal technique for labor analgesia would have a quick onset, predictable quality, and adjustable depth and duration. Moreover, it would be easy to perform and have minimal maternal and fetal side effects. A catheter-based neuraxial approach encompasses these desirable characteristics and includes the epidural, combined spinal epidural, dural puncture epidural, and intrathecal catheter techniques. In this review, we outline the unique technical considerations, analgesic characteristics, and side effect profiles for each technique that can ultimately impact the maternal–fetal dyad. The selection of neuraxial analgesia techniques should consider the patient and team's goals and expectations, the clinical context, and the institutional culture. Labor analgesic techniques that initiate with an intentional dural puncture component have a faster onset, greater bilateral and sacral spread, and lower rates of epidural catheter failure. Further elucidation of the mechanisms, benefits, and risks of each neuraxial initiation technique will continue to benefit patients and care providers.

Abbreviations: EPL, standard epidural technique; CSE, combined spinal epidural technique; DPE, dural puncture epidural technique; ITC, intrathecal catheter technique; IDP, inadvertent dural puncture; HELLP, hemolysis, elevated liver enzymes, low platelet count; PDPH, post-dural puncture headache; LOR, loss of resistance; CSF, cerebrospinal fluid.

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Introduction

Neuraxial techniques are often considered a singular method for providing effective labor analgesia with few maternal or fetal side effects; however, in contemporary clinical practice, a myriad of techniques and agents are used to both initiate and maintain analgesia. In this paper, we will consider the initiation of analgesia with the epidural (EPL), combined spinal epidural (CSE), dural puncture epidural (DPE), and intrathecal catheter (ITC) techniques. These catheter-based techniques allow extension of labor analgesia to surgical anesthesia and postoperative pain management if necessary, thereby minimizing the need, risks, and complications of systemic, inhaled (e.g., nitrous oxide), and general anesthetic agents. Ultimately, while the choice of neuraxial technique is individualized, factoring in the clinical context, institutional culture, and experience of the anesthesia provider(s), the selection and initiation of analgesia can have consequential impacts on the experience and outcomes for the maternal–fetal dyad. The preparation, techniques, and agents necessary to initiate neuraxial labor analgesia will be outlined.

Preparation

Management of patient expectations and inquiries

A vital element of successful neuraxial analgesia is determining the patient's goals and expectations related to the timing, spread, and quality of the sensory or motor blockade, and concerns regarding maternal or fetal side effects. Information sources, such as friends, the Internet, social media, and even published studies may create confusion, controversy, and concern. The use of dilute higher volume solutions of neuraxial local anesthetics combined with opioids allows for a greater maternal participation in the labor and delivery process [1], while simultaneously allaying concerns regarding the effect of neuraxial analgesia on the progress of labor and rate of cesarean delivery. Meta-analyses of trials comparing mixed parity parturients randomized to labor epidural analgesia, versus parenteral opioids, indicated a prolongation of the first and second stages of labor by 42 min and 14 min, respectively [2] and no association with higher rates of cesarean delivery [3].

Management of patient Co-morbidities: thrombocytopenia

Several co-morbidities (e.g., cardiac, musculoskeletal) have relevance to the initiation and use of neuraxial techniques, although hematologic issues are among the most pressing challenges, given their potential therapeutic responsiveness and association with catastrophic neuraxial bleeding and hematoma sequelae. The dilutional effects of an expanded plasma volume due to physiological changes in pregnancy decrease platelet counts with increasing gestation. However, fewer than 2% of pregnant women have severe thrombocytopenia ($<100 \times 10^9$/L) [4]. Obtaining a routine platelet count before neuraxial placement is not necessary for the healthy parturient and should be based on the patient's history, physical examination, and clinical signs [1].

Recently, an interdisciplinary consensus statement led by the Society for Obstetric Anesthesia and Perinatology (SOAP), in conjunction with the American Society of Regional Anesthesia and Pain Medicine (ASRA), the American College of Obstetricians and Gynecologists (ACOG), and the Society for Maternal-Fetal Medicine (SMFM) [5], concluded that the risk for spinal epidural hematoma associated with a platelet count $> = 70 \times 10^9$/L was very low in obstetric patients in the absence of other risk factors. When thrombocytopenia is associated with hypertensive disorders of pregnancy consistent with HELLP (hemolysis, elevated liver enzymes, low platelet count) syndrome, obtaining a platelet count within 6 h of neuraxial placement is recommended. When platelet counts are between 50 and 70×10^9/L, a clinical risk–benefit assessment should consider clinical, technical, and patient factors such as underlying etiology, speed, and severity of platelet decline; pre-existing bleeding conditions; concomitant medications; airway assessment; and difficulty in the neuraxial procedure. When platelet counts are below 50×10^9/L, avoidance of neuraxial procedures may be reasonable (Table 1). As a wide array of clinical permutations exist, clinical judgment, coupled with evidence-based insights on coagulation and fibrinolysis and point-of-care testing, may further refine care [6]. The initiation of analgesia resulting in a less dense sensory and motor blockade may allow earlier and ongoing assessment of block progression and more expedient resolution.

Table 1
The risk of spinal epidural hematoma [95% confidence interval (CI)] in parturients with thrombocytopenia and recommendations for neuraxial placement. The 95% CI value is estimated based on the rule of three [7] and may under- or overestimate the event rate [5,8,9].

Platelet Count	Recommendation	95% CI for risk of spinal epidural hematoma
70–99 × 10^9/L	May be reasonable to proceed	0–0.19%
50–69 × 10^9/L	Individualized risk/benefit analysis	0–2.6%
0–49 × 10^9/L	May be reasonable to avoid	0–9%

Preprocedural neuraxial ultrasound

Neuraxial ultrasound can identify midline structures, specific lumbar interspaces (typically L3–4 or L4–5), and the epidural space depth; however, the difficulty in performing a simultaneous real-time evaluation, the need for experience and training, and the inability to reduce vascular trauma, are inherent limitations at this time [10]. The epidural technique takes approximately 50 attempts to achieve a consistent and confident success [11]; the use of ultrasound can improve this learning curve [12,13]. Whereas the success rate of epidural techniques in parturients with easily palpable landmarks appears unaffected by the ultrasound use [14], there is a likely value when a “difficult placement” was experienced previously, when anatomic landmarks are not palpable (e.g., elevated body mass index), or when pathology exists (e.g., scoliosis, disc disease, and surgical interventions).

Techniques

The ideal technique for labor pain analgesia would have a quick onset, predictable quality, and adjustable depth and duration; moreover, it would be easy to perform and have minimal maternal and fetal side effects. Neuraxial techniques possess these characteristics, but with the limited duration of “single-shot” techniques, a catheter-based approach is most often used; these include the EPL, CSE, DPE, and ITC techniques.

Following placement, assessment of sensory level should occur in a caudad to cephalad direction and optimally on both sides in the mid-axillary line. Pinprick, cold (e.g., ice or ethyl chloride spray), or touch (e.g., neurotip [15]) are modalities frequently used to assess sensation; significant variation in stimuli response exists within and between individuals, with touch appearing to be the most reproducible stimulus [16]. Future modalities may include high-resolution thermography, which reveals progressive warming of lower extremities following epidural bupivacaine administration [17,18]. Motor strength (i.e., 5/5 = full, 4/5 = against resistance, 3/5 = against gravity, 2/5 = with gravity eliminated, 1/5 = trace, and 0/5 = none) should also be assessed; with the dilute analgesic solutions used in contemporary practice, a score less than 3/5 strength should alert the clinician to possible intrathecal placement or communication.

Epidural technique

Typically performed via a loss of resistance to air, saline, or a combination, with observed non-superiority of a single indicator [19], the epidural technique employs 17G–19G needles and uni- or multi-orifice 19G–20G catheters placed 4–5 cm into the epidural space. In laboring women, both uni- [20] and multi-port [21,22] catheters inserted 2–4 cm resulted in greater failed blockade (likely due to catheters moving out of the epidural space), whereas catheters inserted 6–8 cm had more one-sided blockade or venous trauma and cannulation [23]. The incidence of complete or partial epidural labor analgesia failure rates can be as high as 23%, with a wide heterogeneity due to a myriad of technical elements and variation in the definition of failures [24,25]. A few practical issues related to the failed epidural analgesia are discussed next.

Equivocal loss of resistance

Several anatomic elements may lead to an equivocal loss of resistance (LOR) and subsequent failed epidural block or inadvertent dural puncture. Using a midline approach, the epidural needle transects through the supraspinous and interspinous ligaments before entering the ligamentum flavum. Yet in magnetic resonance imaging (MRI) and cadaver dissection studies, fat-filled gaps in the interspinous ligament, approximately the size of an epidural needle tip [26], and midline gaps in the ligamentum flavum have been frequently observed [27,28]; the incidence of lumbar ligamentum flavum midline gaps is approximately 10%. While the paramedian, versus the midline, approach has been noted to provide a "crisp" LOR [29,30], venous trauma and possible cannulation are more likely, as the epidural venous plexus is mostly paramedian and significantly engorged in pregnancy [31]. Moreover, with the CSE and DPE techniques, a midline approach is optimal for spinal needle passage into the CSF (see below).

Sacral block sparing

The sacral nerve fibers, compared to lumbar nerve fibers, are more difficult to block due to their larger diameter and thicker myelin sheaths [32,33]; moreover, analgesic solutions administered in the lumbar epidural space have a greater propensity for cephalad, rather than caudal, spread [34]. As a consequence, sacral blockade following an EPL technique is often delayed, inadequate, or absent. Using a lower lumbar insertion point diminishes the distance to the sacral elements but does not appear to fully mitigate sacral sparing. In parturients randomized to ultrasound-guided epidural catheter insertion at the L2–3 or L3–4, compared to the L5–S1 interspace, a similar incidence of S2 blockade was observed 30 min after 10 mL of 0.125% bupivacaine (81% vs. 91%, $p = 0.24$) [35].

Epidural catheter fixation

The parturient women, especially those with high body mass index (BMI), placed in a seated curved position for catheter insertion should be repositioned to a seated relaxed or preferably a lateral recumbent position prior to fixing or taping the catheter in place [36]. Repositioning allows soft tissues to relax (up to 4 cm in BMI >30) around the catheter, retaining the desired catheter length (5 cm) in the epidural space. Epidural catheter migration can be minimized by drying the insertion site, enhancing adhesion by application of tincture of benzoin and Tegaderm™ tape or other securement devices. An underpowered ($n = 165$) randomized controlled trial of three commercial catheter securement devices Epi-Fix™ (ConvaTec Limited, Deeside, UK), Tegaderm™ (3M Healthcare, St. Paul, MN, USA), and LockIt Plus® (Smiths Medical International Limited, Ashford, UK) found migration (median [range]) was least for the LockIt Plus® device: (1.0 [−2.0 to 9.5] cm, 0.5 [−1.5 to 8.0] cm, and 0.0 [−1.0 to 5.5] cm, respectively, $p = 0.003$) [37].

Combined spinal epidural technique

The CSE technique uses an epidural needle to puncture the ligamentum flavum, which then serves as an introducer for a longer spinal needle (typically 25G–27G). Advancement of the spinal needle finds resistance that increases at the curved end of the epidural needle (unless there is a separate linear exit hole) and then suddenly decreases (e.g., "pop") with passage through the dural ligament. The return of cerebrospinal fluid (CSF) represents an objective endpoint that is further confirmed with a response to the spinal administration of a local anesthetic, opioid, or both. The spinal needle is withdrawn and the epidural catheter is placed and connected to an infusion pump for the maintenance of analgesia.

The CSE technique harnesses the spinal and epidural spaces to achieve rapid and ongoing labor analgesia [38]. A Cochrane review found a faster onset time from injection to effective analgesia with the CSE vs. EPL technique (mean difference −5.42 min; 95% CI, −7.26 to −3.59), with more women achieving effective analgesia at 10 min (relative risk 1.94; 95% CI 1.49 to 2.54) [39]. The CSE technique also allows a more uniform spread of analgesia resulting in lower catheter failure and higher maternal satisfaction [38].

Depending on the dose used, the initial spinal analgesia of the CSE technique may result in an untested epidural catheter. However, compared to the EPL technique, a large ($n = 2395$) single-center retrospective cohort study found catheters associated with the CSE technique less likely to fail for labor analgesia (hazard ratio 0.58; 95% CI 0.43 to 0.79; $p = 0.0002$) and no difference in the time to recognition of poorly functioning catheters [40].

Augmented uterine tone

The CSE technique and parenteral opioids have a lesser association with instrumented deliveries when compared to intermittent epidural boluses of concentrated (0.25%) bupivacaine [41]. Moreover, when nulliparous, less than 3 cm dilated, parturients were randomized to a CSE technique with 1 mL of spinal 0.25% bupivacaine, versus an EPL technique with 12–15 mL of 0.25% bupivacaine, more rapid cervical dilation and progress of labor was observed [42,43]. The uterine reactivity following initiation of the CSE technique can result in uterine hypertonus, which can necessitate the administration of a tocolytic (i.e., nitroglycerine, terbutaline); this occurs less commonly with the DPE and EPL techniques [44]. Table 2 indicates sample labor analgesia regimen for the CSE technique.

Fetal bradycardia

The CSE, versus EPL, technique is associated with an increased risk of fetal bradycardia (odds ratio 1.81; 95% CI 1.04 to 3.14), with a number needed-to-harm of 28 [45], and a mean (SD) onset of 24.1 (16.9) min [46,47]. The underlying mechanism for fetal bradycardia following CSE initiation has not been fully elucidated, although a plausible theory is an abrupt reduction in catecholamines [48,49].

A more rapid decline in epinephrine (e.g., a tocolytic) versus norepinephrine results in a sudden net loss of beta-2 agonist activity, which can present as uterine irritability, tachysystole, and tetanic contractions. If prolonged, uterine hyperactivity can lead to placental hypoperfusion and fetal bradycardia [50,51]. Although a mostly transient event with no increase in the incidence of cesarean delivery or adverse neonatal outcomes, the fetal bradycardia can prompt parental anxiety and provider (i.e., nursing, obstetric, and anesthetic) presence and concern.

Management involves basic measures for intrauterine resuscitation (i.e., call for assistance, stopping oxytocin, correcting maternal hypotension, administering oxygen and bolus fluid, and instituting left uterine displacement) and administration of tocolytic agents (e.g., nitroglycerin or terbutaline). There are currently no known effective prevention measures, although some studies have found an association between higher doses of intrathecal opioids and increase in fetal heart rate abnormalities [52]; however, other studies have found no differences in the rates of fetal bradycardia with initial CSE fentanyl doses of 2.5 mcg, 5 mcg, 10 mcg, and 15 mcg [53]. Although catecholamine imbalance is currently the predominant theory, the prophylactic use of intravenous ephedrine 10 mg IV administration at the time of CSE placement has been ineffective in reducing the risk of fetal bradycardia [54].

Pruritus

A higher incidence of pruritus is observed after the CSE technique, compared to other epidural initiation techniques, when intrathecal opioids are used. The time to the maximum effect and resolution of pruritus is approximately 15 min and 45–60 min, respectively [55,56]. The opioid dose–response relationships to analgesia and pruritus are identical [57] and can be reversed by mu opioid receptor antagonists [58]; thus, lower opioids doses (e.g., fentanyl 10–15 mcg) and treatment with low-dose intravenous nalbuphine (2.5–5 mg) can reduce severe cases of pruritis. Nalbuphine is a mixed agonist–antagonist that produces an analgesic effect at kappa and mu opioid receptors; due to its high affinity for mu opioid receptors, it can block and, therefore, treat the pruritis effect from mother opioids [59,60].

Table 2
Sample labor analgesia dosing regimen for the CSE technique.

	Route	Agent	Volume	Dose
Initiation	IT	Bupivacaine 0.25%	0.8–1 mL	2–2.5 mg
	IT	Fentanyl 50 mcg/mL	0.2–0.3 mL	10–15 mcg
Maintenance, continuous infusion no PCEA bolus	EPL	0.08%–0.125% Bupivacaine + Fentanyl 2 mcg/mL	6–10 mL/h	2.4–12.5 mg/h bupivacaine +12–20 mcg/h fentanyl
Inadequate Analgesia	EPL	0.125% Bupivacaine	6–10 mL bolus	2.4–12.5 mg bolus

EPL. epidural; IT, intrathecal; PCEA, patient-controlled epidural analgesia.

Dural puncture epidural technique

The dural puncture epidural (DPE) technique provides labor analgesia that improves the block quality issues associated with the EPL technique (e.g., slow onset, unilateral and sacral block sparing) without the side effects associated with the CSE technique (e.g., fetal bradycardia, uterine hypertonus, and pruritus). The technique has been investigated for labor analgesia and anesthesia by Tsen and colleagues, who coined the name and DPE acronym [61]. The DPE technique introduces an epidural needle, uses a spinal needle within the epidural shaft to create a dural puncture with CSF return, but it omits the direct administration of medications into the CSF. The spinal needle is withdrawn and the epidural catheter is threaded and dosed. The initial and ongoing analgesia is achieved by agents that traverse the dural puncture conduit into the intrathecal space and by those that remain within the epidural space; this translocation of agents has been demonstrated in radiographic (e.g., contrast and fluoroscopy) [62], *in vitro* [63] and cadaveric dye studies [64].

Technical considerations

The selection of a pencil point spinal needle to perform a DPE versus CSE technique requires a few additional considerations. First, the spinal needle should have a diameter larger than that of a 27G needle for effective translocation (Table 3). Bernards et al. indicated that the flux of lidocaine and morphine was no different with and without a 27G dural puncture of meningeal tissues mounted in an *in vitro* diffusion cell [63]. Similarly, in a clinical setting, Thomas et al. found no difference in analgesic onset or quality in laboring women who had undergone a 27G DPE versus an EPL technique [65].

By contrast, when larger-diameter spinal needles (i.e., 25G or 26G) are used, Contreras et al. found a significantly faster onset of a DPE technique with a 25G versus 27G spinal needle [66]. Similarly, when the DPE technique with 25G and 26G needles was compared to the EPL technique, improved labor analgesia onset and block quality (e.g., more S2 block coverage, lower PCEA use, and greater bilateral symmetric blockade) were observed [44,61,67,68]. One study that used a DPE technique with a 26G needle observed a difference in analgesic onset only [69].

Table 3
Summary of randomized clinical trials in the obstetric population using the dural puncture epidural technique.

Study	Spinal needle size used for DPE	Total initial epidural volume, including test dose (test dose volume)	Initial Epidural Solution (test dose)	Maintenance Technique	Key Findings
Thomas et al. [65]	27G Whitacre	10 mL (2 mL)	2% Plain Lidocaine (2% Plain lidocaine)	CEI	No difference
Cappiello et al. [61]	25G Whitacre	12 mL	0.25% Bupivacaine	CEI	Improved onset and block quality
Chau et al. [44]	25G Whitacre	20 mL	0.125% Bupivacaine	CEI	Improved onset and block quality
Wilson et al. [69]	26G Whitacre	15 mL (3 mL)	0.125% bupivacaine with 50 mcg fentanyl (1.5% lidocaine with epinephrine 5 mcg/mL)	CEI	Improved onset No difference in block quality
Contreras et al. [66]	27G and 25G Whitacre	20 mL	0.125% Bupivacaine + fentanyl 2 mcg/mL	CEI	Improved onset in the 25G needle
Song et al. [67]	25G Whitacre	13 mL (3 mL)	0.1% ropivacaine + 0.3 mcg/mL sufentanil (1.5% Lidocaine with epinephrine 5 mcg/mL)	CEI and PIEB	Improved onset and block quality
Wang et al. [68]	25G Whitacre	10 mL	0.08% ropivacaine + 0.4 mcg/mL sufentanil	PIEB	Improved onset and block quality

CEI, continuous epidural infusion; PIEB, programmed intermittent epidural bolus.

Second, the optimal length of a maximally inserted spinal needle should be just 10–20 mm longer than the epidural needle (Table 4). If less than 10 mm, the spinal needle may not reach the dura even if the epidural needle is perfectly positioned in the epidural space; if greater than 20 mm, the spinal needle can puncture the dural sac without the epidural needle being in the epidural space, which is only 4–6 mm wide in the lumbar segments. Failure to obtain CSF with an appropriate-sized spinal needle may indicate [1] the need to further advance the spinal needle or, if already fully engaged, the needle should be withdrawn, the epidural needle advanced, and then spinal needle reintroduced or (2) the epidural and spinal needles are off midline and should be re-oriented. A subgroup analysis of laboring parturients who had an epidural catheter inserted following an attempted DPE technique, where the dural puncture was unable to obtain CSF confirmation, had a significantly higher epidural catheter replacement rate than when the dural puncture was successful (22% vs. 9.3%) [65].

Clinical features of the DPE technique

The DPE technique has an intermediate onset of action compared to the CSE and EPL techniques. The median (IQR) time to achieve a numeric rating scale score of 1 during early labor was 2 (0.5–6) min for CSE, 11 (4–120) min for DPE, and 18 (10–120) min for EPL [44]. The analgesic onset is reflective of the symmetric sacral coverage afforded by the DPE and CSE techniques. Chau and colleagues [44] observed that S2 blockade at 20 min was achieved by 100% parturients in the CSE and DPE groups compared to only 62.5% in the EPL group, with 5% in the EPL group never experiencing an S2 blockade for the entire duration of labor. A related, yet novel, finding of this study was that the DPE technique had significantly fewer physician top-up interventions compared to CSE and EPL techniques (RR 0.45; 95% CI 0.23–0.86; $P = 0.012$). Requests for additional analgesia occurred with the CSE technique when the spinal portion transitioned to the epidural portion, and with the EPL technique when patchy, unilateral, or sacral sparing blocks were revealed. Supportive of this explanation with the CSE technique, Patel et al. [73] observed an increase in the minimum local analgesic concentrations (MLAC) of epidural bupivacaine by a factor of 1.45 ($p = 0.026$) for second injections in patients who received CSE (2.5 mg bupivacaine with 5 mcg fentanyl) compared to EPL analgesia (20 mL 0.1% bupivacaine and 2 mcg/mL fentanyl) techniques.

Potential risks

The risk of meningitis following dural puncture is rare, not infrequently related to aseptic technique violations [74]and not higher for CSE and DPE techniques than EPL techniques [75,76]. Similarly, the incidence of post-dural puncture headache (PDPH) is low (<1%) and not higher with CSE and DPE techniques compared to EPL technique. In a large meta-analysis of 57 studies ($n = 16{,}416$), pencil point needles were found to have a significantly lower incidence of PDPH than cutting needles (RR 0.41; 95% CI 0.3–0.54, $p < 0.001$) and no significant difference in rates due to the needle gauge (range 22–27G); by contrast, significantly higher rates of PDPH occurred with smaller gauge, larger diameter cutting needles [77]. Female gender, but not obstetric (vs. non-obstetric) surgery, was found to have a lower incidence of PDPH. Whether the incidence of PDPH following DPE or CSE technique is altered by CSF influx or efflux with the infusion of labor analgesia agents or maternal pushing during labor is unknown. Large population-level cohort studies on the DPE or CSE technique will help further clarify risks associated with these techniques.

Table 4
Distance of spinal needle protrusion from epidural needle tip and incidence of failed dural puncture.

	Distance of spinal needle protrusion from epidural needle tip	Failed dural puncture with no CSF obtained
Riley ET et al. [70]	9 mm	17%
Joshi et al. [71]	10 mm	15%
Thomas et al. [65]	12.5 mm	14%
Joshi et al. [71]	13 mm	3%
Hoffmann VLH et al. [72]	15 mm	1.3%
Riley ET et al. [70]	17 mm	0%

CSF, cerebrospinal fluid

Continuous spinal technique

The oldest catheter-based neuraxial technique is the continuous spinal technique, also called an intrathecal catheter (ITC), which is effective and reliable but limited by PDPH and other complications. In an attempt to reduce the incidence of PDPH, continuous spinal labor analgesia transitioned from the use of *macro*-(18G–20G) to *micro*- (28G–32G) catheters. While a reduction in PDPH was observed, an increase in the frequency of transient (0.4%) and permanent (0.1%, e.g., cauda equina syndrome) deficits was also reported [78,79]. The postulated causes of CES include a caudal orientation of the catheter tip [80], restricted flow rates, and high local anesthetic concentrations (i.e., 5% lidocaine), resulting in pooling by the nerves [81]. Postspinal pain syndrome (PSPS, also called transient radicular irritation) occurs more frequently in female, ambulatory patients who have been in the lithotomy position. Serious neurological complications, including meningitis, epidural or spinal abscess, hematoma, arachnoiditis, or cauda equina syndrome, are uncommon [82].

There are several potential advantages of using an ITC technique: the analgesia onset is rapid, with a dense and symmetric blockade, minimal medication is needed, and conversion to surgical anesthesia is reliable. In the largest randomized clinical trial of continuous spinal vs. continuous epidural analgesia in obstetric patients ($n = 100$), those who received an ITC with a 28G microcatheter ($n = 329$) had significantly lower pain scores for 60 min after initial drug injection, greater median maternal satisfaction score at 24 h postpartum ($p = 0.004$), and less motor blockade; however, the ITC group had a higher incidence of pruritus and PDPH [83].

The incidence of PDPH is higher with macro-catheters, as a function of the larger 17G–18G epidural needle used to create a dural puncture; consequently, ITC as a *de novo* initiation technique is not routinely used, except in certain clinical situations (e.g., morbid obesity or following an inadvertent dural puncture, IDP, see below). Although a recent meta-analysis found the incidence of PDPH and need for EBP was significantly reduced when an ITC was placed after an IDP, the trial sequential analysis indicated that a false-positive result could not be excluded [82].

Inadvertent dural puncture

When an inadvertent dural puncture (IDP) occurs, one approach is to re-site the epidural catheter at a different location, although this takes time, involves more attempts, and carries a 10% risk of another ADP [84]. An alternative approach is to insert and use the epidural catheter for continuous spinal analgesia. There is no consensus on the best course of action, however, which depends on individual and institutional practices. The main concern about an ITC is the risk of inadvertent administration of epidural doses, which can result in a high or total spinal and hemodynamic consequences. However, an ITC may be the most prudent alternative in some clinical situations, particularly when multiple prolonged attempts have been made, significant parturient distress is present, and delivery appears imminent [85].

Among the issues to consider when an ITC is initiated after IDP is the efficacy of the blockade. Most studies on ITC after IDP indicate similar or better analgesic quality than with a re-sited epidural catheter (RR 1.05; 95% CI 0.83–1.32) [84,86,87], although one retrospective study ($n = 235$) found higher failure rates requiring replacement with ITC (14% vs. 2%, $p \leq 0.01$) [88]. Postulated reasons for this observation may be the conservative management of an ITC, often due to limited provider experience with the technique.

The second issue to consider is whether to remove the ITC within 2 h or 24 h postpartum. Three retrospective studies found a reduced incidence of both PDPH and the need for an epidural blood patch (EBP) when the ITC was left *in situ* for at least 24 h postpartum compared to being removed immediately [89–91]. The extended time is purported to facilitate dural repair by fibrosis, as demonstrated in animal studies [92,93]. Whereas a prospective study did not observe a significant difference in PDPH rates in which ITCs were left *in situ* for 24–36 h versus the epidural procedure being repeated at another interspace, the mode of delivery may have an impact [94]; a lower incidence of PDPH was found in patients with an ITC who delivered via cesarean, versus vaginal delivery, perhaps due to CSF efflux that occurs with the strenuous Valsalva breathing patterns used for delivery.

Table 5
Sample labor analgesia dosing regimen using the intrathecal catheter (ITC) technique.

	Route	Agent	Volume	Dose
Initiation	IT	Bupivacaine 0.25%	0.8–1 mL	2–2.5 mg
	IT	Fentanyl 50 mcg/mL	0.2–0.3 mL	10–15 mcg
Maintenance, continuous infusion no PCEA bolus	IT	0.08% Bupivacaine + Fentanyl 2 mcg/mL	3 mL/h	2.4 mg/h bupivacaine +6 mcg/h fentanyl
Inadequate analgesia	IT	0.08% Bupivacaine	1 mL bolus, then increase infusion by 0.5 mL increments aiming for sensory level of T4	0.8 mg bolus then +0.4 mg/h to infusion aiming for sensory level of T4

PCEA, patient-controlled epidural analgesia.

Initiation of intrathecal catheters

The initiation of labor analgesia (and anesthesia when required) via an ITC should acknowledge the direct conduit to the CSF, which highlights the need for strict asepsis and “spinal doses” of agents for initiation and maintenance. Inadvertent administration of epidural doses of agents can lead to an almost immediate high or total spinal sequelae. As such, the catheter, pump, and anesthetic record should be clearly labelled “Spinal Catheter” so that all team members, including the patient, remain vigilant. When appropriate dosing is used, standard monitors are sufficient with no additional cardiovascular or respiratory monitoring; however, as with any analgesic technique, resuscitation medications and equipment (e.g., self-inflating bag) should be readily available.

Initiated with the same agents as the CSE technique for labor analgesia, a number of dosing strategies are available (Table 5) [39,95].

Agents used in epidural initiation

Epidural agents and adjuvants

The initiation of labor epidural analgesia has evolved significantly over the years. In an effort to minimize motor block, preserve maternal effort to push during the second stage, and lower the need for assisted vaginal delivery, initiation and maintenance solutions have become less concentrated (e.g., ≤0.1% bupivacaine or ≤ 0.17% ropivacaine) without compromising overall analgesic efficacy [96]. Some providers have also lowered the traditional lidocaine test dose or eliminated the use of lidocaine in the initiation of epidural analgesia altogether [97].

A combination local anesthetic (e.g., bupivacaine, ropivacaine, or levobupivacaine) and opioid solution (e.g., fentanyl or sufentanil) is often used to initiate the epidural catheter in a fractionated manner with the first dose serving as the test dose. With dilute solutions, the total loading volume (including test dose) of 10–15 mL in the epidural space is typically required, although higher volumes of up to 20 mL may be needed especially if a very dilute solution is used.

Neostigmine, clonidine, and dexmedetomidine have been investigated, but their value as adjuvants to neuraxial labor analgesia remains controversial and need further evaluation [98–100].

Spinal agents and adjuvants

The evidence for the use of intrathecal epinephrine is conflicting. One study found that adding epinephrine intrathecally at a dose of 12.5 mcg significantly prolongs the duration of intrathecal analgesia by approximately 25 min; higher epinephrine doses (i.e. 25, 50, or 100 mcg) produced no additional benefits [101]. By contrast, another study found epinephrine (100 mcg) did not significantly prolong the duration of intrathecal fentanyl alone or with bupivacaine, but it was instead associated with a higher incidence of severe nausea and motor block [102]. The use of intrathecal dexmedetomidine (10 mcg) and clonidine (75 mcg) as adjuvants or in place of intrathecal fentanyl has indicated no significant adverse effects in parturients undergoing vaginal [103] and caesarean delivery under spinal anesthesia [104,105].

Practice points

- The choice of neuraxial technique should be individualized and appropriate for the institutional culture, the experience of the anesthesia team, and the clinical context.
- Neuraxial ultrasound is particularly useful when difficult placement is anticipated, when spinous processes are not palpable, or when usual spine anatomy is distorted.
- The incidence of incomplete midline fusion of the lumbar ligamentum flavum is approximately 10%, which may contribute to an equivocal loss of resistance and accidental dural puncture.
- Labor and delivery units, where intrathecal catheters after inadvertent dural puncture are routinely used, should develop an institutional policy.
- Dural puncture is a hallmark of CSE and DPE techniques. Return of cerebrospinal fluid in the spinal needle can result in a lower risk of epidural catheter failure.
- The DPE technique should be performed with a 25G or 26G spinal needle that protrudes approximately 15 mm from the tip of the epidural needle tip when maximally inserted.

Research agenda

- Explore novel techniques and methods to minimize failure of neuraxial techniques and inadvertent dural puncture with an epidural needle.
- Elucidate the mechanisms for fetal bradycardia and uterine hypertonus, particularly after combined spinal epidural techniques, so these risks can be better identified and managed.
- Gather larger population data on the dural puncture epidural and intrathecal catheter techniques to better understand the benefits and risks; thus, more anesthetists would consider adding these techniques to their clinical practice.

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