Initiation and maintenance of modern neuraxial analgesia for labor, a narrative review

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Abstract

Effective management of labor pain is a cornerstone of modern obstetric anesthesia, with neuraxial techniques representing the gold standard. This narrative review explores current strategies for initiation and maintenance of neuraxial labor analgesia, focusing on the classic epidural (EPL), combined spinal–epidural (CSE), and dural puncture epidural (DPE), as well as maintenance methods including continuous epidural infusion (CEI), programmed intermittent epidural bolus (PIEB), and patient-controlled epidural analgesia (PCEA). A comprehensive literature search was performed across major databases, emphasizing prospective trials, systematic reviews, and meta-analyses.
Evidence suggests that while EPL remains widely used and reliable, it is associated with slower onset and risk of patchy block. CSE provides the fastest onset and reliable analgesia but carries a slightly higher risk of maternal hypotension, pruritus, and fetal bradycardia. DPE offers marginal improvements in onset and block quality compared to EPL, with fewer side effects than CSE, although its clinical advantages remain limited. For maintenance, PIEB has demonstrated superiority over CEI in terms of analgesic quality, motor block reduction, and maternal satisfaction. PCEA, whether alone or in combination, increases maternal autonomy, reduces physician interventions, and lowers local anesthetic consumption.
Overall, neuraxial techniques should be tailored to maternal and fetal needs, balancing rapid onset and reliable analgesia against potential side effects. CSE and PIEB emerge as strong candidates for initiation and maintenance respectively, while ongoing research is required to refine the role of DPE and high-volume PCEA in modern practice.

Keywords: **Labor, Obstetric [MeSH], Anaesthesia, Obstetrical [MeSH], Pain, Labor [MeSH], Initiation, Maintenance.**

Introduction

Labor pain is one of the most intense experiences many women will encounter in their lifetime, making effective pain management a crucial aspect of obstetric care. Neuraxial analgesia represents the gold standard for labor pain management, offering significant relief and contributing to a more positive labor experience. The ideal technique should provide rapid onset, consistent and adjustable analgesia, and be easily customizable to match both the intensity and duration required by the patient. Additionally, it should be straightforward to administer while minimizing side effects for both the mother and fetus. However, no single method meets all these criteria perfectly, as each technique has its own set of benefits and limitations.

There are three main options for the initiation of neuraxial analgesia: the classic epidural (EPL), the combined spinal-epidural (CSE) and the dural puncture epidural (DPE). The standard epidural technique has been widely used for decades and is known for its efficacy in pain control but is also associated with certain limitations, such as delayed onset of analgesia and the risk of a patchy or inadequate block. The CSE technique offers both immediate pain relief from the spinal component and prolonged analgesia from the epidural component, providing distinct advantages, like a faster onset of analgesia. Meanwhile DPE, a relatively new approach, seeks to combine the benefits of both previous techniques by facilitating the spread of analgesia through intentional dural puncture without intrathecal drug administration, potentially offering a balanced profile of efficacy and safety.

Techniques for maintenance of analgesia during labor and delivery should aim to provide adequate comfort for the parturient while minimizing adverse outcomes for both the mother and fetus. Historically physicians administered manual intermittent boluses to the parturients although this was labor-intensive and often unreliable. The introduction of continuous epidural infusion (CEI) and later programmed intermittent epidural bolus (PIEB) reduced the need for manual intervention by healthcare professionals. Patient controlled epidural analgesia (PCEA) was introduced in the 90's and gave patients greater autonomy in managing their pain.

The technique of the spinal catheter and continuous spinal anaesthesia offers excellent analgesia during labor, although it's more invasive than other epidural techniques. In modern practice it is used in cases of accidental dural puncture with the goal of reducing post-dural puncture headache and the need for an epidural blood patch[1,2]. This falls outside of the scope of this review and will not be discussed further.

Despite extensive use of these techniques, the available evidence still poses many questions regarding their comparative efficacy, onset of analgesia, side effects, and impact on labor outcomes. This paper aims to provide a comprehensive review of initiation and maintenance of neuraxial labor analgesia.

Methodology

A comprehensive search of electronic databases, including PubMed, Cochrane Library, Scopus, and Google Scholar, was conducted in March 2024 and repeated in March 2025 to capture the most current evidence. The search targeted studies published up to the time of review, prioritizing prospective trials, systematic reviews, and meta-analyses. MeSH terms included "Anaesthesia, Obstetrical," "Labor, Obstetric," "Pain, Labor," and "Parturition." Key free-text terms included "labour analgesia initiation," "labour analgesia maintenance," "epidural analgesia," "combined spinal-epidural analgesia," "dural puncture epidural," "continuous epidural analgesia," "programmed intermittent epidural bolus," and "patient-controlled analgesia." Titles and abstracts were screened for relevance, and full texts were reviewed when appropriate. Reference lists of included articles were manually searched using a snowballing approach to identify additional relevant studies. Articles were included if they reported outcomes related to quality of analgesia, maternal outcomes, or fetal outcomes. Retrospective studies were screened for relevance but excluded from the main synthesis (Fig. 1).

Initiation

Epidural analgesia (EPL)

The practice of administering medication in the epidural space has a history spanning over a century. This technique has undergone significant evolution and has become a cornerstone of obstetric anaesthesia. The procedure begins with the identification of the appropriate lumbar level and midline, followed by the advancement of a non-cutting epidural needle through the skin, subcutaneous tissue, the supraspinous and interspinous ligaments, and finally reaching the ligamentum flavum. The 'loss of resistance' technique, employing either saline or air, is used to locate the epidural space accurately. Once the needle is correctly positioned, a catheter is inserted. To detect an accidental intravenous or intrathecal placement of the catheter, a test dose of lidocaine and low-dose epinephrine is administered. If the positioning is correct, a loading dose is given, providing adequate analgesia within 10 to 15 minutes.

Traditionally, a relatively high dose of local anaesthetic, such as 0.25% Bupivacaine, was used, which often led to motor block and a diminished sensation of contractions. Since the early 2000s, there has been a shift towards low-dose epidural techniques with low-concentration mixtures (bupivacaine or ropivacaine 0.08% - 1.5% combined with fentanyl 2 µg/mL or sufentanil 0.3µg/mL). This mixture is then administered at high volumes of 10mL to 15mL. This was supported by evidence, most famous of which is the COMET trial published in 2001, which demonstrated significant benefits in delivery outcomes. Low-dose epidurals reduce the incidence of motor block and preserved the sensation of contractions, allowing patients to better synchronize with the final stages of labor. This adjustment reduced the need for instrumental vaginal delivery by approximately one in four, without affecting the rates of cesarean sections[3].

Combined spinal-epidural (CSE)

The concept of administering a local anaesthetic in both the subdural and epidural spaces was pioneered by Soresi in 1937, who injected procaine in both spaces to provide surgical analgesia with both a fast onset from the subdural component and a prolonged effect from the epidural component[4]. The first use of CSE for obstetrics was reported in 1981 by Brownridge who employed a sequential approach by first placing an epidural catheter followed by a single-shot spinal punction for elective cesarean sections[5].

There are multiple technical variations for the placement of a CSE. The most common method is

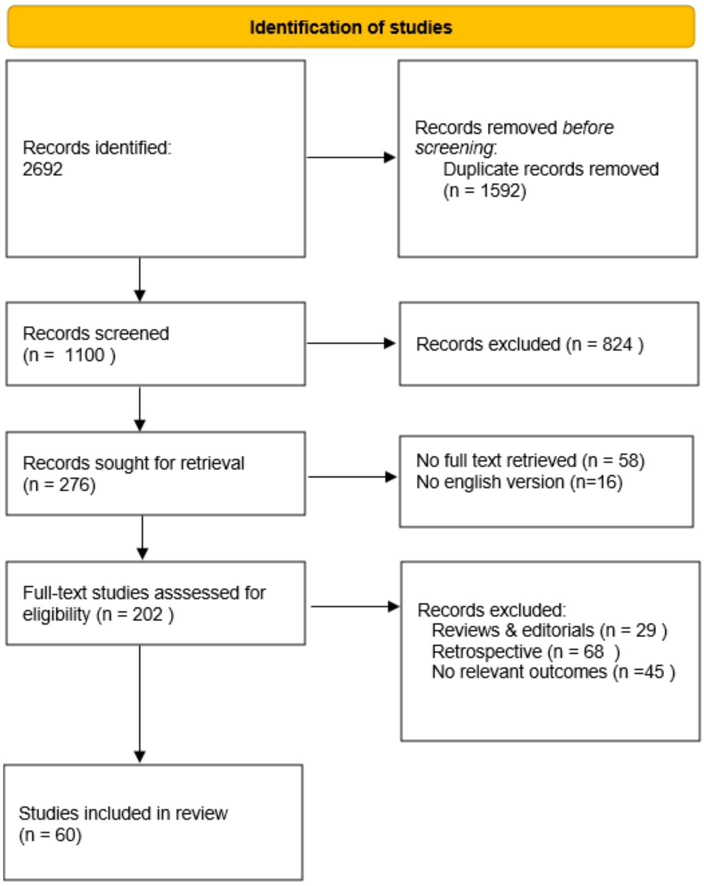

Fig. 1 — PRISMA flow chart.

the needle-through-needle technique in which an epidural needle is advanced into the epidural space, after which a 25G or 27G spinal needle is advanced through the former to perform the spinal puncture. The local anaesthetic is injected into the intrathecal space and a catheter is advanced into the epidural space. Less commonly a separate-needle technique is used in which the spinal component and epidural component are administered independently, although this method is associated with a higher failure rate. An addition to the CSE technique is the concept of Epidural Volume Expansion (EVE), whereby an early epidural 'top-up' of local anaesthetic or saline after a successfully placed CSE can reduce the total dose of local anaesthetic and opioid administered by improving the cephalad and sacral spread of the block. This is particularly useful in high-risk parturients undergoing cesarean section[6].

There is a large heterogeneity of products and combinations used across different studies on CSE, with varying results making adequate comparison difficult. Usually the products used for the intrathecal dose consist of a mixture of a low concentration long-lasting local anaesthetic (Ropivacaine, bupivacaine or levobupivacaine 1.5mg to 2mg) and an opioid (fentanyl 25µg or sufentanil 2-5µg), although some studies use only opioids intrathecally (Tables I & III).

CSE has been proven safe and effective for all stages of labor. The technique has seen widespread adaptation with a recent survey showing 43% of obstetric fellowship programs in the USA using CSE as the preferred technique for the initiation of neuraxial analgesia (compared to 29% for EPL and 21% for DPE)[7].

Dural puncture epidural (DPE)

DPE was introduced by Thomas et al. in 2005[8], with the primary aim to evaluate if epidural catheters placed using CSE showed any superiority over those inserted via the traditional epidural approach. DPE is similar to the conventional CSE, employing a needle-through-needle technique for spinal puncture, but crucially does not involve the administration of intrathecal medication. Instead, a standard epidural catheter is left in place, and an epidural loading dose is given after verifying the catheter's correct placement. The loading dose usually consists of the same products as described for EPL, at a volume of 10 to 15 mL.

DPE was hypothesized to present fewer side effects compared to the traditional CSE method, such as maternal pruritus, fetal bradycardia, reduced Bromage scores, and delays in functional testing of the epidural catheter. Meanwhile, it aims to retain the key advantages of the CSE, like rapid

Table I. — Overview of selected articles comparing CSE to DPE.

Study	Design / # of Patients	Loading Dose	Effectiveness	Motor block	Hypotension	Fetal outcomes	PDPH
Dresner et al. 1999 (40)	RCT 1000 patients	EPL: 20ml of bupivacaine 0.1% + fentanyl 2µg/mL CSE: Spinal bupivacaine 2.5mg + fentanyl 25µg	No significant difference in analgesia or patient satisfaction.	No difference.	No difference between EPL and CSE	Not reported	No difference between EPL and CSE
Hepner et al. 2000 (41)	RCT 50 patients	EPL: 16ml bupivacaine 0.0625% + fentanyl 2µg/mL CSE: bupivacaine 2.5mg + fentanyl 25µg	CSE provides a faster onset of analgesia in the first 15 minutes. No difference afterwards.	CSE: 2 patients EPL: 1 patient	No difference between EPL and CSE	Not reported	No difference between EPL and CSE
COMET group 2001 (3)	RCT 1054 patients	High-dose EPL: 0.25% bupivacaine Low-dose EPL: bupivacaine 0.1% + fentanyl 2 µg/ml CSE: bupivacaine 2.5mg + fentanyl 25µg	The CSE group had lower VAS scores in the first hour after initiation and a lower total consumption of local anaesthetic. There was no difference at the time of delivery.	Not reported	Not reported	Not reported	
Kayacan et al. 2006 (42)	RCT 50 patients	EPL: bupivacaine 0.125% + fentanyl 2µg/ml CSE: bupivacaine 2.5mg + fentanyl 25µg	Significantly lower VAS scores reported in the CSE group in the first 2 hours.	Not reported	Lower blood pressure in the EPL group compared to CSE at 2, 3 and 4 hours	No significant difference between EPL and CSE.	Not reported
COMET group 2009 (43)	RCT 1054 patients Analysis of secondary outcomes	High-dose EPL: 0.25% bupivacaine Low-dose EPL: bupivacaine 0.1% + fentanyl 2 µg/ml CSE: bupivacaine 2.5mg + fentanyl 25µg	Effectiveness already reported in the previous publication.	More motor block in both EPL groups compared to CSE.	Not reported	Not reported	Not reported.
Skupski et al. 2009 (44)	RCT 127 patients	EPL: 15ml of bupivacaine 0.0625% + 2µg/ml fentanyl CSE: bupivacaine 2.5mg + fentanyl 20µg	CSE: Significantly lower pain scores in the first 50 minutes after initiation. No difference in patient satisfaction	Not reported	More hypotension in the CSE group at 5 and 10 minutes	No difference between EPL and CSE.	No difference between EPL and CSE
Goodman et al. 2009 (45)	Non-randomized prospective study 100 patients	EPL: 10mL bupivacaine 0.125% + fentanyl 50µg CSE: Bupivacaine 2.5mg + fentanyl 25µg	CSE: Better VAS scores at 10 and 30 minutes after initiation	Not reported	CSE: Lower blood pressure at 10 and 20 minutes. More use of vasopressors compared to EPL.	Not reported	Not reported

Table I. — Overview of selected articles comparing CSE to DPE - continued.

Study	Design / # of Patients	Loading Dose	Effectiveness	Motor block	Hypotension	Fetal outcomes	PDPH
Pascual-Ramirez et al. 2011 (46)	RCT 144 patients	EPL: 10 mL of 0.125% or 0.25% levobupivacaine + 50 µg of fentanyl CSE: Bupivacaine 2.5mg + fentanyl 25µg + Morphine 0.2mg.	CSE: Lower pain scores during stage II of labor.	No difference between EPL and CSE	No difference between EPL and CSE	No difference between EPL and CSE.	Not reported
Patel et al. 2012 (47)	RCT 115 patients	EPL: 20ml of bupivacaine 0.1% + fentanyl 2µg/ml CSE: 2.5mg bupivacaine + fentanyl 5µg	The CSE group had lower VAS scores at min 15. There was no benefit beyond the first 15 minutes.	Lower bromage scores at 15 minutes in the CSE group, not statistically significant.	No difference between EPL and CSE	Not reported	Not reported
Gambling et al. 2013 (48)	RCT 800 patients	EPL: 15ml of bupivacaine 0.125% + fentanyl 2µg/ml CSE: 3.125mg bupivacaine + fentanyl 5µg	CSE: Faster onset of analgesia and better quality of analgesia during the first hour and the first stage of labor.	No difference between EPL and CSE	More use of vasopressors in the CSE group	Higher incidence of fetal bradycardia in the CSE group.	Not reported
Patel et al. 2014 (16)	Randomized prospective trial 115 patients	EPL: 20ml of bupivacaine 0.1% + fentanyl 2µg/ml CSE: 2.5mg bupivacaine + fentanyl 5µg	Not reported	CSE: Higher incidence of motor block.	No difference between EPL and CSE	No statistically significant difference (CSE 13% vs EPL 6%).	Not reported
Bakhet et al. 2021 (22)	RCT EPL vs CSE vs DPE 120 patients	EPL/DPE: 10ml of bupivacaine 0.1% + fentanyl 2µg/ml CSE: 2.5 mg bupivacaine	Faster onset of analgesia for CSE. Lower pain scores for CSE and DPE during the first hour after initiation. No benefit after the first hour.	No difference between CSE, EPL and DPE	CSE: Higher incidence of maternal hypotension (not statistically significant)	No difference between CSE, EPL and DPE.	Not reported

Table II. — Overview of selected articles comparing EPL to DPE.

Study	Design	Spinal Needle	Loading Dose	Effectiveness	Motor block	Hypotension	FHR changes	PDPH
Thomas et al. 2005 (8)	RCT 251 patients	27G	Bupivacaine 0.11% + fentanyl 2µg/ml	No difference in effectiveness or catheter failure	No difference between DPE and EPL	No difference between DPE and EPL	Not reported	Not reported
Cappiello et al. 2008 (9)	RCT 80 patients	25G	12 mL bupivacaine 0.25%	DPE: lower pain scores at 20min, reduced incidence of unilateral block and better sacral spread.	No difference between DPE and EPL	No difference between DPE and EPL	No difference between DPE and EPL	No difference between DPE and EPL

Table II. — Overview of selected articles comparing EPL to DPE - continued.

Study	Design	Spinal Needle	Loading Dose	Effectiveness	Motor block	Hypotension	FHR changes	PDPH
Gupta et al. 2013 (49)	RCT 131 patients	25G	bupivacaine 0.125% + fentanyl 10µg/ml	DPE was not superior to EPL and was associated with more intra-procedural paresthesias.	Not reported	No difference between DPE and EPL	Not reported	Not reported
Chau et al 2017 (21)	RCT 120 patients EPL vs DPE vs CSE	25G	EPL/DPE: 20 mL bupivacaine 0.125% + fentanyl 2 µg/mL CSE: bupivacaine 1.7 mg + fentanyl 17 µg	Faster onset of analgesia for CSE > DPE > EPL. No significant difference between EPL and DPE in pain scores. DPE and CSE show better sacral spread compared to EPL.	No difference between EPL and DPE and CSE	No difference between EPL and DPE. Higher incidence of hypotension in CSE.	No significant difference between CSE, EPL and DPE	No PDPH in any patient
Wilson et al 2018 (10)	RCT 80 patients	26G	12 mL, 0.125% bupivacaine + 50 µg fentanyl	No difference in VAS scores at 10 minutes after initiation.	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE
Yadav et al. 2018 (50)	RCT 60 patients	27G	10ml, Ropivacaine 0.2% + Fentanyl 2µg/mL	DPE: Faster onset of analgesia and lower VAS scores at 5 and 10 minutes after initiation	Not reported	Not reported	Not reported	No difference between EPL and DPE
Song et al. 2021 (51)	RCT 120 patients 3 groups: EPL + CEI, DPE + CEI, DPE + PIEB	25G	10mL ropivacaine 0.1% + sufentanil 0.3 µg/mL	DPE : Faster onset of analgesia	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE
Bakhet et al. 2021 (22)with fewer side effects than a combined spinal-epidural (CSE	RCT 120 patients EPL vs CSE vs DPE	25G	EPL/DPE: 10ml of bupivacaine 0.1% + fentanyl 2µg/mL CSE: 2.5 mg bupivacaine	Faster onset of analgesia for CSE. Lower pain scores for CSE and DPE during the first hour after initiation. No benefit after the first hour.	No difference between CSE, EPL and DPE	CSE: Higher incidence of maternal hypotension (not statistically significant)	No difference between CSE, EPL and DPE	Not reported
Wang et al. 2021 (52)	RCT 200 patients	25G	10 mL ropivacaine 0.08% + sufentanil 0.4 µg/mL	DPE : Faster onset of analgesia and lower VAS scores at 10 min	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE
Lin et al. 2023 (53)	RCT 130 patients	25G	15 mL of ropivacaine 0.1%	No statistically significant difference between DPE and EPL.	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE
Pazur et al. 2023 (54)8	RCT 76 patients	27G	10 mL of bupivacaine 0.125% + Fentanyl 1.5µg/mL	DPE: Lower pain scores at 10 min after initiation. No observable difference at 15 min.	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE

Table II. — Overview of selected articles comparing EPL to DPE - continued.

Study	Design	Spinal Needle	Loading Dose	Effectiveness	Motor block	Hypotension	FHR changes	PDPH
Maeda et al. 2023 (55)dural (EPL	Prospective, double-blind, sequential allocation trial 100 patients	25G	The administered dose of Bupivacaine was determined by the response of the previous subject.	The ED90 of DPE shows a 35% reduction in local anaesthetic dose necessary.	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE
Khetarpal et al. 2024 (56)	RCT 60 patients EPL vs CSE vs DPE	27G	EPL/DPE : levobupivacaine 0.125% + fentanyl 2µg/mL CSE : levobupivacaine 2.5 mg + fentanyl 25 µg	Faster onset of analgesia CSE > DPE > EPL. Higher incidence of asymmetrical blockade in the EPL group.	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE	No difference between EPL and DPE

Table III. — Overview of selected articles comparing CSE to DPE.

Study	Design	Spinal Needle	Loading Dose	Effectiveness	Motor block	Hypotension	FHR changes	PDPH
Chau et al 2017 (21)	RCT 120 patients EPL vs DPE vs CSE	25G	EPL/DPE: 20 mL bupivacaine 0.125% + fentanyl 2 µg/mL CSE: bupivacaine 1.7 mg + fentanyl 17 µg	Faster onset of analgesia for CSE > DPE > EPL. No significant difference between EPL and DPE in pain scores. DPE and CSE show better sacral spread compared to EPL	No difference between EPL and DPE and CSE	No difference between EPL and DPE. Higher risk of hypotension in CSE.	No significant difference between CSE, EPL and DPE	No PDPH in any patient
Bakhet et al. 2021 (22)	RCT 120 patients EPL vs CSE vs DPE	25G	EPL/DPE: 10ml of bupivacaine 0.1% + fentanyl 2µg/ml CSE: 2.5 mg bupivacaine	Faster onset of analgesia for CSE. Lower pain scores for CSE and DPE during the first hour after initiation. No benefit after the first hour.	No difference between CSE, EPL and DPE	CSE: Higher incidence of maternal hypotension (not statistically significant)	No difference between CSE, EPL and DPE	Not reported
Okahara et al. 2023 (57)	Prospective pilot study 302 patients	27G	DPE: 15ml of 0.125% levobupivacaine with fentanyl 2.5 µg/mL CSE: bupivacaine 2.5 mg + fentanyl 10 µg (0.2ml)	Not reported	Not reported	Not reported	Significantly higher incidence of prolonged decelerations for the CSE group.	Not reported
Khetarpal et al. 2023 (56)	RCT EPL vs DPE vs CSE 60 patients	27G	EPL/DPE : levobupivacaine 0.125% + fentanyl 2µg/mL CSE : levobupivacaine 2.5 mg + fentanyl 25 µg	Faster onset of analgesia CSE > DPE > EPL.	No difference between CSE, EPL and DPE	No difference between CSE, EPL and DPE	No difference between CSE, EPL and DPE	No difference between CSE, EPL and DPE

Table III. — Overview of selected articles comparing CSE to DPE - continued.

Study	Design	Spinal Needle	Loading Dose	Effectiveness	Motor block	Hypotension	FHR changes	PDPH
Zang et al. 2025 (58)	RCT 100 patients	25G	DPE : Ropivacaine 0.1% 8 ml + fentanyl 2µg/mL CSE : Bupivacaine 2mg + fentanyl 10µg	Lower pain scores for CSE at 15 minutes. No significant difference in quality of analgesia in a composite of outcomes.	No difference in motor block reported.	No difference between CSE and DPE	No difference between CSE and DPE	No difference between CSE and DPE

Table IV. — Overview of selected articles comparing PIEB to CEI.

Study	Design	Technique	Products	Effectiveness	Side effects
Chua et al. 2004 (25)	RCT 42 patients	PIEB vs CEI after CSE	ropivacaine 0.1% + fentanyl 2µg/mL	PIEB offers a longer duration of analgesia and better cephalad spread	No difference in maternal side effects
Lim et al 2005 (59)	RCT 60 patients	PIEB vs CEI	levobupivacaine 0.1% + fentanyl 2 µg/mL	PIEB offers a lower incidence of breaktrough pain and higher satisfaction scores.	No difference in maternal side effects.
Wong et al. 2006(60)	RCT 158 patients	PIEB + PCEA vs CEI + PCEA	bupivacaine 0.625 % + fentanyl 2µg/mL	The PIEB group had a lower total consumption of local anaesthetic, a lower need for rescue boluses and higher satisfaction scores	No side effects reported.
Fettes et al. 2006 (61)	RCT 40 patients	PIEB vs CEI	ropivacaine 0.2% + fentanyl 2µg/mL	PIEB: lower total consumption of local anaesthetic, less need for rescue boluses and a longer lasting block	No difference in side effects between groups.
Capogna et al. 2011 (33)	RCT 145 patients	PIEB + PCEA vs CEI + PCEA	levobupivacaine 0.0625% + sufentanil 0.5 µg/mL	PIEB is associated with a lower total anaesthetic use and lower need for rescue PCEA boluses.	The PIEB group has a lower incidence of motor block and is at a lower risk for instrumental delivery.
Lin et al. 2016 (62)	RCT 200 patients	CEI + PCEA vs PIEB + PCEA	ropivacaine 0.1% + sufentanil 0.3 µg/mL	The PIEB group had lower VAS scores after 90 minutes and a lower total consumption of local anaesthetics	No difference in maternal or fetal outcomes.
Ferrer et al. 2017. (63)	RCT 132 patients	CEI + PCEA vs PIEB + PCEA	bupivacaine 0.1% + fentanyl 2 µg/mL	No significant difference in VAS scores between the groups. The PIEB group had lower total anaesthetic consumption.	No significant difference in side effects between the two groups.
Fidkowski et al 2019 (64)	RCT 150 patients	PIEB 5ml/30 min vs PIEB 10ml/1hr vs CEI 10ml/hr	bupivacaine 0.125% + fentanyl 2 µg/mL	High-volume PIEB is associated with less breakthrough pain compared to low-volume PIEB and CEI.	No difference in bromage scores or other maternal or fetal outcomes.
Rodríguez-Campoó et al. 2019 (65)	RCT 200 patients	PIEB + CEI + PCEA vs PIEB + PCEA	levobupivacaine 0.125% + fentanyl 2 µg/mL	The PIEB group had higher total anaesthetic consumption compared to the CEI group. No difference in VAS scores or satisfaction scores.	Higher rate of instrumental delivery in the PIEB group.
Ojo et al. 2020 (34)	RCT 120 patients	PIEB + PCEA vs CEI + PCEA	ropivacaine 0.1% + fentanyl 2 µg/mL	No difference in VAS scores or use of anaesthetic between the groups	The PIEB group has a lower incidence of motor block. .

Table V. — Overview of selected articles comparing CEI to PCEA.

Study	Design	Technique	Products	Effectiveness	Side effects
Gambling et al. 1988(35)	RCT 27 patients	CEI + PCEA vs CEI	bupivacaine 0.125%	PCEA lowers the total drug administered and increases patient satisfaction.	No difference between the two groups.
Wong et al. 2006 (60)	RCT 158 patients	PIEB + PCEA vs CEI + PCEA	bupivacaine 0.625 % + fentanyl 2µg/mL	The PIEB group had a lower total consumption of local anaesthetic, a lower need for rescue boluses and higher satisfaction scores	No side effects reported.
Vallejo et al 2007 (31)	RCT 195 patients	CEI vs CEI + PCEA vs PCEA	ropivacaine 0.1% + Fentanyl 2µg/mL	Lower total dose of anaesthetic CEI < CEI + PCEA < PCEA.	No difference in side effects reported between groups.
Okutomi et al. 2009 (66)	RCT 66 patients	PCEA + CEI vs PCEA alone	ropivacaine 0.1% + fentanyl 2 µg/mL	No difference in VAS scores or total dose of anaesthetic used between the groups.	No difference in maternal side effects.
Haydon et al 2011 (37)	RCT 270 patients	CEI vs PCEA + CEI vs PCEA	bupivacaine 0.1% + 2 µg/mL fentanyl	Use of PCEA is associated with lower total anaesthetic consumption but also more breakthrough pain during the final stage of labor.	No difference in maternal or fetal outcomes.
Lovach-Chepujnoska et al 2014 (67)	RCT 51 patients	CEI vs PCEA	bupivacaine 0.08% + fentanyl 2 µg/ml	Effectiveness of analgesia is not reported.	CEI is associated with a higher incidence of motor block. No difference in fetal side effects.

onset, improved cephalad and sacral spread of the analgesia, and a more uniform block.

A critical aspect of the DPE technique is the size of the needle used for the dural puncture. In vitro studies have demonstrated that the amount of fluid passing through the dural puncture is directly related to the size of the spinal needle used, ranging from 18g to 25g. Initial studies utilized a 27 gauge needle, but subsequent research has explored the use of slightly larger 26 gauge or 25 gauge needles to enhance the effectiveness[9,10]. Findings from a study by Contreras et al. suggest that a 25 gauge needle may offer a marginally quicker onset of analgesia, though the difference may not hold clinical significance. Furthermore, this adjustment showed no impact on maternal outcomes or the method of delivery[11].

CSE vs EPL

Quality of analgesia

There is extensive research comparing CSE to EPL (Table I). Use of CSE has been associated with a faster onset of analgesia and lower VAS scores in the first hour after placement. Most studies report no difference in maternal satisfaction scores or pain at delivery when compared to EPL. A 2014 meta-analysis by Heesen and colleagues of 10 studies on CSE vs EPL showed a significantly reduced rate of unilateral block and catheter replacement rate after initiation with CSE[12]. This is likely because of the dural puncture confirming the correct midline position of the epidural needle, making the catheter position more secure.

Maternal outcomes

As CSE is a more invasive procedure compared to EPL there is significant concern for side effects caused by the intrathecal injection. There is contradicting evidence on this topic, as there is significant heterogeneity between studies in both the techniques used and the data reported. This makes adequate comparison difficult so we rely mostly on pooled data through meta-analyses and reviews. There are contradicting reports on motor block and maternal hypotension after CSE. A 2012 Cochrane review reported no difference in motor block or maternal hypotension between CSE and both high-dose and low-dose EPL.

The extra dural puncture performed during CSE raises concerns for post-dural puncture headache (PDPH). As rates of PDPH vary between 0.5% and 1.5%, most prospective studies aren't sufficiently powered to produce statistically significant results. Once again we rely on the 2012 Cochrane analysis of pooled data, which shows no difference in PDPH rates between the two techniques. This is also confirmed by multiple retrospective analyses.

Fetal outcomes

One of the major concerns about the use of neuraxial techniques is the higher risk for fetal heart rate abnormalities in both CSE and EPL[13]. A 2002 meta-analysis associates intrathecal opioids with an increased incidence of fetal bradycardia[14]. A later meta-analysis published in 2016 by Hattler and colleagues showed a significant increase in fetal bradycardia in patients receiving CSE when compared to EPL. Nonetheless this remains a controversial topic with large heterogeneity in most studies which makes adequate comparison difficult. Some research suggests that fetal bradycardia and uterine hyperactivity are more common when higher doses of epidural Bupivacaine or intrathecal Sufentanil (7.5µg) are used[15-17].

DPE vs EPL

Quality of analgesia

Most literature on this topic is quite recent, as research surrounding DPE only started picking up around 2013 (Table II). In general most studies suggest a slightly faster onset of analgesia for DPE when compared to EPL and lower early VAS scores. There is little difference in quality of analgesia after the first 20 minutes. In 2022 Yin et al performed a meta analysis of 10 RCTs comparing DPE and EPL[18]. Analysis of the pooled data shows a faster onset of analgesia for DPE when compared to EPL, providing lower VAS scores at the 10 minute and 20-minute mark. However, there were no differences noted in the quality of analgesia, the need for top-up boluses or catheter failure rates. There is also no difference in maternal satisfaction.

DPE may offer some advantage in very obese patients, as has been reported in some retrospective studies. This is attributed to the confirmation of the correct positioning of the epidural needle when CSF is obtained[19]. Epidural catheters placed using DPE may also have longer survival times[20].

Maternal outcomes

As DPE serves as an intermediary technique, it was theorized that side effects would be comparable to those seen in EPL. There are multiple studies reporting on side effects such as increased motor block, maternal hypotension or PDPH when comparing DPE to EPL. None of the studies included in this review show any statistically significant difference in maternal outcomes between the two techniques. The pooled data from the meta-analysis confirms there is no significant difference in side effects[18].

Fetal outcomes

There are no differences between DPE and EPL on fetal heart rate changes and other fetal outcomes.

CSE vs DPE

Quality of analgesia

There are few trials directly comparing CSE to DPE and most are very recent (Table III). The two techniques are very similar in setup and require the same materials for initiation. In general CSE provides a faster onset of analgesia compared to DPE. One study suggests a lower hourly consumption of local anaesthetic in the CSE group. All studies performed on this subject so far have small sample sizes and the quality of evidence is low. More research is required to create a better understanding of the difference between these two techniques.

Maternal outcomes

There are no studies that report a difference in motor block or PDPH between the two techniques. A study by Chau and colleagues show a higher risk of hypotension in the CSE group[21]. This is backed by a later 2021 study by Bakhet et al, although this was not statistically significant[22].

Fetal outcomes

A 2023 study by Okahara and colleagues showed that CSE is associated with deteriorating CTG tracings and more instances of prolonged fetal bradycardia when compared to DPE. There was no impact on the progression of labor, fetal outcomes or APGAR scores. Other studies show no difference in FHR tracings.

Maintenance

Following initiation of neuraxial analgesia, the goal should be to provide continuous analgesia during labor and delivery. In the past analgesia was provided using an intermittent manual bolus by an anaesthesiologist or trained nurse or midwife. Although this technique provides effective analgesia, it also comes with significant practical disadvantages like increased personnel requirements and inconsistency in the timing of the provided doses. With the advancement of technology different methods of automation became available. The current available techniques are the continuous epidural infusion (CEI), programmed intermittent epidural bolus (PIEB) and patient controlled epidural bolus (PCEA).

Continuous epidural infusion (CEI)

In the early '80s Davies and Fettes introduced

CEI as a way to continuously provide analgesia throughout labor[23]. Today this is still a commonly used technique for the maintenance of neuraxial analgesia. After placement of the epidural catheter and administration of a loading dose, a continuous infusion of local anaesthetic is given. This can be supplemented by intermittent manual top-ups for breakthrough pain or PCEA. The addition of a continuous infusion during labor allows for more consistent analgesia and fewer fluctuations in the level of sensory and motor block, though it is associated with a higher overall use of local anaesthetic[24]. CEI is easy to use, requires little knowledge and cooperation from the patient and doesn't require specific software to operate.

Initially high-concentration local anaesthetics such as 0.25% bupivacaine were used at a rate of 6 ml per hour. Starting in the late 90's there was a shift to low-concentration, high-volume infusions, such as 0.1% bupivacaine or ropivacaine with sufentanil 0.5 µg/ml or fentanyl 25µg/ml at a rate of 10 to 15 ml per hour. This change reduced the incidence of instrumental deliveries by improving maternal sensation and motor function during labor as was confirmed during the COMET trial[3].

Programmed intermittent epidural bolus (PIEB)

A newer approach to maintain neuraxial analgesia involves the use of intermittent epidural boluses administered at pre-programmed intervals. After the placement of the epidural catheter and the initial loading dose, a pump is set to deliver a dose of local anaesthetic every 30 minutes to 1 hour without a continuous background infusion. This technique, introduced in 2004 by Chua and colleagues, has since gained widespread use globally[25]. A typical regimen for PIEB is for example a dose of 6 to 10 ml of a long lasting local anaesthetic (ropivacaine or bupivacaine 0.0625% - 0.1%) with an opioid (sufentanil 0.3 – 0.6µg/ml or fentanyl 2.5-5µg/mL) every 40 minutes to 1 hour (Table IV). PIEB is theorized to combine the advantages of manual epidural boluses with the consistency of an automated system. The rapid bolus delivery promotes better distribution of the local anaesthetic within the epidural space, outpacing resorption, and providing a more even and broad sensory block while reducing the incidence of motor block.

There has been some research into the optimal interval and dose of local anaesthetic for PIEB. In 2011, Wong and colleagues[26] compared 3 different regimens: 2.5 ml every 15 minutes, 5 ml every 30 minutes, and 10 ml every hour. They found no significant between the three groups, except for a slight reduction in local anaesthetic use in the 10 ml group. In 2017, Kanczuk and colleagues determined the optimal interval to provide effective analgesia for 90% of women in labor is 40 minutes when using 10 ml of Bupivacaine 0.0625% with fentanyl 2 µg/ml[27]. In 2021 Mazda and colleagues compared different bolus infusion speeds: 125ml per hour versus 250ml per hour. There was no difference in the spread of the sensory block, quality of analgesia or maternal satisfaction[28]. In 2022, Zuo and colleagues compared 3 different volumes of anaesthetic: 4ml, 6ml and 8ml every 45 minutes. Higher volumes of local anaesthetic per dose were associated with a significantly decreased incidence of breakthrough pain, longer duration of analgesia and lower pain scores with no increase in adverse effects or difference in outcomes[29].

Patient-controlled epidural analgesia (PCEA)

The use of patient controlled epidural analgesia was adapted from its first use in intravenous PCA by Gambling and colleagues in 1988. PCEA can be used as a standalone maintenance technique without a background infusion, or as a supplement to CEI or PIEB. The use of PCEA provides the patient with a certain level of autonomy to manage their own level of analgesia during labor, and effectively treating breakthrough pain while ensuring safety[30,31]. There is once again a large heterogeneity in the regiments used in various studies. The choice of local anaesthetic is once again a low-dose local anaesthetic (Ropivacaine or bupivacaine 0.1%) combined with an opioid (sufentanil or fentanyl). The volume of anaesthetic per dose varies between 3ml and 10ml with a lockout period of 10 to 30 minutes.

PIEB vs CEI

Quality of analgesia

PIEB when compared to CEI reduces the incidence of breakthrough pain and lowers the total consumption of local anaesthetic. Most studies don't report a difference in VAS scores although this is usually not a primary reported outcome. These findings have been confirmed by a recent Cochrane review[32]. Some studies also report higher maternal satisfaction scores for PIEB. These benefits are likely due to a more effective distribution of the local anaesthetic within the epidural space (Table IV).

Maternal and fetal outcomes

There is conflicting evidence on the topic of side effects of CEI vs PIEB. Most studies report no significant difference in outcomes between the two techniques. Only 2 studies report a lower incidence of motor block for PIEB[33,34]. Capogna and colleagues in 2011 reported lower rates of instrumental delivery for PIEB, although this is controversial. The Cochrane review of the pooled data shows no statistically significant difference in cesarian delivery or instrumental delivery between the two groups[32]. The lack of difference in bromage scores is likely due to the low concentrations of local anaesthetics used in modern obstetric analgesia. There are no studies that report a difference in fetal outcomes.

CEI vs PCEA

Quality of analgesia

There are few studies reporting on the topic of CEI vs PCEA. An early study by Gambling and colleagues in 1988 showed a reduction in total local anaesthetic used in the PCEA group with no difference in pain scores or breakthrough pain[35]. A study by Boutros et al in 1999 found a reduction in local anaesthetic dose, less need for rescue analgesia and less motor block in the PCEA group, without a difference in pain scores[36]. A 2007 RCT by Vallejo et al reported a reduction in total local anaesthetic dose for PCEA with no difference in pain scores or breakthrough pain[31]. A 2011 study by Haydon and colleagues confirmed a lower total dose of local anaesthetic in the PCEA group, although there was more pain during delivery[37].

Maternal and fetal outcomes

A 2014 study by Lovach-Chepujnoska and colleagues reported an increase in motor block at 3, 4 and 5 hours after initiation of analgesia in the CEI group, although this was on a small sample size. There was no increased incidence of maternal hypotension. None of the studies reported a difference in the mode of delivery (Cesarian or instrumental) or Apgar scores after birth.

PIEB vs PCEA

Quality of analgesia

There are only 2 studies reporting on PIEB vs PCEA, both performed by the same research group[38,39]. The first study in 2020 utilized a 5ml PCEA bolus with a 12 minute lockout period. In this study the PCEA group had a higher incidence of breakthrough pain, with higher VAS scores starting 2 hours after initiation of analgesia. The total dose of local anaesthetic was also much lower in the PCEA group which is likely the cause for the superiority of PIEB in this study. In 2023 there was a follow-up study in which a higher dose of 10ml PCEA bolus was used with a lockout period of 30 minutes. In this study PCEA alone was non-inferior to PIEB + PCEA as there was no difference in breakthrough pain.

Maternal and fetal outcomes

There is no study reporting a difference in mode of delivery or other maternal and fetal outcomes[38,39].

Conclusion

The management of pain during labor remains a difficult balancing act between adequate analgesia and the reduction of maternal and fetal side effects. EPL offers a much slower onset of analgesia and the risk of an incomplete or patchy block, but also has few side effects and doesn't require the perforation of the dura mater. CSE with a low concentration, high volume local anaesthetic and intrathecal opioid offers the fastest onset of analgesia and the most reliable block, though with a slightly increased risk of maternal hypotension and pruritus and fetal bradycardia. DPE with a 25G spinal needle provides a slightly faster onset of analgesia when compared to EPL but offers few other benefits in the healthy parturient.

For maintenance of analgesia, a high-volume low-concentration intermittent bolus is superior to a continuous infusion of local anaesthetic. PIEB is superior to CEI, providing better pain relief and less motor block with few other adverse effects. PCEA can be used both with or without a background infusion and increases maternal satisfaction while reducing the need for physician intervention. High-volume PCEA appears to be non-inferior to PIEB while reducing total local anaesthetic use, although more research is needed on this topic.

References

1. Heesen M, Hilber N, Rijs K, van der Marel C, Rossaint R, Schäffer L, et al. Intrathecal catheterisation after observed accidental dural puncture in labouring women: update of a meta-analysis and a trial-sequential analysis. Int J Obstet Anesth. 2020 Feb;41:71–82.
2. Deng J, Wang L, Zhang Y, Chang X, Ma X. Insertion of an intrathecal catheter in parturients reduces the risk of post-dural puncture headache: A retrospective study and meta-analysis. PLOS ONE. 2017 July 5;12(7):e0180504.
3. COMET study group. Effect of low-dose mobile versus traditional epidural techniques on mode of delivery: a randomised controlled trial. Lancet. 2001 July 7;358(9275):19–23.
4. Soresi AL. Episubdural Anesthesia.*. Anesthesia & Analgesia. 1937 Dec;16(6):306.
5. Brownridge P. Epidural and subarachnoid analgesia for elective Caesarean section. Anaesthesia. 1981;36(1):70–70.
6. Kane T, Tubog TD, Kane J. Effect of Epidural Volume Extension on Quality of Combined Spinal-Epidural Anesthesia for Cesarean Delivery: A Systematic Review and Meta-Analysis. AANA J. 2018 Apr;86(2):109–18.
7. Callahan E, Yeh P, Carvalho B, George RB. A survey of labour epidural practices at obstetric anesthesia fellowship programs in the United States. Can J Anaesth. 2022 May;69(5):591–6.

8. Thomas JA, Pan PH, Harris LC, Owen MD, D'Angelo R. Dural puncture with a 27-gauge Whitacre needle as part of a combined spinal-epidural technique does not improve labor epidural catheter function. Anesthesiology. 2005 Nov;103(5):1046–51.
9. Cappiello E, O'Rourke N, Segal S, Tsen LC. A randomized trial of dural puncture epidural technique compared with the standard epidural technique for labor analgesia. Anesth Analg. 2008 Nov;107(5):1646–51.
10. Wilson SH, Wolf BJ, Bingham K, Scotland QS, Fox JM, Woltz EM, et al. Labor Analgesia Onset With Dural Puncture Epidural Versus Traditional Epidural Using a 26-Gauge Whitacre Needle and 0.125% Bupivacaine Bolus: A Randomized Clinical Trial. Anesthesia & Analgesia. 2018 Feb;126(2):545.
11. Contreras F, Morales J, Bravo D, Layera S, Jara Á, Riaño C, et al. Dural puncture epidural analgesia for labor: a randomized comparison between 25-gauge and 27-gauge pencil point spinal needles. Reg Anesth Pain Med. 2019 May 22;rapm-2019-100608.
12. Heesen M, Van de Velde M, Klöhr S, Lehberger J, Rossaint R, Straube S. Meta-analysis of the success of block following combined spinal-epidural vs epidural analgesia during labour. Anaesthesia. 2014 Jan;69(1):64–71.
13. Maetzold E, Lambers DS, Devaiah CG, Habli M. The effect of combined spinal epidural versus epidural analgesia on fetal heart rate in laboring patients at risk for uteroplacental insufficiency. J Matern Fetal Neonatal Med. 2022 Jan;35(1):46–51.
14. Mardirosoff C, Dumont L, Boulvain M, Tramèr MR. Fetal bradycardia due to intrathecal opioids for labour analgesia: a systematic review. BJOG. 2002 Mar;109(3):274–81.
15. Hattler J, Klimek M, Rossaint R, Heesen M. The Effect of Combined Spinal-Epidural Versus Epidural Analgesia in Laboring Women on Nonreassuring Fetal Heart Rate Tracings: Systematic Review and Meta-analysis. Anesth Analg. 2016 Oct;123(4):955–64.
16. Patel NP, El-Wahab N, Fernando R, Wilson S, Robson SC, Columb MO, et al. Fetal effects of combined spinal-epidural vs epidural labour analgesia: a prospective, randomised double-blind study. Anaesthesia. 2014 May;69(5):458–67.
17. Van de Velde M, Teunkens A, Hanssens M, Vandermeersch E, Verhaeghe J. Intrathecal sufentanil and fetal heart rate abnormalities: a double-blind, double placebo-controlled trial comparing two forms of combined spinal epidural analgesia with epidural analgesia in labor. Anesth Analg. 2004 Apr;98(4):1153–9.
18. Yin H, Tong X, Huang H. Dural puncture epidural versus conventional epidural analgesia for labor: a systematic review and meta-analysis of randomized controlled studies. J Anesth. 2022 June;36(3):413–27.
19. Arnolds D, Scavone B. Neuraxial labor analgesia failure rates in women with a body mass index ≥50 kg/m(2): a single-center retrospective study. Int J Obstet Anesth. 2021 Nov;48:103176.
20. Berger AA, Jordan J, Li Y, Kowalczyk JJ, Hess PE. Epidural catheter replacement rates with dural puncture epidural labor analgesia compared with epidural analgesia without dural puncture: a retrospective cohort study. Int J Obstet Anesth. 2022 Nov;52:103590.
21. Chau A, Bibbo C, Huang CC, Elterman KG, Cappiello EC, Robinson JN, et al. Dural Puncture Epidural Technique Improves Labor Analgesia Quality With Fewer Side Effects Compared With Epidural and Combined Spinal Epidural Techniques: A Randomized Clinical Trial. Anesth Analg. 2017 Feb;124(2):560–9.
22. Bakhet WZ. A randomized comparison of epidural, dural puncture epidural, and combined spinal-epidural without intrathecal opioids for labor analgesia. J Anaesthesiol Clin Pharmacol. 2021;37(2):231–6.
23. Davies AO, Fettes IW. A simple safe method for continuous infusion epidural analgesia in obstetrics. Can Anaesth Soc J. 1981 Sept;28(5):484–7.
24. van der Vyver M, Halpern S, Joseph G. Patient-controlled epidural analgesia versus continuous infusion for labour analgesia: a meta-analysis. Br J Anaesth. 2002 Sept;89(3):459–65.
25. Chua SMH, Sia ATH. Automated intermittent epidural boluses improve analgesia induced by intrathecal fentanyl during labour. Can J Anaesth. 2004;51(6):581–5.
26. Wong CA, McCarthy RJ, Hewlett B. The effect of manipulation of the programmed intermittent bolus time interval and injection volume on total drug use for labor epidural analgesia: a randomized controlled trial. Anesth Analg. 2011 Apr;112(4):904–11.
27. Epsztein Kanczuk M, Barrett NM, Arzola C, Downey K, Ye XY, Carvalho JCA. Programmed Intermittent Epidural Bolus for Labor Analgesia During First Stage of Labor: A Biased-Coin Up-and-Down Sequential Allocation Trial to Determine the Optimum Interval Time Between Boluses of a Fixed Volume of 10 mL of Bupivacaine 0.0625% With Fentanyl 2 µg/mL. Anesthesia & Analgesia. 2017 Feb;124(2):537.
28. Mazda Y, Arzola C, Downey K, Ye XY, Carvalho JCA. Programmed intermittent epidural bolus for labour analgesia: a randomized controlled trial comparing bolus delivery speeds of 125 mL·hr-1 versus 250 mL·hr-1. Can J Anaesth. 2022 Jan;69(1):86–96.
29. Zuo RH, Dang JJ, Zhuang JW, Chen QM, Zhang JY, Zheng HW, et al. The incidence of breakthrough pain associated with programmed intermittent bolus volumes for labor epidural analgesia: a randomized controlled trial. Int J Obstet Anesth. 2022 Aug;51:103571.
30. Halpern SH, Carvalho B. Patient-controlled epidural analgesia for labor. Anesth Analg. 2009 Mar;108(3):921–8.
31. Vallejo MC, Ramesh V, Phelps AL, Sah N. Epidural labor analgesia: continuous infusion versus patient-controlled epidural analgesia with background infusion versus without a background infusion. J Pain. 2007 Dec;8(12):970–5.
32. Tan HS, Zeng Y, Qi Y, Sultana R, Tan CW, Sia AT, et al. Automated mandatory bolus versus basal infusion for maintenance of epidural analgesia in labour. Cochrane Database Syst Rev. 2023 June 5;6(6):CD011344.
33. Capogna G, Camorcia M, Stirparo S, Farcomeni A. Programmed intermittent epidural bolus versus continuous epidural infusion for labor analgesia: the effects on maternal motor function and labor outcome. A randomized double-blind study in nulliparous women. Anesth Analg. 2011 Oct;113(4):826–31.
34. Ojo OA, Mehdiratta JE, Gamez BH, Hunting J, Habib AS. Comparison of Programmed Intermittent Epidural Boluses With Continuous Epidural Infusion for the Maintenance of Labor Analgesia: A Randomized, Controlled, Double-Blind Study. Anesth Analg. 2020 Feb;130(2):426–35.
35. Gambling DR, Yu P, Cole C, McMorland GH, Palmer L. A comparative study of patient controlled epidural analgesia (PCEA) and continuous infusion epidural analgesia (CIEA) during labour. Can J Anaesth. 1988 May;35(3 (Pt 1)):249–54.
36. Boutros A, Blary S, Bronchard R, Bonnet F. Comparison of intermittent epidural bolus, continuous epidural infusion and patient controlled-epidural analgesia during labor. International Journal of Obstetric Anesthesia. 1999 Oct 1;8(4):236–41.
37. Haydon ML, Larson D, Reed E, Shrivastava VK, Preslicka CW, Nageotte MP. Obstetric outcomes and maternal satisfaction in nulliparous women using patient-controlled epidural analgesia. Am J Obstet Gynecol. 2011 Sept;205(3):271.e1-6.

38. Roofthooft E, Barbé A, Schildermans J, Cromheecke S, Devroe S, Fieuws S, et al. Programmed intermittent epidural bolus vs. patient-controlled epidural analgesia for maintenance of labour analgesia: a two-centre, double-blind, randomised study†. Anaesthesia. 2020 Dec;75(12):1635–42.
39. Roofthooft E, Filetici N, Van Houwe M, Van Houwe P, Barbé A, Fieuws S, et al. High-volume patient-controlled epidural vs. programmed intermittent epidural bolus for labour analgesia: a randomised controlled study. Anaesthesia. 2023 Sept;78(9):1129–38.
40. Dresner M, Bamber J, Calow C, Freeman J, Charlton P. Comparison of low-dose epidural with combined spinal-epidural analgesia for labour. Br J Anaesth. 1999 Nov;83(5):756–60.
41. Hepner DL, Gaiser RR, Cheek TG, Gutsche BB. Comparison of combined spinal-epidural and low dose epidural for labour analgesia. Can J Anaesth. 2000 Mar;47(3):232–6.
42. Kayacan N, Ertugrul F, Cete N, Coskunfirat N, Akar M, Karsli B, et al. Comparison of epidural and combined spinal-epidural analgesia in the management of labour without pain. J Int Med Res. 2006 Dec;34(6):596–602.
43. Wilson MJA, MacArthur C, Cooper GM, Shennan A, Uk on behalf of the CSG. Ambulation in labour and delivery mode: a randomised controlled trial of high-dose vs mobile epidural analgesia. Anaesthesia. 2009;64(3):266–72.
44. Skupski DW, Abramovitz S, Samuels J, Pressimone V, Kjaer K. Adverse effects of combined spinal-epidural versus traditional epidural analgesia during labor. Int J Gynaecol Obstet. 2009 Sept;106(3):242–5.
45. Goodman SR, Smiley RM, Negron MA, Freedman PA, Landau R. A randomized trial of breakthrough pain during combined spinal-epidural versus epidural labor analgesia in parous women. Anesth Analg. 2009 Jan;108(1):246–51.
46. Pascual-Ramirez J, Haya J, Pérez-López FR, Gil-Trujillo S, Garrido-Esteban RA, Bernal G. Effect of combined spinal-epidural analgesia versus epidural analgesia on labor and delivery duration. Int J Gynaecol Obstet. 2011 Sept;114(3):246–50.
47. Patel NP, Armstrong SL, Fernando R, Columb MO, Bray JK, Sodhi V, et al. Combined spinal epidural vs epidural labour analgesia: does initial intrathecal analgesia reduce the subsequent minimum local analgesic concentration of epidural bupivacaine? Anaesthesia. 2012 June;67(6):584–93.
48. Gambling DR, Berkowitz J, Farrell Tr, Pue A, Shay D. A randomized controlled comparison of epidural analgesia and combined spinal-epidural analgesia in a private practice setting: pain scores during first and second stages of labor and at delivery. Anesthesia and analgesia [Internet]. 2013 Mar [cited 2025 July 27];116(3). Available from: https://pubmed.ncbi.nlm.nih.gov/23400985/
49. Gupta D, Srirajakalidindi A, Soskin V. Dural puncture epidural analgesia is not superior to continuous labor epidural analgesia. Middle East J Anaesthesiol. 2013 Oct;22(3):309–16.
50. Yadav P, Kumari I, Narang A, Baser N, Bedi V, Dindor BK. Comparison of Dural Puncture Epidural Technique Versus Conventional Epidural Technique for Labor Analgesia in Primigravida. Journal of Obstetric Anaesthesia and Critical Care. 2018 June;8(1):24.
51. Song Y, Du W, Zhou S, Zhou Y, Yu Y, Xu Z, et al. Effect of Dural Puncture Epidural Technique Combined With Programmed Intermittent Epidural Bolus on Labor Analgesia Onset and Maintenance: A Randomized Controlled Trial. Anesthesia & Analgesia. 2021 Apr;132(4):971–8.
52. Wang J, Zhang L, Zheng L, Xiao P, Wang Y, Zhang L, et al. A randomized trial of the dural puncture epidural technique combined with programmed intermittent epidural boluses for labor analgesia. Ann Palliat Med. 2021 Jan;10(1):404–14.
53. Lin W, Lin J, Yang Y, Lin L, Lin Q. Dural puncture epidural with 25-G spinal needles versus conventional epidural technique for labor analgesia: A systematic review of randomized controlled trials. Technol Health Care. 2023 July 27;
54. Pažur I, Ožegić O, Lijović L, Jaić KK, Pešić M. The Efficacy of Dural Puncture Epidural Performed by 27-gauge Whitacre Needle in Labour Epidural Analgesia: Randomized Single-Blinded Controlled Study. Turk J Anaesthesiol Reanim. 2023 Aug 18;51(4):304–10.
55. Maeda A, Villela-Franyutti D, Lumbreras-Marquez MI, Murthy A, Fields KG, Justice S, et al. Labor Analgesia Initiation With Dural Puncture Epidural Versus Conventional Epidural Techniques: A Randomized Biased-Coin Sequential Allocation Trial to Determine the Effective Dose for 90% of Patients of Bupivacaine. Anesth Analg. 2023 Oct 12;
56. Khetarpal R, Chatrath V, Grover S, Kaur P, Taneja A, Madaan A. Comparison of Epidural, Combined Spinal Epidural, and Dural Puncture Epidural Techniques for Labor Analgesia. Journal of Obstetric Anaesthesia and Critical Care. 2024 June;14(1):45.
57. Okahara S, Inoue R, Katakura Y, Nagao H, Yamamoto S, Nojiri S, et al. Comparison of the incidence of fetal prolonged deceleration after induction of labor analgesia between dural puncture epidural and combined spinal epidural technique: a pilot study. BMC Pregnancy Childbirth. 2023 Mar 16;23(1):182.
58. Zang H, Padilla A, Pham T, Rubright SM, Fuller M, Craig A, et al. Combined spinal-epidural vs. dural puncture epidural techniques for labour analgesia: a randomised controlled trial. Anaesthesia. 2025;80(1):29–37.
59. Lim Y, Sia ATH, Ocampo C. Automated regular boluses for epidural analgesia: a comparison with continuous infusion. International Journal of Obstetric Anesthesia. 2005 Oct 1;14(4):305–9.
60. Wong CA, Ratliff JT, Sullivan JT, Scavone BM, Toledo P, McCarthy RJ. A randomized comparison of programmed intermittent epidural bolus with continuous epidural infusion for labor analgesia. Anesth Analg. 2006 Mar;102(3):904–9.
61. Fettes PDW, Moore CS, Whiteside JB, McLeod GA, Wildsmith J a. W. Intermittent vs continuous administration of epidural ropivacaine with fentanyl for analgesia during labour. Br J Anaesth. 2006 Sept;97(3):359–64.
62. Lin Y, Li Q, Liu J, Yang R, Liu J. Comparison of continuous epidural infusion and programmed intermittent epidural bolus in labor analgesia. Ther Clin Risk Manag. 2016;12:1107–12.
63. Ferrer LE, Romero DJ, Vásquez OI, Matute EC, Van de Velde M. Effect of programmed intermittent epidural boluses and continuous epidural infusion on labor analgesia and obstetric outcomes: a randomized controlled trial. Arch Gynecol Obstet. 2017 Nov;296(5):915–22.
64. Fidkowski CW, Shah S, Alsaden MR. Programmed intermittent epidural bolus as compared to continuous epidural infusion for the maintenance of labor analgesia: a prospective randomized single-blinded controlled trial. Korean J Anesthesiol. 2019 Oct;72(5):472–8.
65. Rodríguez-Campoó MB, Curto A, González M, Aldecoa C. Patient intermittent epidural boluses (PIEB) plus very low continuous epidural infusion (CEI) versus patient-controlled epidural analgesia (PCEA) plus continuous epidural infusion (CEI) in primiparous labour: a randomized trial. J Clin Monit Comput. 2019 Oct 15;33(5):879–85.
66. Okutomi T, Saito M, Mochizuki J, Amano K, Hoka S. A double-blind randomized controlled trial of patient-controlled epidural analgesia with or without a background infusion following initial spinal analgesia for labor pain. Int J Obstet Anesth. 2009 Jan;18(1):28–32.

67. Lovach-Chepujnoska M, Nojkov J, Joshevska-Jovanovska S, Domazetov R. Continuous versus patient-controlled epidural analgesia for labour analgesia and their effects on maternal motor function and ambulation. Pril (Makedon Akad Nauk Umet Odd Med Nauki). 2014;35(2):75–83.

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