Maintaining labour epidural analgesia: what is the best option?
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Introduction
Labour pain has been described as one of the most painful experiences a woman can undergo [1]. Decades of medical research have been dedicated to enhancing the provision of labour analgesia to enable mothers to have a satisfactory birthing experience. The introduction of labour epidural analgesia has been one of the most promising developments in this field, as it far surpasses older methods of labour analgesia such as inhaled nitrous oxide, parenteral opioids and alternative therapies like acupuncture, hydrotherapy or transcutaneous electrical nerve stimulation [2].

Understanding the dynamic and multifactorial nature of labour pain is the first step in our quest to tailor a suitable analgesic regimen for each of our patients. The degree of labour pain experienced is influenced by a multitude of factors, including the presence of dysfunctional labour, initiation of oxytocin augmentation regimens, duration and progression of labour and various psychological and socio-cultural factors that may have a bearing on the way pain is perceived by the parturient.

Neuraxial blocks for labour analgesia should preferably be able to provide adequate analgesia throughout the different phases of labour (with minimal need for analgesic supplementation by the attending anaesthetist or midwife), without increasing the incidence of adverse obstetric or neonatal outcomes.

Initiation of labour analgesia: combined spinal epidural technique
Since the turn of the century, the combined spinal epidural (CSE) technique has gained widespread popularity for...
initiating labour analgesia [3,6,7,8, 10]. The intrathecal dose provides profound analgesia of rapid onset with minimal motor block, thus allowing the parturient greater mobility during labour and improving maternal comfort. The introduction of new CSE sets employing the ‘needle-through-needle’ technique has also been thought to aid more accurate midline placement of the epidural catheter by prior verification of the subarachnoid space with the spinal needle [3–6]. In addition, the dural rent created during the CSE technique may increase subarachnoid transfer of epidurally administered drugs, thus improving the quality of epidural analgesia, at least initially [9,10].

Clinicians have attempted to elucidate the optimal regimen associated with efficacious analgesia and minimum side effects or adverse outcomes. In comparison with intrathecal levobupivacaine and ropivacaine, 2.5 mg bupivacaine conferred the longest duration of analgesia but was also associated with the highest incidence of lower limb motor blockade [11]. The greater potency of bupivacaine was also suggested by Camorcia and colleagues [12], who reported that the minimum effective intrathecal analgesic dose was 3.64 mg [95% confidence interval (CI), 3.33–3.96] for ropivacaine, 2.94 mg [95% CI, 2.73–3.16] for levobupivacaine and 2.37 mg [95% CI, 2.17–2.58] for bupivacaine. Nevertheless, another study [13] showed that at doses of at least 2.5 mg, there was no significant difference between intrathecal levobupivacaine and ropivacaine with regard to the duration of analgesia, incidence of side effects or abnormal fetal heart tracing.

In an effort to optimize initiation of analgesia in parturients during late labour, our institution investigated the effect of sequential administration of intrathecal hyperbaric bupivacaine (after the initial administration of intrathecal hypobaric fentanyl) on the duration of spinal analgesia for parturients with cervical dilatation of at least 5 cm [14]. Patients who received hyperbaric bupivacaine (group H) had a longer median duration of analgesia (122 min; range, 80–210 min) than those who received plain bupivacaine (group P) (95 min; range, 75–125 min) (P < 0.01). Group H also had a more limited dermatomal spread (median highest sensory level of T8 versus T4 in group P; P < 0.05). The side effect profile was similar in both groups.

Many studies have demonstrated analgesic efficacy using various intrathecal drug combinations apart from local anaesthetics. These include opioids [15–17], adjuvants such as clonidine [18,19], adrenaline [20,21] and neostigmine [22].

While current literature supports a faster onset time to effective analgesia when the CSE technique is used for initiation of labour analgesia as compared with the plain epidural technique, it is equivocal with regard to the impact of CSE on overall maternal satisfaction with analgesia [7,23]. As the effects of the intrathecal drugs typically wear off in 2–3 h, subsequent quality of labour analgesia is largely determined by the effects of the drugs administered via the indwelling epidural catheter. Hence, the need for an effective analgesic regimen and epidural drug delivery system to maintain adequate labour analgesia cannot be overemphasized.

**Maintenance of labour analgesia**

Over the past decade, developments in labour epidural analgesia have been focused on maintaining effective pain relief throughout labour while minimizing the undesirable effects of maternal motor blockade to preserve maternal comfort, retain the option of ambulation as well as ensure adequate strength to perform expulsive efforts at the time of delivery [24].

**Mobile epidural/low-concentration epidural infusate**

Historically, undiluted bupivacaine (0.5%) was popular for both the initiation and maintenance of epidural analgesia. The addition of an opioid, fentanyl, to the local anaesthetic solution permitted a significant reduction in the effective concentration of bupivacaine, thus alleviating the problem of dense maternal motor blockade. Chestnut and colleagues [25] reported efficacious analgesia with concentrations as low as 0.065% bupivacaine when combined in a solution with 2 μg/ml fentanyl.

In the landmark Comparative Obstetric Mobile Epidural Trial (COMET) [26] performed in the United Kingdom, traditional epidural labour analgesia (using 0.25% bupivacaine) was compared with low-dose CSE and low-dose epidural infusion (0.1% bupivacaine and 2 μg/ml fentanyl). The investigators randomly assigned 1054 nulliparous women requesting epidural pain relief to traditional epidural (n = 353), low-dose CSE (n = 351) or low-dose infusion epidural (n = 350). The authors found that the use of a low-dose maintenance infusion after the induction of labour analgesia with either CSE or plain epidural led to higher rates of normal vaginal delivery. The normal vaginal delivery rate was 35.1% in the traditional epidural group, 42.7% in the low-dose CSE group [odds ratio (OR) 1.38 (95% CI, 1.01–1.89); P = 0.04] and 42.9% in the low-dose infusion epidural (n = 350). The authors concluded that continued routine use of traditional epidurals might not be justified. The use of low-dose epidurals for labour analgesia maintenance has since gained much popularity.
New epidural drug delivery systems
Historically, labour epidural analgesia was maintained via manually administered epidural boluses, a practice that is labour intensive and cumbersome. With the advent of automated infusion pumps, it became possible to administer a continuous infusion of local anaesthetic solution via an indwelling epidural catheter. Recent years have witnessed an increasing awareness of the benefits of providing parturients greater autonomy over their own labour analgesic regimens, spurring the development of more interactive and flexible analgesic modalities.

Patient-controlled epidural analgesia
Patient-controlled epidural analgesia (PCEA) is a mode of epidural drug delivery that allows the parturient to self-administer intermittent boluses of epidural solution and thus provides flexibility to accommodate her increasing analgesic requirements as labour progresses or as labour augmentation regimens are started. The attending anaesthetist has the option of varying PCEA programme settings such as demand bolus, lockout interval, background infusion rate and hourly maximum dose limits accordingly.

The earliest study comparing PCEA with continuous epidural infusion (CEI) was published in 1988 by Gambling et al. [27]. Since then, there have been numerous studies affirming the various advantages of PCEA over CEI as a mode of labour epidural drug delivery. The use of PCEA has been shown to reduce the total volume of local anaesthetic solution used without compromising quality of analgesia, resulting in a lower incidence of side effects and greater maternal satisfaction with labour analgesia [28–37].

An earlier meta-analysis by Van der Vyver et al. [38] reviewed nine studies involving a total of 640 parturients, which compared demand-only PCEA (without background infusion) with CEI. The authors found that parturients in the PCEA group required lower total doses of local anaesthetic solution, had less lower limb motor blockade and were less likely to require epidural rescue medication than parturients in the continuous infusion group.

D’Angelo [39] conducted another review of 19 PCEA studies, which demonstrated that PCEA had several advantages over CEI and intermittent epidural boluses. These include reduced consumption of local anaesthetics, reduced motor blockade, reduced pain scores, reduced clinician workload, and increased maternal satisfaction. Although five studies failed to show a clear advantage of the PCEA over continuous infusion, none of the studies demonstrated advantages of a continuous infusion over PCEA.

Although PCEA for labour analgesia has gained acceptance among clinicians and parturients, the optimal PCEA programme settings are yet to be elucidated.

The role of a basal infusion in particular has been the subject of much debate. Ferrante et al. [33] found that PCEA with background infusion resulted in a reduced requirement for anaesthetist-administered supplementary epidural boluses. They also demonstrated that PCEA with background infusion provided more efficacious analgesia without increasing consumption of local anaesthetics compared with demand-only PCEA, a result that was reproduced in two other randomized controlled trials [40,41].

On the contrary, there are other studies [42,43] that demonstrated that demand-only PCEA provided similar analgesic efficacy while reducing total consumption of local anaesthetics as compared to PCEA with background infusion.

Amidst the conflicting evidence with respect to the role of a background infusion in PCEA for labour analgesia, it cannot be overemphasized that the needs and expectations of each individual parturient should be discussed and analysed before a suitable analgesic plan may be customized for her.

Automated intermittent mandatory boluses
Experimentally, the spread of infusate from a multi-orificed catheter has been found to be greater when intermittent boluses were used instead of a continuous infusion, despite a similar rate of infusion [44]. Moreover, when a continuous infusion was used, there was practically no flow through the distal hole, whereas when intermittent bolusing was used, the infusate flowed out from all the holes. Based on his study in human cadavers, Hogan [45] also suggested that the use of intermittent boluses could produce a more uniform epidural block than a continuous infusion owing to the difference of injectate pressure.

The present theory has been explored in a clinical setting in several trials. Fettes et al. [46] recruited 40 primigravidae who were given plain epidural analgesia using an induction dose of epidural ropivacaine (0.2%, 15–20 ml). Patients were then randomized to receive either an infusion of ropivacaine (2 mg/ml) with fentanyl (2 μg/ml) at 10 ml/h, or hourly boluses of 10 ml of the same solution. Their results showed that regular intermittent epidural injection is associated with a reduced need for epidural rescue medication, less epidural drug use and a longer time to first rescue bolus, while providing equivalent pain relief, than continuous infusion of the same solution of ropivacaine and fentanyl.
At our institution, we studied [47] the impact of intermittent epidural boluses on quality of labour analgesia following initiation via the CSE technique. After induction of analgesia using a standard dose of intrathecal fentanyl (25 µg), 42 nulliparous parturients were randomized to receive either automated continuous intermittent boluses (CIB) of 0.1% ropivacaine and 2 µg/ml fentanyl at 5 ml/h or CEI of the same solution at 5 ml/h. Our results showed that parturients in the CIB group enjoyed a longer duration of analgesia after CSE, reported lower pain scores and achieved a higher sensory block than those in the CEI group. We went on to determine the effect of doubling the hourly maintenance dose and found that the incidence of breakthrough pain requiring anaesthetist-administered epidural boluses was lower in the CIB group than in the CEI group [48]. We inferred that continual bolusing, with its attendant greater driving pressure, could have resulted in an improved spread of the analgesics in the epidural space. Continual bolusing may also have a more profound epidural volume expansion (EVE) effect than a slow continuous infusion, resulting in a greater cephalad spread of sensory block [49]. Stienstra and colleagues [50] also discovered that a bolus of local anaesthetic solution through a catheter in the epidural space resulted in a significantly higher level of sensory blockade than a bolus of saline in the event of a prior intentional dural puncture during CSE. This has been attributed to some degree of direct migration of analgesics into the subarachnoid space through the dural rent after CSE.

**Automated intermittent mandatory boluses with patient-controlled epidural analgesia**

Attempts have been made to incorporate background automated intermittent mandatory boluses (AMB) into a PCEA programme. Wong et al. [51] randomized 158 multiparous subjects to receive either programmed intermittent boluses (PIB) in conjunction with PCEA or continuous basal infusion with PCEA, utilizing a dual pump system. The authors demonstrated that PIB with PCEA reduced total drug consumption but provided similar analgesia to and better patient satisfaction than continuous basal infusion with PCEA.

![Figure 1 A schematic representation of the algorithm used in our model of patient-controlled epidural analgesia with automated intermittent mandatory boluses](image)

CSE: intrathecal fentanyl 15 µg + ropivacaine 2 mg + epidural 1.5% lidocaine 2 ml

After 30 min, AMB 5 ml

- No PCEA demand over next hour
- PCEA demand over next hour

AMB 5 ml

- No PCEA demand within next hour
- PCEA demand within next hour

PCEA bolus = 5 ml, lockout 10 min,

Maximum hourly dose (PCEA + AMB) = 20 ml,

alarm activated when the maximum hourly dose is reached

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At our institution, we designed a novel computer programme that enables an ordinary infusion pump to function as a PCEA pump with the option of delivering either background intermittent boluses or a basal infusion in addition to patient-delivered boluses. Personal digital assistant (PDA) software with preprogrammed PCEA algorithms was integrated into a normal infusion pump. After successful induction of CSE analgesia, 42 healthy parturients in early labour were randomized to receive either a PCEA with basal continuous infusion (PCEA and BCI) or a PCEA with AMB (PCEA and AMB) [52*]. The detailed PCEA and AMB algorithm is as illustrated in Fig. 1. Our results showed that the PCEA and AMB group had reduced overall hourly consumption of ropivacaine, with a smaller proportion of parturients who required self-administration of PCEA bolus and a longer duration of analgesia before the first PCEA self-bolus. There was, however, no difference in the incidence of breakthrough pain requiring anaesthetist supplementation.

This particular PCEA and AMB algorithm may be beneficial in early labour but further refinement is necessary to define its role in clinical practice.

Computer-integrated patient-controlled epidural analgesia
Despite empowering patients to titrate their epidural analgesia according to changing analgesic requirements throughout labour, a conventional PCEA pump still lacks the flexibility to vary its basal infusion rate. The role of a basal infusion is likely to become increasingly important as pain intensifies with the progress of labour, or when labour augmentation regimens are started.

In 2005, our institution devised a programme, based on a novel clinical algorithm, which converts an ordinary continuous infusion pump into a computer-integrated (CI)-PCEA pump that is responsive to the patient’s needs. This interactive pump records the history of the patient’s analgesic requirement over the past hour and increases the magnitude of its basal infusion proportionally to the

**Figure 2 A schematic representation of the algorithm used in computer-integrated patient-controlled epidural analgesia**

| CSE: intrathecal fentanyl 15 µg + ropivacaine 2 mg + epidural 1.5% lidocaine 2 ml |

- **No infusion**
- **Demand dose: 5 ml**, lockout 10 min
- Change infusion to 5 ml/h
  - **No demand in 1 h**
  - **Demand within 1 h**
    - Change infusion to 10 ml/h
      - **No demand in 1 h**
      - **Demand within 1 h**
        - Change infusion to 15 ml/h
          - **No demand in 1 h**
          - **Demand within 1 h**
            - **Stop infusion and activate alarm**
number of demand-boluses made. A schematic representation of the CI-PCEA algorithm is shown in Fig. 2 [53]. We tested the feasibility of the CI-PCEA in a pilot study [54] involving 40 parturients in early labour who were randomized to receive either a CEI of 10 ml/h (n = 20) or the CI-PCEA regimen (n = 20) following successful induction of CSE analgesia. We found that there was a significant reduction in the incidence of breakthrough pain with the use of the CI-PCEA without increasing local anaesthetic consumption or incidence of side effects. In a follow-up study [55], we compared the CI-PCEA pump with a conventional PCEA pump with no background infusion, looking specifically at epidural drug consumption. We found no difference in the time-weighted consumption of local anaesthetic between both groups. The incidence of breakthrough pain requiring anaesthetist supplementation was 35% in the conventional PCEA group and 15% in the CI-PCEA group, but this difference did not reach statistical significance. The CI-PCEA group, however, did report significantly higher maternal satisfaction scores.

From our preliminary studies, the CI-PCEA programme appears to reduce the incidence of breakthrough pain during maintenance of labour epidural analgesia, without increasing total drug consumption or side effects. The interactive CI-PCEA pump could become an established mode of labour epidural drug delivery in the future even though further feasibility studies are required.

### Conclusion
For anaesthetists to recognize that labour pain is an intensely personal and constantly evolving experience for each parturient is imperative. As such, there may not be a ‘best option’ for maintaining labour epidural analgesia. Instead, each analgesic regimen should be individualized and customized to fit the changing needs of the parturient as labour progresses. Recent advances in clinical research and medical technology have certainly equipped us with an armamentarium of labour epidural techniques and novel modalities of drug delivery, which will aid our quest to administer the ideal labour epidural that will ensure a memorable birthing experience for our parturients.

### References and recommended reading
Papers of particular interest, published within the annual period of review, have been highlighted as:

* of special interest
* of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 413–414).


This is a recently updated version of the first review published in 2003. In contrast to the earlier review, there were no differences between CSE and epidural with regard to overall maternal satisfaction, despite the faster onset of analgesia with CSE.


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Comprehensive practice guidelines based on collation and review of evidence from recently published meta-analyses and pooling of expert opinion from a panel of consultants.


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Boselli E, Debon R, Cimino Y, et al. Background infusion is not beneficial during labor patient-controlled analgesia with 0.1% ropivacaine plus 0.5 mg/ml sufentanil. Anesthesiology 2004; 100:968–972.


A randomized trial evaluating the efficacy of a single modified infusion pump which incorporates automated intermittent mandatory epidural boluses into a PCEA programme.

