Modern Neuraxial Anesthesia for Labor and Delivery [version 1; peer review: 2 approved]

Marie-Louise Meng, Richard Smiley

Department of Anesthesiology, Columbia University Medical Center, New York, NY, USA

Abstract
The availability of safe, effective analgesia during labor has become an expectation for women in most of the developed world over the past two or three decades. More than 60% of women in the United States now receive some kind of neuraxial procedure during labor. This article is a brief review of the advantages and techniques of neuraxial labor analgesia along with the recent advances and controversies in the field of labor analgesia. For the most part, we have aimed the discussion at the non-anesthesiologist to give other practitioners a sense of the state of the art and science of labor analgesia in the second decade of the 21st century.

Keywords
neuraxial, analgesia, epidural,
Although neuraxial (caudal and single lumbar epidural) injections were used sporadically throughout the early 20th century to reduce labor pain, the provision of labor analgesia by administration of local anesthetics via catheters inserted into the epidural space or spinal fluid is a technique that dates from the mid-20th century and did not truly become widely available until the 1980s. Over the past two decades, there have been significant advances in the quality and safety of the analgesic techniques used. The long-standing and important controversy regarding whether and how neuraxial labor analgesia affects the course of labor has been addressed and at least partially resolved. The modern era of obstetric analgesia probably should be regarded as beginning in the 1990s with the widespread adoption into clinical practice of the understanding that one could reduce local anesthetic concentrations in epidural analgesia by 40% to 60% by adding small doses of opioids (usually fentanyl or sufentanil). Other advances have included the introduction of the combined spinal-epidural (CSE) technique and, more recently, the similar “dural puncture epidural” (DPE) technique. Equipment has driven improvements too; the almost universal use of continuous infusion pumps has replaced the need for anesthesiologists to dose catheters every hour or two, which improves the obvious issue of breakthrough pain if clinician-based dosing is not timed properly. Most epidural infusion pumps now allow patient-administered top-ups (extra doses), and the newest generation of epidural pumps can be programmed to administer intermittent timed boluses (programmed intermittent epidural bolus, or PIEB).

Anatomy and physiology
Labor pain, apart from the physical component, also has emotional and cognitive elements. Pain during labor and delivery is different for every woman, and the goals of each patient’s pain relief vary, depending on how she perceives the physical, emotional, and cognitive dimensions of pain. For the parturient, satisfaction with pain relief during labor not only may be a function of relief of physical pain but also is very dependent on practitioners’ attitudes, the parturient’s expectations, and her ability to exercise some control over the delivery. Interestingly, it has been reported that partners of laboring patients have less anxiety and feel more involved in the labor process if their partners receive epidural analgesia. Researchers are investigating the possibility that women who receive neuraxial pain relief in labor may be at a lower risk of post-partum depression and mood disorders.

Pain and the stress response to labor induce the release of corticotropin, cortisol, norepinephrine, β-endorphins, and epinephrine into the maternal circulation and this can result in a decrease in uterine blood flow. Pain reduction and sympathectomy caused by neural blockade result in lower levels of catecholamines and improved uteroplacental perfusion, especially in states of low uterine blood flow (pre-eclampsia and intrauterine growth retardation). The pain of uterine contractions and cervical dilation originates in the visceral afferent nerve fibers that enter the spinal cord at the levels of T10–L1. As the fetus descends into the vaginal canal, the somatic pain arising from the maternal pelvic floor travels along the pudendal nerve fibers S2–4. The ability to rapidly convert labor epidural analgesia to epidural surgical anesthesia and avoid general anesthesia (for mom and fetus) is generally regarded as an additional benefit of placing an epidural catheter during labor. Maternal airway anatomy changes during pregnancy, making difficult ventilation and difficult intubation real possibilities in the pregnant patient; multiple studies suggest that the incidence of failed intubation in pregnancy is much higher than in non-pregnant surgical patients. A functioning epidural catheter in a patient who may be difficult to intubate or ventilate is a safety strategy, as the catheter can be used to provide surgical anesthesia and airway manipulation can be avoided should a patient require an emergency intrapartum cesarean delivery (CD).

Effect of presence and timing of analgesia on the course of labor
The possible effect of epidural analgesia on the course of labor has been and still is a subject of major controversy. Studies examining whether epidural analgesia (usually compared with intravenous opioids) slows labor or results in increased CD rates are very difficult to do because of ethical/consent issues and because of crossover from subjects who opt to receive epidural analgesia as “rescue” analgesia after being assigned to the non-epidural group. Still, the consensus from the studies that have been done is that if there is any effect, it is small and probably dose-dependent. The concern is that with larger doses of local anesthetic, the muscle relaxation and motor block may be greater, which may have an effect on the descent of the fetus and on the voluntary maternal expulsive efforts. Modern local anesthetic (combined with opioid) epidural techniques probably have little to no effect on CD rates. A multicenter randomized controlled trial (RCT) demonstrated that there is also no increase in operative vaginal delivery with the use of low-dose epidural analgesia. A meta-analysis comparing epidural anesthesia with intravenous opioids for labor pain revealed that epidural anesthesia prolongs the second stage of labor (time from full cervical dilation to delivery of the fetus) by only 15 to 28 minutes. Therefore, it has been well established and stated best by the American College of Obstetricians and Gynecologists and the American Society of Anesthesiologists that “In the absence of a medical contraindication, maternal request is a sufficient medical indication for pain relief during labor.”

The timing of administration of epidural analgesia was also controversial until recently, and women were often told that they needed to wait until the cervix was dilated 4 or 5 cm before they could receive epidural analgesia because to have epidural analgesia earlier would slow labor and increase CD rates. The question of timing (“early” versus “later”) as opposed to use of analgesia at any time is much easier to study in an effective way. Several high-quality randomized trials performed in the first decade of the 21st century have demonstrated clearly that epidural (or CSE) analgesia provided very early in labor versus waiting for a pre-determined (4 or 5 cm) dilatation does not affect the overall course of labor and delivery. Wong et al. performed two RCTs, which demonstrated that in nulliparous women in either spontaneous or induced labor, early versus late initiation of neuraxial anesthesia did not increase the risk of CD or affect the time in labor. Two similar studies—one in Israel and an extremely large (>13,000 women) study from China—confirmed...
demonstrated that the more certain midline epidural catheter heart tracing but wanting to provide improved sacral analgesia and looking to avoid the mild hypotension that may be caused with DPE may become a valuable technique for the anesthesiologist of epidural, leading to a greater chance of bilateral block. Dural puncture truly aids in confirmation of midline placement of medication intrathecally or that the performance of a technique and requirement for the extra needle, but also by pruritus causing the return of cerebral spinal fluid via the spinal needle passed through the epidural needle and just beyond its tip, the anesthesiologist can confirm objectively that the epidural needle is actually in the epidural space. This may decrease the rate of “epidural failure” from misplaced catheters.

The technique of combined spinal epidural analgesia has been used broadly at academic medical centers to produce rapid onset of analgesia for labor pain and improve the spread of sacral analgesia. Widespread acceptance of the technique in the community has been limited somewhat by the complexity of the technique and requirement for the extra needle, but also by pruritus from spinal opioids and some evidence that the rapid onset or other factors in spinal analgesia may have effects on the fetal heart rate, possibly from increased rate or strength of uterine contraction. A new technique, DPE, involves the performance of a CSE but without administration of an intrathecal medication dose. A recent RCT by Chau et al. demonstrated that the DPE provided faster onset and greater spread of sacral analgesia and less asymmetric blocks compared with a standard epidural analgesic, suggesting that the dural puncture might facilitate medication transfer intrathecally or that the performance of a dural puncture truly aids in confirmation of midline placement of epidural, leading to a greater chance of bilateral block. The DPE may become a valuable technique for the anesthesiologist looking to avoid the mild hypotension that may be caused with rapid onset of spinal analgesia, pruritis, or alterations in the fetal heart tracing but wanting to provide improved sacral analgesia and a more certain midline epidural catheter.

Technique

In the standard epidural technique, a needle is placed into the epidural space, identifying the space by a “loss of resistance” to injection of saline or air because of the low pressure in the epidural space compared with the ligamentous structures that have been traversed. A catheter is generally placed via the needle, the needle removed, and medications given via the catheter to provide analgesia or anesthesia. In the 1990s, prompted by the availability of small-gauge “pencil point” spinal needles that rarely cause post-dural puncture headaches, many practitioners started placing long, thin spinal needles through the epidural needle, to allow a medications to be given into the cerebrospinal fluid, before threading the epidural catheter that will be used once the spinal dose wears off in 60 to 120 minutes. Opioids alone (fentanyl, sufentanil, or morphine) were found to be effective for early- and mid-first-stage labor pain, providing pain relief with no associated sympathetic or motor block. A low dose of local anesthetic (bupivacaine or ropivacaine) is now usually added, providing improved analgesia particularly in women who are already in or near the second stage and experiencing the somatic pain in the sacral regions which is associated with second-stage labor.

Another claimed advantage of the CSE technique is that, by seeing the return of cerebral spinal fluid via the spinal needle passed through the epidural needle and just beyond its tip, the anesthesiologist can confirm objectively that the epidural needle is actually in the epidural space. This may decrease the rate of “epidural failure” from misplaced catheters.

Dosing

Labor analgesia is usually initiated with both dilute long-acting local anesthetic and a lipophilic opioid either in low doses through the spinal needle if a CSE is performed (for example, bupivacaine 2.5 mg with fentanyl 5 to 20 μg) or in higher dose and volume (for example, bupivacaine 0.125% 10 to 15 mL with fentanyl 100 μg) in the epidural space as an epidural “load” when epidural or DPE analgesia is performed. The optimal maintenance infusion of medication into the epidural space is a combination of dilute long-acting local anesthetic and lipophilic opioid. This combination is synergistic, improving the analgesia while minimizing the toxicity of either agent, limiting motor blockade and significant numbness. With optimal epidural analgesia, patients experience mild pressure with contractions, sense rectal pressure and the urge to bear down at the start of the second stage, and maintain the motor ability to push. This can frequently be achieved with concentrations of bupivacaine or ropivacaine in the 0.0625 to 0.125% range, combined with fentanyl 2 μg/mL, at infusion rates of around 10 to 12 mL/hour. In these doses, the concentration of local anesthesia is unlikely to impact labor outcomes.

Because labor pain and the effect of any given analgesia mixture and rate of infusion are unpredictable, contemporary practice frequently includes the option of patient-controlled administration, similar to the ubiquitous intravenous patient-controlled opioid administration that has been commonly used for post-operative analgesia. Patient-controlled epidural analgesia (PCEA) was first described by Gambling et al. in 1988 and has become the standard approach. A button connected to the pump allows the parturient to dose herself with extra epidural infusion medication should she desire or require stronger analgesia. This PCEA results in increased maternal satisfaction, as control over one’s own analgesia is a factor that is highly valued by laboring women. Multiple recipes and strategies have been published and are used, as a wide range of acceptable doses is possible when the patient can “titrate” to what they need.

Newer epidural pumps can administer a programmed volume intermittently, at a higher infusion rate than the traditional continuous infusion, facilitating medication spread in the epidural space, resulting in improved analgesia with less motor block and with less overall consumption of local anesthesia. There is evidence that this mode of administration works slightly but consistently better than a continuous infusion and perhaps this is due to better spread of medication in the epidural space when larger volumes are infused over a relatively short time by the pump. This mode of dosing is called PIEB. The optimal dose volume and time interval of dosing are in early stages of investigation but are likely about 10 mL of epidural medication every 40 minutes with maternal option of periodic extra boluses.

Other analgesia options

There are few if any effective options for labor pain relief outside of neuraxial techniques. Intravenous and intramuscular opioids are still used but are well known to be relatively ineffective. The various breathing and relaxation and self-hypnotic techniques promoted over the years often as part of “natural childbirth” have some
For patients who cannot receive neuraxial anesthesia secondary to severe coagulopathy or anatomical abnormality such as scoliosis, a continuous intravenous infusion or patient-controlled administration of fentanyl or remifentanil is an option. Fentanyl is a commonly used opioid in post-operative patient-controlled analgesia (PCA) and similar PCA infusions can be used in labor with modest efficacy. Remifentanil is a synthetic, short-acting opioid that is readily hydrolyzed by plasma esterases, resulting in a short context-sensitive half-life in both mother and fetus/neonate. Because of its rapid clearance, remifentanil may be administered at doses that cause effects that would not be acceptable for a drug that lasts hours. Although it is tricky and imperfect to time boluses of medication with the onset of contraction well enough to provide analgesia during the contractions, the fast-on-and-fast-off analgesia and sedation of remifentanil make it an effective opioid for continuous infusion or PCA infusion during labor.

In summary, labor analgesia in 2017 is a far different “product” and experience than two decades ago. Most women can expect rapid, effective analgesia with limited weakness and numbness for most of labor and a degree of control over the dosing and timing of medication and can be reassured that accepting effective pain relief for labor does not impair their labor process or negatively affect its outcome.

Abbreviations
CD, cesarean delivery; CSE, combined spinal-epidural; DPE, dural puncture epidural; PCA, patient-controlled analgesia; PCEA, patient-controlled epidural analgesia; PIEB, programed intermittent epidural bolus; N₂O, nitrous oxide; RCT, randomized controlled trial.

Competing interests
The authors declare that the spouse of Richard Smiley owns stock in Abbott, AbbVie and Amgen Inc.

Grant information
The author(s) declared that no grants were involved in supporting this work.

References
1. Ange P, Landy CK, Charles C, et al.: Phase 1 development of an index to measure the quality of neuraxial labour analgesia: exploring the perspectives of childbearing women. Can J Anaesth. 2010; 57(5): 468–78. PubMed Abstract | Publisher Full Text | Free Full Text
2. Camann W: Pain, Pain Relief, Satisfaction and Excellence in Obstetric Anesthesia: A Surprisingly Complex Relationship. Anesth Analg. 2017; 124(2): 383–5. PubMed Abstract | Publisher Full Text | F1000 Recommendation
3. Capogna G, Camorcia M, Stirparo S: Expectant fathers’ experience during labor with or without epidural analgesia. Int J Obstet Anesth. 2007; 16(2): 110–5. PubMed Abstract | Publisher Full Text
4. Ding T, Wang DX, Qu Y, et al.: Epidural labor analgesia is associated with a decreased risk of postpartum depression: a prospective cohort study. Anesth Analg 2014; 119(2): 383–93. PubMed Abstract | Publisher Full Text | F1000 Recommendation
5. Ginogos Y, Nadjar M, Hoffman A, et al.: Antepartum continuous epidural ropivacaine therapy reduces uterine artery vascular resistance in pre-eclampsia: a randomized, dose-ranging, placebo-controlled study. Br J Anaesth 2009; 102(3): 369–78. PubMed Abstract | Publisher Full Text | F1000 Recommendation
6. Strümper D, Louwen F, Durieux ME, et al.: Epidural local anesthetics: a novel treatment for fetal growth retardation? Fetal Diagn Ther. 2005; 20(3): 208–13. PubMed Abstract | Publisher Full Text
7. Ramos-Santos E, Devoe LD, Wakefield ML, et al.: The effects of epidural anesthesia on the Doppler velocimetry of umbilical and uterine arteries in normal and hypertensive patients during active term labor. Obstet Gynecol. 1991; 77(1): 20–6. PubMed Abstract | Publisher Full Text
8. Abboud TK, Sarkis F, Hung TT, et al.: Effects of epidural anesthesia during labor on maternal plasma beta-endorphin levels. Anesthesiology 1983; 99(1): 1–5. PubMed Abstract
9. Quinn AC, Milne D, Colomb M, et al.: Failed tracheal intubation in obstetric anesthesia: 2 yr national case-control study in the UK. Br J Anaesth. 2013; 110(1): 74–80. PubMed Abstract | Publisher Full Text | F1000 Recommendation
10. Wang TT, Sun S, Huang SQ: Effects of Epidural Labor Analgesia With Low Concentrations of Local Anesthetics on Obstetric Outcomes: A Systematic Review and Meta-analysis of Randomized Controlled Trials. Anesth Analg. 2017; 124(5): 1571–80. PubMed Abstract | Publisher Full Text | F1000 Recommendation
11. Cambic CR, Wong CA: Labour analgesia and obstetric outcomes. Br J Anaesth. 2010; 105(Suppl 1): 80–60. PubMed Abstract | Publisher Full Text
12. Halpern SH, Muir H, Breen TW, et al.: A multicenter randomized controlled trial comparing patient-controlled epidural with intravenous analgesia for pain relief in labor. Anesth Analg. 2004; 99(5): 1526–34; table of contents. PubMed Abstract | Publisher Full Text
13. Liu EH, Sia AT: Rates of cesarean section and instrument vaginal delivery...
in nulliparous women after low concentration epidural infusions or opioid analgesia: a systematic review. BMJ. 2004; 328(7453): 1410. PubMed Abstract | Publisher Full Text | Free Full Text

14. ACOG Committee Opinion #295: pain relief during labor. Obstet Gynecol. 2004; 104(1): 212. Published Abstract

15. Goetel LM; ACOG Committee on Practice Bulletins-Obstetrics: ACOG Practice Bulletin. Clinical Management Guidelines for Obstetrician-Gynecologists Number 26, July 2002. Obstetric analgesia and anesthesia. Obstet Gynecol. 2002; 100(1): 177–91. PubMed Abstract | Publisher Full Text

16. Wong CA, McCarthy RJ, Sullivan JT, et al.: Early compared with late neuraxial analgesia in nulliparous labor induction: a randomized controlled trial. Obstet Gynecol. 2009; 113(3): 1066–74. PubMed Abstract | Publisher Full Text

17. Wong CA, Scavone BM, Peaceman AM, et al.: The risk of cesarean delivery with neuraxial analgesia given early versus late in labor. N Engl J Med. 2005; 352(7): 655–65. PubMed Abstract | Publisher Full Text

18. Ofel G, Gonen R, Vaida S, et al.: Early versus late initiation of epidural analgesia in labor: does it increase the risk of cesarean section? A randomized trial. Am J Obstet Gynecol. 2006; 194(3): 600–5. PubMed Abstract | Publisher Full Text | F1000 Recommendation

19. Wang F, Shen X, Guo X, et al.: Epidural analgesia in the latent phase of labor and the risk of cesarean delivery: a five-year randomized controlled trial. Anesthesiology. 2009; 111(4): 871–80. PubMed Abstract | Publisher Full Text

20. Nagotte M: Timing of conduction analgesia in labor. Am J Obstet Gynecol. 2006; 194(3): 598–9. PubMed Abstract | Publisher Full Text

21. Eisenach JC: Combined spinal-epidural analgesia in obstetrics. Anesthesiology. 1999; 91(1): 259–302. PubMed Abstract

22. Abouleish A, Abouleish E, Camann W: Epidural and Combined Spinal Epidural Techniques: A Randomized Clinical Improves Labor Analgesia Quality With Fewer Side Effects Compared With Epidural Analgesia. Anesth Analg. 2009; 108(1): 246–51. PubMed Abstract | Publisher Full Text

23. Wong CA, Blair WH, Guo X, et al.: Epidural analgesia in the latent phase of labor and the risk of cesarean delivery: a five-year randomized controlled trial. Anesthesiology. 2009; 111(4): 871–80. PubMed Abstract | Publisher Full Text

24. Brussels JM, Pan JC, Ross VH, et al.: Combined Spinal Epidural Technique for Labor Analgesia Does Not Delay Recognition of Epidural Catheter Failures: A Single-center Retrospective Cohort Survival Analysis. Anesthesiology. 2016; 125(3): 516–24. PubMed Abstract | Publisher Full Text | F1000 Recommendation

25. Groden J, Gonzalez-Flo A, Aaronson J, et al.: Catheter failure rates and time to course with epidural versus combined spinal-epidural analgesia in labor. Int J Obstet Anesth. 2016; 26: 4–7. PubMed Abstract | Publisher Full Text

26. Abouleish A, Abouleish E, Camann W: Epidural and Combined Spinal Epidural Techniques: A Randomized Clinical Improves Labor Analgesia Quality With Fewer Side Effects Compared With Epidural Analgesia. Anesth Analg. 2009; 108(1): 246–51. PubMed Abstract | Publisher Full Text

27. Clarke VT, Smiley RM, Finster M: Uterine hyperactivity after intrathecal injection of fentanyl for analgesia during labor: a cause of fetal bradycardia? Anesthesiology. 1994; 81(4): 1083. PubMed Abstract

28. van de Velde M, Teunenko A, Hanssens M, et al.: Intraplacental 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; 98(4): 1153–9. table of contents. PubMed Abstract | Publisher Full Text

29. Chau A, Bibbo C, Huang CC, 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; 124(2): 560–9. PubMed Abstract | Publisher Full Text | F1000 Recommendation

30. Ginosar Y, Columb MO, Cohen SE, et al.: The site of action of epidural fentanyl infusions in the presence of local anesthetics: a minimum local anesthetic concentration infusion study in nulliparous labor. Anesth Analg. 2003; 97(5): 1439–45. PubMed Abstract | Publisher Full Text

31. Polley LS, Columb MO, Naughton NN, et al.: Effect of intravenous versus epidural fentanyl on the minimum local analgesic concentration of epidural bupivacaine in labor. Anesthesiology. 2000; 93(1): 122–8. PubMed Abstract

32. Polley LS, Columb MO, Wagner DS, et al.: Dose-dependent reduction of the minimum local analgesic concentration of bupivacaine by sufentanil for epidural analgesia in labor. Anesthesiology. 1998; 89(3): 626–32. PubMed Abstract

33. Comparative Obstetrical Mobile Epidural Trial (COMET) Study Group UK: Effect of low-dose mobile versus traditional epidural techniques on mode of delivery: a randomised controlled trial. Lancet. 2001; 358(9275): 19–23. PubMed Abstract | Publisher Full Text

34. Cheung DT, Vandewalker GE, Owen CL, et al.: The influence of continuous epidural bupivacaine analgesia on the second stage of labor and method of delivery in nulliparous women. Anesthesiology 1987; 66(6): 774–80. PubMed Abstract

35. Chestnut DH, Laszewski LJ, Pollack KL, et al.: Continuous epidural infusion of 0.0625% bupivacaine-0.0002% fentanyl during the second stage of labor. Anesthesiology 1990; 72(4): 613–8. PubMed Abstract

36. Gambling DR, Yu P, Cole C, et al.: A comparative study of patient controlled epidural analgesia (PCEA) and continuous infusion epidural analgesia (CIEA) during labour. Can J Anaesth. 1988; 35(3 (Pt 1)): 249–54. PubMed Abstract | Publisher Full Text

37. Smiley RM, Stephenson L: Patient-controlled epidural analgesia for labor, Int Anesthesiol Clin. 2007; 45(1): 83–96. PubMed Abstract | Publisher Full Text

38. Carvalho B, George RB, Cobb B, et al.: Implementation of Programmed Intermittent Epidural Bolus for the Maintenance of Labor Analgesia. Anesth Analg. 2016; 123(4): 965–71. PubMed Abstract | Publisher Full Text | F1000 Recommendation

39. Fettes PD, Moore CS, Whittide JB, et al.: Intermittent vs continuous administration of epidural ropivacaine with fentanyl for analgesia during labour. Br J Anaesth. 2006; 97(3): 359–64. PubMed Abstract | Publisher Full Text

40. F1000 Recommendation | Publisher Full Text

41. F1000 Recommendation | Publisher Full Text

42. Boileau S, Columb MO, Naughton NN, et al.: Effect of intravenous versus epidural fentanyl on the minimum local analgesic concentration of epidural bupivacaine in labor. Anesthesiology. 2000; 93(1): 122–8. PubMed Abstract

43. Polley LS, Columb MO, Wagner DS, et al.: Dose-dependent reduction of the minimum local analgesic concentration of bupivacaine by sufentanil for epidural analgesia in labor. Anesthesiology. 1998; 89(3): 626–32. PubMed Abstract

44. Comparative Obstetrical Mobile Epidural Trial (COMET) Study Group UK: Effect of low-dose mobile versus traditional epidural techniques on mode of delivery: a randomised controlled trial. Lancet. 2001; 358(9275): 19–23. PubMed Abstract | Publisher Full Text

45. Cheung DT, Vandewalker GE, Owen CL, et al.: The influence of continuous epidural bupivacaine analgesia on the second stage of labor and method of delivery in nulliparous women. Anesthesiology 1987; 66(6): 774–80. PubMed Abstract

46. Aaronson J, Abramovitz S, Smiley R, et al.: A Survey of Intravenous Remifentanil Use for Labor Analgesia at Academic Medical Centers in the United States. Anesth Analg. 2017; 124(4): 1208–10. PubMed Abstract | Publisher Full Text

47. Bimbach DJ, Ranasinghe JS: Is remifentanil a safe and effective alternative to neuraxial labor analgesia? It all depends. Anesth Analg. 2014; 118(3): 491–3. PubMed Abstract | Publisher Full Text | F1000 Recommendation

48. van de Velde M, Carvalho B: Remifentanil for labor analgesia: an evidence-based narrative review. Int J Obstet Anesth. 2016; 25: 66–74. PubMed Abstract | Publisher Full Text | F1000 Recommendation

49. Stoelck D, Matot L, Einav S, et al.: A randomized controlled trial of the efficacy and respiratory effects of patient-controlled intravenous remifentanil analgesia and patient-controlled epidural analgesia in laboring women. Anesth Analg. 2014; 118(3): 589–97. PubMed Abstract | Publisher Full Text | F1000 Recommendation
Open Peer Review

Current Peer Review Status: ✔️ ✔️

Editorial Note on the Review Process

Faculty Reviews are review articles written by the prestigious Members of Faculty Opinions. The articles are commissioned and peer reviewed before publication to ensure that the final, published version is comprehensive and accessible. The reviewers who approved the final version are listed with their names and affiliations.

The reviewers who approved this article are:

1. **Paloma Toledo**
   Northwestern University, Feinberg School of Medicine, Chicago, IL, USA
   **Competing Interests:** No competing interests were disclosed.

2. **Alex Tiong Heng Sia**
   Department of Women's Anaesthesia, KK Women's and Children's Hospital, Bukit Timah, Singapore
   **Competing Interests:** No competing interests were disclosed.

The benefits of publishing with F1000Research:

- Your article is published within days, with no editorial bias
- You can publish traditional articles, null/negative results, case reports, data notes and more
- The peer review process is transparent and collaborative
- Your article is indexed in PubMed after passing peer review
- Dedicated customer support at every stage

For pre-submission enquiries, contact research@f1000.com