Mechanisms and management of an incomplete epidural block for cesarean section

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Article outline

Anesthetic care for parturients requiring abdominal delivery has always been considered a complex task that is potentially associated with anesthesia-related mortality. Epidural anesthesia is one of the most frequent techniques for cesarean section because most women who have urgent cesarean sections have an epidural catheter in situ. In the United States, epidural anesthesia is used for approximately 29% to 44% of abdominal deliveries [1,2]. Historically, in the United Kingdom, epidural anesthesia has been favored over spinal anesthesia. However, a 1997 survey conducted in the United Kingdom found that epidural anesthesia was used for 22% of all cesarean sections (elective and emergent) versus single-shot spinal anesthesia in 47% [3].

It is a general perception and conventional wisdom that general anesthesia presents a much greater risk for obstetric patients than regional anesthesia. Hawkins et al [4] demonstrated a dramatic increase of the case-fatality risk ratio for general anesthesia to regional anesthesia from 2.3 before 1985 to 16.7 after 1985. A significant shift (Table 1) from general to regional anesthesia is generally considered an important reason for the decrease in maternal mortality related to anesthesia [1,5].

Table 1. Anesthesia for Cesarean section: changes in practices (general versus regional anesthesia)

	USA		UK	
	1981	1997	1990	1998
Rate of general anesthesia	35%–46%	8%–11%	49%	24%
Rate of regional anesthesia	39%–63%	88%–92%	51%	76%

There are advantages and disadvantages to both epidural and spinal anesthesia (Table 2). One of the major concerns with epidural anesthesia is the inability to produce a dense enough anesthetic block or adequate level to proceed with the planned operation. The incidence of this event is rather inconsistent among reports, apparently reflecting variability in definitions, authors' clinical judgment and perception, practice parameters, hospital settings, and so forth (Table 3).

Table 2. Advantages and disadvantages of spinal versus epidural anesthesia for cesarean section

Technique	Advantages	Disadvantages
Spinal anesthesia	Quick	Fixed (limited in) density, duration and level
	Low dose (no LA toxicity)	Sudden sympathectomy with a risk of hypotension
	Better quality of block	Possibility of high spinal block
	No missed segments (low incidence of failure)	
Epidural anesthesia	Flexibility to allow adjustment of density, level, and duration of the block	Large dose (possibility of LA toxicity)
	Cardiovascular stability	Inadequate block
	Lower incidence of post dural puncture headache	Time consuming
	Can be used for both, labor analgesia and cesarean section	

Table 3. Terms and incidence of unsatisfactory epidural block

Term	Incidence	Author	Year
Catheter failure rate	13.1%	Eappen et al [10]	1998
Epidural replacement rate	4.63%	Pratt et al [11]	1999
Epidural replacement rate	14.3	Segal et al [13]	1997
Failure to produce anesthesia	4.1%	Tanaka et al [12]	1993
Failure to produce a block	1.2%	Norris [86]	1999
Inadequate block	Up to 25%	Morgan et al [61]	1990

Intraoperative discomfort/ pain	10% – 50%	Crawford et al [8]	1986
Inadequate analgesia	Up to 50%	Beck and Griffins [64]	1992
Inadequate analgesia	22%	Choi et al [96]	2000
Inadequate analgesia	21.2% – 31.8%	D'Angelo et al [14]	1997
Inadequate analgesia	28%–36%	Beilin et al [42]	2000
Inadequate analgesia	Up to 20%	Pernoll and Mandell [15]	1995
“Some discomfort”	33%	Keohane [17]	1996
Visceral pain	56.5%	Alahuhta et al [16]	1990
Unsatisfactory block	1.5% – 21%	Narang and Linter [30]	1988
Unsatisfactory block	33%	Michael et al [6]	1990

Various descriptions

Several terms are used to describe the inability to proceed with the original anesthetic technique (epidural or spinal) without either a radical intervention or supplementation. The terms used include failed, partially failed, incomplete, inadequate, spotty (patchy) block, and unsatisfactory block. Some authors specifically reserve the term “incomplete” to describe a persistent insufficiency to block caudal or cephalad segments, or both [6]. An incomplete block includes the following clinical situations: (1) unilateral block; (2) unblocked sacral segments (sacral sparing); (3) low level; and (4) unblocked (missed) segments or a patchy (spotty) block. Some use the terms incomplete and inadequate interchangeably. For the purpose of this review we will not differentiate between them. The term *failed epidural* is mostly reserved for situations in which either insertion of the catheter is impossible or no sensory block is produced after injecting a local anesthetic.

Incomplete and failed epidural anesthesia may originate from either de novo initiation of an epidural or from a pre-existing labor epidural. The diagnosis of a problematic epidural can be made either preoperatively or intraoperatively. When diagnosed intraoperatively, some clinicians use the term inadequate rather than incomplete epidural anesthesia. Bromage has suggested that for practical purposes a “spotty” (which is incomplete) regional anesthetic is a failed anesthetic unless it can be corrected [7].

Reported problems with epidural anesthesia for abdominal delivery and their incidence are: inability to insert the catheter: 0.5% to 2.9% [8,9], failed epidural: 2% to 13.1% [2,10–12], epidural replacement rate: 4.6% to 14.1% [11,13], inadequate analgesia/anesthesia: 18% to 31.8% [14,15]. In addition, the reported incidence of intraoperative discomfort/visceral pain ranges from 10% to 56% [8,16,17].

The etiology and mechanisms of failed or dysfunctional epidural anesthesia in obstetrics are complex, multifactorial, and not entirely understood. Depending on the situation, the causes might be evident or puzzling and difficult to explain. In the rare case of inability to place an epidural catheter, there are two possible factors involved. These factors are the technical skill of the operator [18] and the anatomic peculiarities or abnormalities of the parturient, congenital as well as acquired [19].

If the epidural catheter is successfully inserted but there is no block, either the injected solution does not contain local anesthetic or the local anesthetic was injected into a space other than the epidural or subarachnoid space. Two potential anatomic compartments have been described: immediately superficial to the vertebral lamina and the paraligamentous space adjacent to the interspinous ligament [20]. Additionally, if the catheter is placed intravenously, obviously no block will develop.

The potential causes, contributing factors, and proposed mechanisms of incomplete or inadequate lumbar epidural anesthesia may be grouped into four major categories: anatomic factors; technique, methodology and equipment; patient-related factors; and technical skills, or performance factors (Fig. 1).

Fig. 1. Etiology and contributing factors in unsatisfactory epidural block.

Anatomic considerations

Anatomic factors are frequently implicated to explain missed segments and unilateral epidural blockade. Autopsy, imaging, and endoscopy studies have shown the presence of midline epidural anatomic structures. Plica mediana dorsalis (dura matris) was described for the first time in 1963 [21], using peridurography. The presence of this midline band has been confirmed radiologically and with CT–Epidurography [22]. Gallart et al [23] radiologically confirmed the existence of a connective tissue plane in both dorsolateral compartments of the epidural space. The presence of this connective tissue is used to explain the occasional difficulty in threading a catheter through a Tuohy needle and coiling of a catheter during its introduction. In 1967, Singh described a midline adhesion of dura mater [24]. An anatomic study using epiduroscopy in autopsy cases by Blomberg [25] demonstrated in every case a variable density dorsomedian connective tissue band in the midline of the epidural space with no correlation with the amount of adipose tissue. According to Blomberg, this finding explains the appearance of the Tuohy needle slightly to one side, an uneven spread of local anesthetic, and eventually a unilateral epidural. Some authors also use the term “median epidural septum” [26].

A study of failed epidurals using epidurograms was undertaken by Collier in 1996 [27]. The clinical history of 18 patients with unsatisfactory blocks was correlated with epidurograms. Patients were divided into three groups based on their history and x-ray findings. The first group (four cases), with the poorest nerve block, had transforaminal catheter escape (or “too much catheter”). The second group (11 cases), included patients who developed true unilateral or missed segment block. In this group, five patients had epidurograms supporting the existence of an obstructive barrier in the epidural space. The third group (three cases) included patients with an incomplete block defined by the author as an insufficient caudal or cephalad block, a term borrowed from Michael et al [6].

Another possible cause of poor blockade is the increased difficulty in blocking larger spinal nerve roots, such as the sacral nerve roots. This was confirmed in a study examining the influence of spinal nerve root diameter on the quality of “spinal extradural” anesthesia where a 17.53% failure to block the sacral segments was found [28].

Technique, methodology and equipment-related factors

Initial catheter misplacement (incorrect placement)

Although anatomic epidural midline structures do occur, their role in the pathogenesis of unsatisfactory epidural blockade is seriously questioned as their presence has not been found in all cases of inadequate analgesia. In the above-mentioned Collier's study [27], only five of 18 patients with poor block showed a strong association with midline barriers and their connections. The rest demonstrated either a malposition or malfunction of the catheter. (The argument that malposition of the catheter may occur secondary to undetected anatomic obstacle is a contentious issue). Three major types of catheter malposition were revealed: transforaminal escape [27], passage to the anterior epidural space, and paravertebral (lateral) location [27,29].

A different explanation of the mechanism of the catheter malposition was offered by Narang and Linter [30]. They found a significant correlation between increasing skin-to-extradural space distance and an increase in the incidence of unilateral blocks. The authors proposed that when using a midline approach, increasing the distance would be associated with the deviation of the tip of the needle from the midline, which may result in the incorrect, lateral placement. The results of these studies [27,30] suggest that initial malposition (or incorrect placement) of the catheter due to a technical error is a predominant cause of unilateral and missed segment block, whereas midline anatomic structures that limit circumferential spread is a second contributing factor.

Catheter characteristics: migration and malfunction

Catheter migration, after an initial satisfactory block, is another important contributing factor for the development of inadequate analgesia. Crosby analyzed the relationship between the incidence and extent of catheter migration (by measuring the length of the catheter at the skin) and the quality of analgesia in 211 consecutive parturients [31]. He concluded that catheter migration during labor results in a greater incidence of unsatisfactory analgesia. Fifty-four percent of the catheters migrated during labor, and 70% of those migrated out of the epidural space. A different study, however, showed a reverse direction of migration whereas the percentage of migrated catheters remained the same [32]. In an attempt to elaborate on the factors influencing epidural migration, Bishton et al [33] prospectively studied 153 women in labor. These authors found a statistically significant relationship between catheter migration and body mass index, body weight, and depth to the epidural space and no correlation with height, age, intervertebral space used, or duration of catheterization.

Another study measured the distance from the skin to the epidural space in an effort to correlate change in the position of the epidural catheter with patient movement [34]. Findings of this study included an inward movement of an unsecured catheter as patient moves from sitting flexed to sitting upright, and then to the lateral decubitus position, with the greatest change occurring in patients with a body mass index greater than 30. Gartrell [35] has shown that fixing the catheter to the skin too firmly (eg, by suturing) in a sitting patient may cause the catheter to withdraw from the epidural space when the lateral posture is adopted.

Catheter malfunction and catheter defects

Although the rate of isolated manufacture catheter defects is unknown, it seems to be relatively low. In one report of a failed epidural block, the distal hole of the catheter was located 5 cm from the tip [31]. Reduction of patency and occlusion of the catheter, however, take place more frequently and may be due to a laminar “pincer,” knotting or kinking of the catheter [7,18], or blocked catheter eyes (mostly terminal eye catheters) [36]. Collier reported an unacceptably high incidence of unsatisfactory blocks (32%) with terminal eye catheters compared with lateral eye, epidural catheters. He attributed it, in part, to the tendency of end-hole catheters to get blocked [36].

A number of studies have compared uniport and multiport epidural catheters in laboring women, generating some controversy as to risk and complications. There is some evidence that multi-orifice catheters are associated with a significantly lower incidence of unsatisfactory epidural blocks [6,36,37]. Consistent with these reports, Segal et al [13] showed that the replacement rate in the single-orifice group (14.3%) was considerably higher than in the multi-orifice group (9.3%). In one study, however, the incidence of unilateral, patchy, and replaced blocks appeared to be similar in the two groups [38].

Another catheter-related factor that influences the incidence of inadequate analgesia is the length of catheter in the epidural space. Although the traditional recommendation is to insert epidural catheters 3 to 4 cm into the epidural space [7], a prospective randomized study suggested that the optimal distance to thread an epidural catheter is either 2 or 6 cm, depending on the clinical situation [37]. Similarly, Beilin et al [39], using multi-orifice catheters threaded 3, 5, or 7 cm into the epidural space, found that the 5-cm insertion was associated with the lowest incidence of inadequate blocks.

Identifying the epidural space by a lost of resistance to air method is thought to increase the incidence of inadequate anesthesia. Dalens et al [40] described two pediatric cases in which epidural bubbles were the cause of incomplete analgesia during epidural anesthesia. Using epidurography, Boezaart [41] correlated a painful, unblocked segment in a parturient with an air-filled bubble in the T12-L1 region. A randomized study, comparing air versus saline to identify the epidural space in parturients, found a higher incidence of inadequate analgesia in the air group (36% versus 19%) [42].

Some authors believe that the method of injecting a local anesthetic to induce epidural anesthesia may influence the occurrence of inadequate anesthesia. They suggest that injection through the needle, fractionated or as a bolus, may produce better quality anesthesia compared to incremental injection through the catheter [15,43,44]. However, a randomized direct comparison of the two techniques found no difference for either the time of onset or the quality of anesthesia [45]. Most anesthesiologists discourage large-volume bolus epidural injections in parturients for safety reasons [46,47].

Some authors believe a small initial volume of a slowly delivered local anesthetic is the cause of inadequate, frequently unilateral epidural blockade [26,29]. Evaluation of two different volumes of local anesthetic with the same amount of drug clearly demonstrated the superiority of a larger volume of anesthetic with respect to quality of analgesia in the parturient [48,49].

Both the patient's position during induction of epidural anesthesia and the effect of gravity are also thought to influence the incidence of inadequate block. Traditional recommendations suggest that a sitting [7] or a semi-sitting [8] position during induction reduces the rate of incomplete sacral anesthesia. However, studies examining the impact of the patient's position on the effectiveness of sacral anesthesia have produced conflicting results with some showing no difference [49–51] and others showing improved anesthesia [52,53].

Patient-related and other risk factors

Other predictors of poor epidural analgesia/anesthesia for labor and cesarean section have been proposed. Whether body weight by itself represents an independent risk factor for the development of inadequate block remains uncertain [54,55]. The skin to the epidural space distance [30], the amount of extradural fat, and other consequences of obesity may account for this effect [54]. Morbid obesity and a body mass index greater than 30 are associated with a high initial failure rate and a greater incidence of inadequate analgesia [56,57].

A few other independent risk factors linked to inadequate pain relief for labor and delivery have been identified. These include radicular pain during epidural placement, posterior presentation of the fetus, inadequate analgesia from the initial dose, and duration of labor longer than 6 hours [55]. In a multifactorial analysis of inadequate epidural anesthesia for surgery in nonpregnant patients, the probability of pain was greater for both short and tall individuals [14]. One study suggests that a history of previous (successful or unsuccessful) epidural anesthesia for labor increases the risk of unilateral epidural anesthesia on a subsequent occasion [58]. Previous spinal surgery and a variety of musculoskeletal disorders may present an additional risk factor contributing to a higher rate of inadequate epidural anesthesia [19,59].

Technical skills or performance factor

As many experts in the field acknowledge, the epidural technique is a rather complex method that requires precise manual skills and experience. Therefore, failure or inadequacy of extradural blockade varies inversely with the skill of the anesthesiologist [18]. Attempts have been made to correlate obstetric anesthesia performance and psychomotor aptitude of anesthesia trainees [60]. There was poor correlation between psychomotor abilities and epidural failure during early obstetric epidural training where the overall failure rate was 20%. However, after the initial training, psychomotor abilities may start to play a role in an individual's performance.

Management of incomplete epidural block diagnosed preoperatively

Inadequate epidural anesthesia may be recognized in the labor room or in the operating room after administration of concentrated local anesthetic for surgical anesthesia. Morgan et al [61] demonstrated that almost 90% of patients at risk for cesarean section can be identified early, allowing insertion of an epidural catheter that can be used later for cesarean section anesthesia. Ideally a nonfunctioning or poorly functioning epidural catheter is likely to be detected and replaced before the decision is made for operative delivery, thus avoiding the problem of an inadequate epidural for cesarean section. In cases of an emergent cesarean section, or when the epidural catheter is placed de novo immediately before surgery and a full dose of local anesthetic administered, re-siting the epidural catheter may prove to be a difficult and time-consuming task.

The anesthesiologist is then faced with a challenging decision. Depending on the clinical circumstances and presumed mechanism of incomplete epidural anesthesia the options include: single-shot spinal anesthesia, continuous spinal anesthesia, combined spinal epidural anesthesia, replacement of the epidural catheter, additional epidural or caudal injections, general anesthesia, and local infiltration anesthesia.

Single-shot spinal anesthesia

Use of single-shot spinal anesthesia after incomplete or failed epidural block is controversial due to concerns about high block. In 1989, Stone et al [62] described a parturient whose epidural block was inadequate after it was “topped up” for cesarean section. After the intrathecal injection of hyperbaric bupivacaine for spinal anesthesia there was a rapid onset of a high spinal block. Since that time, multiple publications describing similar occurrences appeared [63–70]. The reported rate of occurrence ranged from 0% (none of 61 cases) [63] to 6% (one of 17 cases) [70] to as high as 11% (three of 27 cases) [66]. At our institution, a 1-year retrospective chart review showed a rate of 4.8% (two of 42 cases) [71]. The patients described in these reports presented with unanticipated high spinal block associated with severe respiratory distress and frequently with hypotension. Although there have been no reported deaths, the question of safety of spinal after failed epidural remains. Several mechanisms are proposed to explain these high blocks: physical compression of the dural sac by residual fluid in the epidural space causing an increased cephalad movement of intrathecally injected drugs [63,72,73]; leakage of the local epidural anesthetic into subarachnoid space through a dural hole [74,75]; presence of “subclinical analgesia” due to an earlier exposure of neuronal tissue to epidural local anesthetic [75,76]; and anatomic aberration (such as septations around the thecal sac) [66].

Attempting a spinal after a failed epidural may be technically difficult because of the inability to obtain cerebrospinal fluid (CSF), probably due to the collapse of the subarachnoid space below the termination of the spinal cord caused by epidural fluid compression [73,77]. The spinal needle may also encounter epidural fluid containing local anesthetic that can easily be mistaken for CSF [2]. Despite these drawbacks, many anesthesiologists favor spinal anesthesia after a failed epidural for cesarean section. [2,46,63,66,69,70,78–80] Several recommendations may make this technique safer and more acceptable for practitioners.

First, to avoid compression of the dural sac, limit the total amount of epidural anesthetic injected into the epidural space in an effort to establish surgical anesthesia. In some of the previously mentioned case reports, the volume given through the epidural catheter before the spinal anesthetic was between 26–35mL [62,66,74]. In contrast, at our institution, we incrementally inject a total of 10 to 12 mL of 3% Chloroprocaine over 3 to 4 minutes. If there are no signs of appropriate blockade (sympathetic, sensory, motor) after 6 to 7 minutes, we consider switching to an alternate technique.

Secondly, some authors believe that baricity of local anesthetic, patient position, and the type of spinal needle and its direction will decrease the incidence of high spinal blocks [66,69]. They strongly suggest careful patient positioning during and after subarachnoid injection of hyperbaric spinal solution. Modifications of the head-up position (sitting, semi-sitting, modified Oxford position), along with meticulous monitoring of progression of sensory level of spinal blockade, are the keys to prevent unacceptably high blocks.

Finally, appropriate modification of the volume and total mass (dose) of spinal anesthetic is accepted by many as a critical measure in preventing high spinal blockade. Even though Adams and colleagues reported uneventful spinal anesthetic with a normal dose of hyperbaric bupivacaine in 61 patients with failed epidural [63], conventional wisdom is to reduce the dose and the volume of the spinal solution by 20% to 30% [46,66,70,81]. Presently, at our institution, we routinely decrease the dose and volume of hyperbaric local anesthetic solution and administer the spinal in the sitting position. To estimate the dose of spinal local anesthetic, we hypothesize that there is already some drug in the nerves, and these partially blocked nerves only require half of the dose as compared with unblocked nerves. Therefore, our calculation of the dose for spinal anesthesia is as follows:

In our retrospective chart review of 23 parturients with failed epidural, no patient had a high block after receiving a reduced dose of spinal anesthetic for abdominal delivery [71].

We believe, as many other practitioners do, that spinal anesthesia after failed epidural presents a useful alternative to general anesthesia, provided that appropriate modification of the technique and meticulous monitoring of the patient are established. In the face of a possibility of excessive spinal blockade with respiratory compromise, it is worthwhile to reiterate that all patients who undergo regional anesthesia warrant precautions for the possible need of emergency airway management and/or general anesthesia [63,70].

Continuous spinal anesthesia

Continuous spinal anesthesia may be an effective and safe alternative to a single-shot spinal or general anesthesia, but there are no reports of this technique after failed epidural for cesarean section. Its flexibility, relatively quick onset of action, ability to titrate to effect and provide postoperative pain control, while avoiding local anesthetic toxicity and the need for general anesthesia, are attractive features. Most of the case reports have shown that continuous spinal anesthesia is safe and can be used successfully in parturients with different pathologic conditions, including difficult airway [82–84]. Fear of a postdural puncture headache, however, remains a leading limiting factor when considering continuous spinal anesthesia. Resurgence of interest in continuous microspinal catheters and hopefully their availability in the near future might make this a technique of choice.

Combined spinal-epidural technique

Combined spinal-epidural anesthesia features the reliability of a spinal block with the flexibility of an epidural [85]. Some authors advocate using a markedly decreased spinal dose and volume (eg, 7.5 mg bupivacaine) to avoid high-spinal block, and then using the epidural catheter to supplement the block as needed [86]. We are not aware of any reports of this method in patients with incomplete epidural anesthesia.

Replacement of the epidural catheter

A common practice is to replace the epidural catheter when a poorly functioning labor epidural cannot be optimized. If an inadequate epidural is diagnosed after the administration of large doses of concentrated local anesthetics, it may not be feasible to replace the epidural catheter. Not only is there the risk of local anesthetic toxicity when more local anesthetic is given through a new catheter [87] but there is no guarantee that the new epidural catheter will be more effective. As noted previously, most of the case reports of total spinal anesthesia after failed epidural have involved the epidural administration of a large volume of local anesthetic. While determining the effectiveness of an epidural, it is prudent to limit the amount of local anesthetic injected into the epidural space.

Supplemental epidural or caudal injections

Some authors suggest that supplemental epidural or caudal injections of local anesthetic be given when unblocked segments are isolated in the sacral or upper abdominal areas [87,88]. Aleksandrov et al [89] reported a significant improvement of epidural anesthesia with the addition of a sacral block. Other options include a single-shot, low thoracic epidural if the level of induced lumbar epidural anesthesia does not progress above T10 [38,88] or a second epidural catheter if there are unblocked segments in a patient with disc pathology [90]. Bailey [91] described two patients where a second and even third catheter were successfully used to overcome incomplete (and, in one patient, unilateral) block, although various authors have advocated that this is not generally considered safe. Inserting a second or third epidural catheter has the risk of one of the catheters being cut by the epidural needle as the space is identified at a different level.

General anesthesia

General anesthesia is another option when faced with a failed epidural anesthetic but it is associated with higher maternal mortality than regional anesthesia. The higher mortality rate is mostly attributed to airway management difficulties and problems associated with ventilation and oxygenation. Incidence of failed intubation in the obstetric population has been traditionally described as one in 280. A recent study suggests that the incidence of failed intubation in the obstetric population is one in 250 or possibly even higher [92]. A parturient with a Mallampati class-I, and otherwise favorable airway, is unlikely to pose problems during intubation [93]. When patient assessment reveals a questionable or an unfavorable airway, the safest choice is to secure the airway with the patient awake and spontaneously breathing. Sometimes the amount of local anesthetic that can be safely given to anesthetize the airway will be limited by the amount previously administered into the epidural space.

Local infiltration anesthesia

Local infiltration anesthesia is frequently used as a supplement to inadequate intraoperative epidural anesthesia. Only under the most unusual circumstances (inability to secure the airway or provide alternative neuraxial anesthesia, patient refusal of alternate techniques) should it be considered as the primary rescue technique in the parturient with a failed epidural. Reisner and Lin [2] referred to infiltration anesthesia as “an all-but-forgotten art” [94]. There are several limitations to this technique. These include an increased risk of systemic toxicity due to the large volumes of local anesthetic required, increased length of time for effective anesthesia, greater patient discomfort and the need for special skills and experience to make this technique succeed. Nevertheless, under unique circumstances, when a compromised parturient with failed epidural block faces an imminent cesarean section with no other feasible alternative, this method should not be overlooked.

Management of intraoperative inadequate epidural anesthesia

The reported incidence of intraoperative discomfort and visceral pain during epidural anesthesia ranges from 10% to 50%, and even higher [8,16]. Textbooks and the literature vary in their recommendations as to the upper dermatomal level necessary for cesarean section anesthesia. It is generally accepted that surgical anesthesia to T4 or T5 should provide optimal conditions in the majority of patients. Controversy exists regarding the ability to reliably detect an inadequate surgical block preoperatively. The most widely used tests to detect effective epidural anesthesia are the loss of cold or sharp pinprick sensation [95]. In spite of their popularity, there is evidence that both of these tests have a poor predictive value [96,97]. Some authors have shown that loss of touch sensation correlates best with adequate surgical anesthesia [97,98]. In the absence of neuraxial opioids, no patient with a level of anesthesia up to and including T5, as tested by loss of touch sensation, experienced pain during cesarean section [97].

There are also a number of surgery-related factors that may influence the occurrence and the degree of pain and discomfort that develop intraoperatively. Certain surgical manipulations, such as exteriorization, overstretching the round ligaments, or rough handling of viscera, produce high-intensity stimulation that may overcome even dense neuraxial blockade that was tested and thought to be adequate before surgery [7,38]. In addition, subdiaphragmatic irritation by blood or amniotic fluid may cause chest and shoulder pain or discomfort. Epidural anesthesia that extends to the upper thoracic levels may not relieve these sensations, as C3 to C5 spinal nerves remain unblocked [99]. Chest discomfort may also result from venous air embolism—a quite common event during uterine repair [38].

Many anesthesiologists add a variety of agents to the epidural local anesthetic solution to enhance the quality of the epidural blockade. Epinephrine, bicarbonate, and opioids, combined with some local anesthetics, are particularly effective for improving the quality of intraoperative analgesia [38,96,100]. Some authors, however, have questioned the effectiveness of these additions to bupivacaine [99,101].

Inadequate epidural anesthesia that becomes apparent during surgery may be very distressful for the patient and frustrating for the surgeon and the anesthesiologist. At this point, the treatment choices are limited to supplementation with a variety of agents or general anesthesia. Before deciding to intervene, it is important to determine how much anxiety contributes to the patient's pain and discomfort. Reassurance, emotional support, and a detailed explanation of the nature of residual sensations may console a surprisingly large number of patients. Some authors advocate playing soft music in the background [38]. If the patient's complaints persist, pharmacologic management is the next logical step. The choice of specific agent may depend on the severity of pain and discomfort, as well as the anesthesiologist's preference. Administering nitrous oxide is a common practice; however, some patients lose airway control when receiving 50% nitrous oxide [47]. Intravenous ketamine, given in small increments of 10 mg to 20 mg, is recognized by many as the drug of choice for mild to moderate pain. Small doses of fentanyl (up to 100 É g), and benzodiazepines are also considered safe, although some authors suggest waiting until the umbilical cord is clamped [38]. When sedation appears necessary, diazepam may be superior to midazolam, because it produces less amnesia of the birth event [81]. If pain is localized in certain areas of the surgical field, supplementation with local infiltration by the surgeon may be a definitive remedy. Swabbing of peritoneal cavity with 0.5% lidocaine has been suggested when unopposed peritoneal stimulation appears to be the patient's major source of discomfort [81].

When all feasible efforts to salvage existing epidural anesthesia seem to be unsuccessful and the patient continues to complain of persistent pain, the only remaining choice is induction of general anesthesia. In this case, surgical manipulation should be stopped momentarily, unless bleeding is not under control. The patient must be thoroughly preoxygenated with her position optimized for direct laryngoscopy. If the patient's airway appears to be favorable, then rapid sequence induction with endotracheal intubation should be performed. It is conventional wisdom and standard of practice to secure the airway with an endotracheal tube in a parturient receiving general anesthesia.

When the patient's airway appears to be problematic, the challenge of intraoperative induction of general anesthesia reaches its highest point. Under these circumstances, the safest plan is to secure the airway while the patient is awake by using fiberoptic intubation or an alternative method. If the airway can not be secured, then an alternative method of general anesthesia that allows the patient to maintain spontaneous or mask-assisted ventilation can be chosen, including laryngeal mask airway [102,103]. Some experts suggest maintaining cricoid pressure under these circumstances [103].

Summary

Epidural blockade is an important option for anesthesia in parturients undergoing abdominal delivery. Despite the multiple benefits of this method, there is at least one significant downside—a relatively high occurrence of unsatisfactory anesthesia that requires intervention. Depending on the presumed mechanism of epidural block failure and other clinically relevant factors (eg, timing of diagnosis, urgency of the procedure, and so forth), certain effective measures are recommended to successfully manage this demanding situation. In general, it is important to make every effort to make the pre-existing epidural effective or replace it with another regional technique, because overall, regional anesthesia is associated with significantly lower maternal mortality.

It is important to identify a dysfunctional epidural block preoperatively before a maximum volume of local anesthetic has been administered. If catheter manipulation does not produce substantial improvement, and there is no time constraint, it is safe and reasonable to replace the epidural catheter. However, risks associated with excessive volume of local anesthetic should be kept in mind. Additional epidural injections or a second catheter placement might be considered under special circumstances.

Single-shot spinal anesthesia after a failed epidural may provide fast onset and reliable surgical anesthesia. Available data, although limited and contradictory, suggest the possibility of unpredictably high or total spinal anesthesia. Many authors, however, believe that appropriate precautions and modifications in technique make this a safe alternative. These modifications include limiting the amount of epidural local anesthetic administered when diagnosing a nonfunctioning epidural and decreasing the dose of intrathecal local anesthetic by 20% to 30%. If there is no documented block when the spinal is inserted, and more than 30 minutes have passed from the last epidural dose, it is probably safe to use a normal dose of local anesthetic.

Continuous spinal anesthesia with a macro catheter might be a dependable alternative, particularly if large amounts of local anesthetic have already been used or the patient's airway is a cause for concern.

Although there are no reports of combined spinal epidural anesthesia being used in this context, it would appear to be an attractive alternative. It allows the anesthesiologist to give smaller doses intrathecally, while still offering the flexibility of augmenting the block if needed.

When inadequate epidural block becomes apparent during surgery there are limited alternatives. Depending on the origin and the pattern of inadequate anesthesia, options may include psychological support, supplementation with a variety of inhalational and intravenous agents, and local anesthetic infiltration. Induction of general anesthesia is typically left as a backup option, but must be strongly considered if the patient continues to have pain/discomfort.

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