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CHOOSING AN OPTIMAL METHOD FOR CONVERTING EPIDURAL ANALGESIA INTO ANESTHESIA DURING CESAREAN SECTION. LITERATURE REVIEW

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Abstract. ***Introduction.*** One of the key components of active labor management is effective pain management. Various methods of neuraxial analgesia (spinal, epidural anesthesia and their modifications) are widely used for analgesic purposes in obstetric practice. So, the question of choosing subsequent anesthetic tactics arises, if woman in labor with an epidural catheter already installed for analgesia purposes needs cesarean section for emergency indications. Conversion of epidural analgesia to anesthesia is one of the options for further anesthetic management. ***Goal of study:*** to determine the optimal method of converting epidural analgesia to anesthesia during emergency surgical delivery, based on scientific literature analysis. Those studies are discussed, in which various options of neuraxial anesthesia for labor pain relief and conversion of epidural analgesia to anesthesia when surgical delivery is necessary are used. ***Materials and methods.*** Inclusion criteria: original works published in peer-reviewed journals, availability of publication's full text. Exclusion criteria: lack of publication's full text, clinical cases, editorial articles, lack of data necessary for analysis. Conversion of labor epidural analgesia to anesthesia for caesarean section is a common procedure. For this, various local anesthetics (lidocaine, bupivacaine, ropivacaine, levobupivacaine, prilocaine, etc.) and adjuvants (adrenaline, sodium bicarbonate, etc.) are used. The time of sensory block onset, duration of motor block, speed of woman's recovery, hemodynamic stability and long-term obstetric and neonatal outcomes are used as efficiency criteria of successful conversion. But no single local anesthetic or combination of local anesthetics has shown clear superior benefits. The following are recognized as risk factors for unsuccessful conversion with varying levels of reliability: age of woman in labor, woman's height over 167 cm, gestational age (the higher it is, the greater is the likelihood of failure), lack of effective pain relief during labor, presence of breakthrough pain episodes, number of local anesthetic additional boluses, duration of labor analgesia, degree of caesarean section urgency and provision of anesthesia by a "non-obstetric" anesthesiologist. The risk of unsuccessful transition from epidural labor analgesia to anesthesia increases with the number of local anesthetic boluses administered during labor, degree of cesarean section urgency, duration of labor analgesia, and the provision of anesthesia by a "non-obstetric" anesthesiologist. ***Conclusion.*** To determine the optimal method of epidural analgesia conversion, choice of local anesthetic, its dosage, concentration and combinations of different drugs that do not have negative effect on the intrauterine state of fetus and newborn, further research is needed.

Keywords: epidural analgesia, conversion of epidural analgesia to anesthesia, cesarean section

ВЫБОР ОПТИМАЛЬНОГО МЕТОДА КОНВЕРСИИ ЭПИДУРАЛЬНОЙ АНАЛГЕЗИИ В АНЕСТЕЗИИ ПРИ КЕСАРЕВОМ СЕЧЕНИИ. ОБЗОР ЛИТЕРАТУРЫ

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Резюме. ***Введение.*** Одним из ключевых компонентов активного ведения родов является эффективное обезболивание. С анальгетической целью в акушерской практике широко применяют различные методики нейроаксиальной аналгезии (спинальная, эпидуральная анестезия и их модификации). Если роженице с уже установленным для аналгезии эпидуральным катетером по экстренным показаниям необходимо кесарево сечение, остро встает вопрос о выборе последующей анестезиологической тактики. Одним из вариантов дальнейшего анестезиологического обеспечения является конверсия эпидуральной аналгезии в анестезию. ***Цель исследования:*** на основе анализа научной литературы определить оптимальный метод конверсии эпидуральной аналгезии в анестезию при экстренном оперативном родоразрешении. Обсуждаются исследования, в которых использованы различные варианты нейроаксиальной анестезии для обезболивания родов, применение конверсии эпидуральной аналгезии в анестезию при необходимости оперативного родоразрешения. ***Материалы и методы.*** Критерии включения работ: оригинальные работы, опубликованные в рецензируемых журналах, наличие полного текста публикации. Критерии невключения: отсутствие полного текста исследования, клинические случаи, редакционные статьи, отсутствие данных, необходимых для анализа. Конверсия родовой эпидуральной аналгезии в анестезию при кесаревом сечении является распространенной процедурой. Для этого используются различные местные анестетики (лидокаин, бупивакаин, ропивакаин, левобупивакаин, прилокаин и др.) и адъюванты (адреналин, бикарбонат натрия и др.). В качестве критериев эффективности удачной конверсии применяются время наступления сенсорного блока, длительность моторного блока, скорость восстановления женщины, стабильность гемодинамики и отдаленные акушерские и неонатальные исходы. Но ни один из местных анестетиков или их комбинация не продемонстрировали однозначные непревзойденные преимущества. В качестве факторов риска неудачного выполнения конверсии с разным уровнем достоверности признаны: возраст роженицы, рост женщины более 167 см, срок беременности (чем он выше, тем вероятность неудачи больше), отсутствие эффективного обезболивания родов, наличие эпизодов прорывной боли, количество дополнительных болюсов местного анестетика, продолжительность обезболивания родов, степень срочности кесарева сечения, а также обеспечение анестезии «неакушерским» анестезиологом. Риск неудачного перехода от эпидуральной аналгезии родов к анестезии возрастает с увеличением количества болюсов местного анестетика, вводимых во время родов, степенью срочности кесарева сечения, продолжительностью обезболивания родов и оказанием помощи «неакушерским» анестезиологом. ***Заключение.*** Для определения оптимального метода конверсии

эпидуральной аналгезии, выбора местного анестетика, его дозировки, концентрации и комбинаций разных препаратов, не оказывающих отрицательного влияния на внутриутробное состояние плода и новорожденного, необходимы дальнейшие исследования.

Ключевые слова: эпидуральная аналгезия, конверсия эпидуральной аналгезии в анестезию, кесарево сечение

INTRODUCTION

Despite availability of numerous methods and schemes of analgesia and anesthesia in labor and abdominal delivery, the search for the safest one is still ongoing [1, 4, 11]. The last two decades were marked by an increased interest in neuraxial anesthesia methods (spinal, epidural anesthesia and their modifications), which, according to many authors, have a number of advantages and are optimal in obstetric practice [2, 14, 16, 19, 21, 21, 30, 33, 82].

From 2017 to 2018, 21% of more than 100,000 cesarean sections performed in England were carried out under epidural anesthesia [35]. Epidural analgesia is recommended by the World Health Organization as the primary method of labor pain relief, and 30% of women laboring in the UK and 60% in the US receive epidural analgesia [46].

The advantages of epidural analgesia are high analgesic efficacy, low complication rates, the possibility of adequate analgesic effect in the postpartum period, and conversion to epidural anesthesia when cesarean section is necessary [3, 5, 13, 36, 57, 65, 65, 92, 98].

When epidural analgesia is used during natural childbirth and situations require operative delivery (for both maternal and fetal indications), the anesthesiologist faces an issue of choosing an appropriate method of anesthesia. This issue depends on various factors, including urgency, mother's and fetus's health, since anesthesia may cause deterioration of uteroplacental and fetal blood flow, which predetermines the outcome of labor and affects a newborn in the early neonatal period [6, 49, 50, 68, 88].

It is known that different local anesthetics administered epidurally, as well as their combination in different concentrations have various effects both in labor and in the postpartum period. Thus, injection of lidocaine into epidural space is accompanied by the fastest development of motor block. Ropivacaine has a relative anesthetic efficacy of 0.6 compared to bupivacaine, is less cardiotoxic/neurotoxic and causes less pronounced motor blockade. Meanwhile, bupivacaine and levobupivacaine have almost the same anesthetic effect and cause dose-dependent motor block [8, 27, 46, 52, 78, 85].

The efficacy of epidural anesthesia for cesarean section does not depend on body mass index, but it can be influenced by height, the number of boluses of anesthetic administered during labor, duration of anesthesia, previous catheterization of epidural space, and other factors [31, 99].

Currently, there are no clear recommendations on converting epidural analgesia during labor to epidural anesthesia for emergency cesarean section. Various variants of neuraxial analgesia and primarily epidural analgesia are widely used worldwide to anesthetize natural childbirth. In the USA, more than 70% of women in labor prefer adequate anesthesia for labor [56].

Disputes about analgesia and its outcomes are probably the most acute issue in the history of obstetric anesthesiology. However, providing effective analgesia is one of the key components of active labor management, and its use is recommended in modern protocols [7, 9, 56].

A population-based study of 575,524 women who underwent their first delivery through natural labor in New York City obstetrics facilities from 2010 to 2017 was conducted. The use of neuraxial analgesia reduced the risk of severe maternal complications by 14%, mainly by reducing postpartum hemorrhage, and the number of these complications was independent of premorbid background and race or ethnicity [44].

Efficiency of analgesia, among other factors, is influenced by the method of anesthetic delivery. Currently, bolus, continuous infusion, patient-controlled epidural analgesia (PCEA) and computer integrated patient-controlled epidural analgesia (CIPCEA), as well as various combinations of these delivery modes are widely used [18, 46, 63, 86]. Each has its own pros and cons [39, 67, 95].

Although epidural analgesia is the most effective method of anesthesia [53, 97], there is a problem described in earlier studies. They showed that epidural analgesia increased the likelihood of operative delivery by caesarean section [37, 83]. However, the 2005 Cochrane Review, which compared epidural analgesia with other methods of analgesia or labor without analgesia, showed no impact of epidural analgesia (EA) on the incidence of cesarean section [20]. It has been demonstrated that 28% of women who were anesthetized with epidural analgesia delivered by cesarean section compared to 31.7% of women who were not anesthetized [53]. Later work has shown a lower cesarean section rate of 4–14% when epidural analgesia is used to anesthetize labor [56].

Neuraxial analgesia in natural childbirth is not a universal procedure, so the techniques used for its implementation may vary in different countries and institutions, which, in turn, may affect the influence of EA on a cesarean section rate [51].

When cesarean section is indicated, the presence of an epidural catheter placed for analgesia may be used for further anesthesia. In this situation, choosing a method of anesthetic support is based on urgency of surgery, anesthesiologist's experience and personal preference.

When it is necessary to convert epidural analgesia to anesthesia, a higher dose of concentrated local anesthetic is injected into the epidural catheter, which allows epidural analgesia to be considered the optimal technique for anesthesia of labor [25, 56]. For this purpose, various local anesthetics are used, and adjuvants such as sodium bicarbonate, adrenaline, and narcotic analgesics are added to enhance the effect of local anesthetics and lead to a faster development of persistent sympathetic blockade [35, 60]. Based on a survey of UK anesthesiologists, 13 combinations of local anesthetics and adjuvants that are used for this purpose have been identified [84].

At the same time, it should be emphasized that injection of narcotic analgesics during neuraxial anesthesia is limited in Russia. Only promedol and morphine are allowed to be administered in the epidural space, while intrathecal administration of narcotic analgesics is not recommended [2]. Moreover, mixing of drugs in an emergency situation may lead to drug dosing errors and delay the time of local anesthetic administration [42, 93].

The choice of local anesthetics and the options for combining them with adjuvants differ from country to country. Thus, the survey of anesthesiologists in the United Kingdom showed that 40% of specialists used only 2% lidocaine hydrochloride solution or its combination with other narcotic analgesics, 72% of respondents used levobupivacaine or bupivacaine [38, 84, 90, 93].

No difference was found in sensory block onset time to the Th_7 level when comparing the use of a mixture of 2% lidocaine solution with adrenaline 1:200,000 and 0.5% bupivacaine hydrochloride solution with 50 μg fentanyl [42].

It has been demonstrated that there is no difference in sensory block time to Th_4 when 0.75% ropivacaine hydrochloride and 0.5% bupivacaine hydrochloride are used [90].

Using a single drug, such as ropivacaine or levobupivacaine, appeared to be more preferable since it reduced the number of errors and the time required to dilute it. This may be clinically significant in emergency situations, such as fetal distress [15, 93]. In other non-life-threatening cases, few more minutes spent on preparing a solution for insertion is not relevant [43, 93].

A prospective, randomized, double-blind, double-center controlled clinical trial compared equipotent doses of intrathecal hyperbaric prilocaine 50 mg or hyperbaric bupivacaine 10 mg, and both drugs in combination with sufentanil 2.5 μg and morphine 100 μg for planned cesarean section. An epidural catheter was placed as a backup, in case spinal anesthesia failed. Median motor block time was significantly shorter in the hyperbaric prilocaine group (110 [104–150] min vs 175 [135–189] min, p=0.001). The woman's first unassisted movement was achieved earlier in the prilocaine group (204.5 [177–246.5] min vs 314 [209.25–400] min, p=0.007), and the incidence of arterial hypotension was significantly higher with bupivacaine (p=0.033). No additional epidural analgesia was required. The authors conclude that prilocaine provides shorter motor block, faster recovery and hemodynamic stability than bupivacaine, while providing equivalent depth of anesthesia [41].

It has been shown that 93.5% of cesarean sections were performed under neuroaxillary anesthesia, and 41% of patients had epidural catheters inserted earlier during labor. These catheters were subsequently used to provide anesthesia for cesarean section [73, 93].

Conversion of epidural analgesia to anesthesia for cesarean section is necessary but not always successful [47, 56, 69].

The ineffectiveness of conversion of epidural analgesia to anesthesia for emergency cesarean section ranges from 0 to 21% [65, 69].

The incidence of failed conversion is recorded as a complication. It is included in the quality of care audit, subsequently analyzed in detail, and depends on many factors. The Association of Anesthesiologists in the United Kingdom recommends that the rates of failed conversion should not exceed 1% for planned caesarean section and 5% for emergency caesarean section [56, 69].

Factors for failed epidural conversion include maternal age [56, 71], woman's height greater than 167 cm [56, 69], gestational age (the greater it is, the higher the likelihood of failure) [56, 71], lack of effective labor analgesia, presence of episodes of breakthrough pain [28, 56], number of additional boluses of local anesthetic, duration of labor analgesia [56], degree of urgency of cesarean section [56, 60], and anesthesia factors such as epidural analgesia without CA [56], as well as provision of anesthesia by a "non obstetric" anesthesiologist [28, 56, 87]. Taking into account the above-mentioned factors, the most important are labor anesthesia by a "non-obstetric" anesthesiologist, a large number of additional boluses of local anesthetic, and the degree of urgency of cesarean section [56, 69].

Crucial factors that influence the choice of anesthesia technique during labor include time required for sensory

block to develop and the urgency of cesarean section. These factors may partially explain the fact that most anesthesiologists choose not to manipulate a catheter or substitute epidural anesthesia. Further administration of local anesthetic may, in addition, increase the risk of systemic toxicity [10, 17, 56, 74].

Risk factors associated with failed conversion of epidural anesthesia have been widely studied. Breakthrough pain in labor may be a marker of poorly functioning epidural analgesia or indicate discoordinated labor [56, 75].

To date, there is no clear consensus on the effect of body mass index (BMI), the degree of cervical opening at the time of initiation of epidural analgesia, and the administration of combined spinal-epidural versus standard epidural analgesia techniques. However, the duration of epidural analgesia in labor has been shown to significantly increase the likelihood of unsuccessful epidural conversion for cesarean section [35, 69].

A literature review revealed controversial data regarding body mass index and the number of successful conversions of epidural analgesia to anesthesia [23, 69]. A meta-analysis that included 6 studies showed that maternal weight was not associated with the efficacy of epidural conversion [24]. Only one of 6 studies demonstrated an association between body weight and failed epidural conversion [71].

Obese women have higher cesarean section rates, are more likely to be diagnosed with difficult airway and have more complications when performing a neuraxial block. This should prompt more careful monitoring and careful management of epidural analgesia in labor. Greater thickness of soft tissue between skin surface and yolk ligament increases the likelihood of catheter displacement in an obese patient during movement [24, 59, 87].

Currently, there is no conclusive evidence that duration of epidural analgesia in labor (brief or prolonged) is a risk factor for unsuccessful conversion to epidural anesthesia. It has been suggested that prolonged labor may result in catheter dislodgement from the epidural space. Conversely, when indications for cesarean section are established immediately after induction of labor anesthesia, there may not be enough time to determine the efficacy of anesthesia for cesarean section. Most authors studying this problem have failed to prove the relationship between the duration of epidural analgesia and the success of conversion [56, 69].

In case the causes of ineffective epidural conversion are identified and this technique is improved according to the analysis of failures, this may prevent the use of more complex and costly methods of anesthesia. Violation of the epidural conversion technique may require conversion to general anesthesia [91].

There are many reasons why general anesthesia is undesirable, including higher incidence of maternal mortality, possibility of pulmonary aspiration, difficult tracheal intubation, neonatal depression, uterine hypotension with volatile anesthetics, postoperative pain, and nausea [27, 56]. Maternal dissatisfaction and pain are leading causes of litigation related to obstetric anesthesia [32, 66, 69].

Definitions of epidural conversion failure are contradictory. Most authors define failure as conversion to general anesthesia [69]. Other authors define failure as conversion to another form of anesthesia [69, 87].

Most anesthesiologists (89%) would consider supplementing the epidural analgesia for further cesarean section. When analyzing whether to supplement existing epidural analgesia of labor, factors influencing the decision were the efficacy of epidural analgesia in labor (99%), the degree of urgency of cesarean section (73%), and the level of sensory blockade (61%).

Anesthesia options include the following: manipulation of the epidural catheter (pull up 0.5–1 cm) or its replacement, performance of combined spinal-epidural or spinal anesthesia, and induction of general anesthesia [35].

In addition to epidural analgesia without dura puncture, labor can be anesthetized by combined spinal-epidural analgesia (CSEA), in which the dura is punctured with a small-gauge spinal needle. There is evidence that CSEA-initiated labor analgesia is more effective in anesthetizing the labor pain [54, 69, 72]. At the same time, a retrospective study including 1,025 laboring women compared epidural with combined spinal-epidural analgesia, where they demonstrated a higher rate of failed conversion with EA compared to CSEA [64]. The CSEA technique allows better identification of the epidural space and subsequent catheter placement, and the puncture hole in the dura improves local anesthetic penetration and thus improves the quality of anesthesia [24, 76].

Other investigators have failed to demonstrate a difference between epidural and combined spinal-epidural analgesia [40, 69].

Thus, combined spinal-epidural analgesia is more reliable as a method of labor analgesia, although there is currently insufficient data to conclude that CSEA is superior to EA for conversion in case of cesarean section. Several studies have shown that neuraxial methods of labor analgesia performed by obstetric anesthesiologists reduces the likelihood of failed epidural conversion [55, 87].

There are 2 out of 70 reported cases of failed conversion after epidural catheter placement performed by an obstetric anesthesiologist compared to 20 out of 170 cases of catheterization performed by a “non-obstetric” anesthesiologist. The obstetric anesthesiologist has been shown to be more successful because he or she can manipulate the epidu-

ral catheter with greater confidence or use other neuraxial anesthesia techniques to avoid the need for general anesthesia [55, 87].

According to Campbell D.C. et al. (2009), the incidence of general anesthesia was 5.5% when the conversion was performed by a "non-obstetric" anesthesiologist compared to 1.2% when the manipulation was performed by an obstetric anesthesiologist. Other authors have shown that failure rates of conversion amounted to 7.2 and 1.6%, respectively [40, 69].

It might be explained by more correct manipulations with an epidural catheter in obstetric patients by obstetric anesthesiologists. It has been demonstrated that 84.6% (22 of 26) of poorly functioning epidural catheters can be successfully repaired by pulling up 1 cm, as evidenced by a pronounced anesthetic effect after such a manipulation. It has been shown that 58.3% of obstetric anesthesiologists use this technique, while only 5.9% of "non-obstetric" anesthesiologists did so [28]. The overall failure rate of epidural anesthesia conversion is also confirmed by other authors [29, 56, 58].

Several studies have reported that additional boluses of local anesthetic required to treat breakthrough pain during epidural analgesia are associated with a higher failure rate of epidural anesthesia conversion [42, 84]. Even a single unplanned bolus increases the likelihood of epidural conversion failure. Quantity of boluses was the best predictor of ineffective conversion from epidural analgesia to anesthesia [28, 69].

A meta-analysis showed that the rate of ineffective epidural conversion increased 3-fold in laboring women who required additional boluses during labor [24].

The degree of emergency cesarean section is also associated with failed epidural conversion. Up to 25% of epidural conversion failures were identified when cesarean section was performed immediately upon the development of fetal life-threatening conditions [48, 56, 69, 77, 81]. The urgency for surgery is related with ineffective epidural conversion. This convertion cannot always be achieved in a few minutes designated for a cesarean section for vital indications. General anesthesia allowed to start surgery on average 8 minutes faster than regional anesthesia [26, 69].

Thus, urgency of cesarean section determines the ineffectiveness of epidural conversion. Nevertheless, it is well known that general anesthesia is often preferred when time is critical.

Attempting to convert epidural analgesia to anesthesia, it is advisable to determine the level of sensory block by needling the skin above Th_5–Th_6, there should be a loss of perception as well as disappearance of cold sensation at Th_3 soon after injection of local anesthetic into the epidural catheter [69, 93]. If a surgical stage of anesthesia cannot be achieved, then a anesthesiologist switches to alternative methods such as different variants of neuraxial anesthesia or general anesthesia. An unsuccessful attempt to convert epidural analgesia into anesthesia when cesarean section is required poses a difficult clinical problem to an anesthesiologist, since it is necessary to choose the most optimal method of anesthesia.

Epidural anesthesia. After a failed epidural conversion, it is possible to insert a new catheter into the epidural space. Lee S. etal. reported that 21 of 1025 catheters were replaced during labor before cesarean section. In all cases of replacement, epidural analgesia was successfully converted to anesthesia for operative delivery [53, 64, 94].

However, epidural catheter replacement is time-consuming. Careful titration of local anesthetic to achieve surgical stage of anesthesia should be kept in mind, as repeated injection of a full dose of local anesthetic into the epidural space may lead to the development of systemic toxicity as a result of possible catheter migration as well as other complications [10, 69].

Spinal anesthesia. Spinal anesthesia for cesarean section may be used after epidural analgesia and is performed more frequently because of inadequately functioning epidural analgesia, either immediately before attempted epidural conversion or after failed epidural conversion. The decision to initiate spinal anesthesia after epidural analgesia for labor remains controversial and should be undertaken with caution. Spinal access involves removal of the epidural catheter and repeat puncture for spinal anesthesia. Spinal anesthesia is preferred by some practitioners who believe it may provide better anesthesia compared to epidural anesthesia [69].

Traditionally, the initiation of spinal anesthesia shortly after discontinuation of epidural anesthesia during labor has not been encouraged because of numerous reports of subsequent development of high or total spinal block [35, 69]. The local anesthetic (LA) dose should be reduced to lower the risk of complications when spinal anesthesia is initiated shortly after an unsuccessful epidural conversion attempt. The local is injected into the spinal space. It is also possible to sustain a pause between the last injection of local anesthetic into the epidural catheter and the spinal space [69].

More than one-third of anesthesiologists have experienced the development of high or total spinal block during spinal anesthesia, but these complications have been reported almost nine times less frequently during CSEA [35, 62].

The optimal dose of local anesthetic for spinal anesthesia after epidural analgesia for labor is unknown. Some studies suggest that decreasing the dose of anesthetic may

adversely affect efficacy of the anesthesia administered. This results in an increased need for intravenous or inhaled anesthetics required for general anesthesia [69].

Combined spinal-epidural anesthesia. CSEA has become widespread in anesthesia practice and is widely used not only in obstetrics, but also in general surgery, traumatology-orthopedics, urology, gynecology and so on. Rapid onset and prolonged effect of anesthesia, the possibility of continuing anesthesia in the postoperative period are the main advantages of CSEA over spinal and epidural anesthesia [12].

This method of anesthesia is an attractive option after unsuccessful epidural conversion because it provides rapid onset, reliable anesthesia, and the possibility of prolonging the blockade by additional injection of local anesthetic into an epidural catheter [69]. When performing combined spinal-epidural anesthesia, a deliberately low dose of local anesthetic is first injected into the subarachnoid space, such as 6–9 mg of 0.75% hyperbaric bupivacaine, which reduces the risk of developing a high spinal block. If the resulting block is not enough for a surgical stage of anesthesia, additional doses of local anesthetic can be administered through a newly placed epidural catheter [69].

Some authors report a longer time required to perform CSEA compared to EA, although only one trial showed a clinically significant difference which amounted to 11 minutes [62]. Specialists have expressed concern regarding an untested epidural catheter when initiating a cesarean section under CSEA. After administering a small dose of LA intrathecally, subsequently inserted LA may increase anesthetic distribution in the spinal canal, thereby increasing the likelihood of sensory block development [69].

Extended spinal anesthesia. Extended spinal anesthesia has long been considered the best option, especially for patients with cardiopulmonary disease, where the level of sensory block must be carefully monitored [69]. Extended spinal anesthesia is also indicated for patients in other categories, such as vertebral neurology, obesity, and anticipated difficult tracheal intubation [69]. However, the likelihood of headache after dura mater puncture with a large-diameter needle remains high [69].

Spinal anesthesia can be unsuccessful in a number of cases. There are many ways to define the term “failed spinal anesthesia” Many publications indicate two main points. First, partial failure is defined as pain or discomfort occurring during surgery and requiring additional intravenous or inhalation analgesia [22]. Second, complete failure is defined as failure to achieve adequate sensory blockade, making it necessary to perform general anesthesia [89]. The incidence of complete failure of spinal anesthesia requiring conversion to general anesthesia for caesarean section ranges from 0.5 to 6.4% [79].

In addition, extended spinal anesthesia may be associated with the development of neurological complications [34, 69]. For these reasons, extended spinal anesthesia is used in patients who experienced unintentional puncture of dura mater during catheterization of the epidural space.

Local anesthetic infiltration. Local anesthetic infiltration has been used in past when neuraxial anesthesia or general anesthesia was not performed. This method of anesthesia is not currently used, mainly due to lack of training and experience, resulting in inadequate anesthesia, and the possibility of delayed care. However, local anesthetic infiltration can be used in an emergency situation to augment inadequately functioning neuraxial anesthesia [69, 80]. Up to 10.7% of patients during caesarean section experience discomfort or anxiety after conversion of epidural anesthesia from analgesia, requiring additional administration of intravenous and/or inhaled anesthetics [69, 80].

General anesthesia. Neuraxial anesthesia is usually more preferable than general anesthesia because it allows a mother to participate in labor, reduces the likelihood of intubation problems with difficult airways, and avoids depressive effects of systemic anesthetic drugs on a fetus and uterine tonus. It is also possible to preserve woman’s consciousness during general anesthesia. At the same time, the use of neuraxial anesthesia facilitates postoperative analgesia [24, 61].

Switching to general anesthesia and avoiding the use of an epidural catheter for a surgical stage during CS is considered an inefficient option for using regional anesthesia [53, 96].

Many specialists prefer to perform general anesthesia during emergency caesarean section due to fetal deterioration without any attempt to pre-convert epidural analgesia to anesthesia [28, 61, 94].

This approach may be based on the notion that it takes less time to induce general anesthesia than to convert epidural analgesia to anesthesia. E. Palmer et al. (2018) demonstrated a significantly shorter time interval from induction to incision with general anesthesia, which was 6 minutes compared to 11 minutes with epidural anesthesia, but this time difference did not correlate with worse neonatal outcomes [72]. On the contrary, the use of general anesthesia is associated with lower Apgar scores five minutes after delivery, the need for mask ventilation and neonatal admissions to intensive care units [35, 70, 96].

Back in 2007, P. Popham et al. showed that there was no significant difference in time taken from the indication for caesarean section to fetal delivery regarding general and epidural anesthesia, which amounted to 17±6 min and 19±9 min, respectively [77].

General anesthesia has been associated with preservation of consciousness during surgery and complications related to aspiration and failed intubation, as well as critical incidents after conversion of regional anesthesia rather than primary conversion to general anesthesia [74, 96].

A major achievement described by S. Ismail et al. (2015) was the reduction of rejections to perform conversion. This was evidenced by performing general anesthesia in 40.3% of cases without attempting to convert epidural analgesia to anesthesia when performing caesarean section. Emergency caesarean section was the main reason for rejecting the use of epidural anesthesia conversion in 50 (28.4%) women. Previously, authors described the use of general anesthesia as the main method of anesthetic management without any attempt to convert epidural analgesia to anesthesia due to the urgency of caesarean section [47, 53].

Conversion of epidural analgesia for labor to anesthesia for caesarean section is an important strategy to limit the use of general anesthesia in obstetrics. A high rate of successful conversions presents a good criterion for quality of care, indicating the prior availability of functional epidural analgesia as well as the avoidance of general anesthesia [24, 45].

Strategies aimed at improving the conversion will enhance safety and quality of anesthetic care provided in obstetrics.

CONCLUSION

Epidural analgesia in labor is presented as the most effective method of relieving labor pain, which can be converted to epidural anesthesia in case of emergency caesarean section, as an existing epidural catheter might be used to administer local anesthetics. The optimal method of epidural analgesia conversion that does not adversely affect the intrauterine condition of the fetus and neonate has not been determined to date. The risk of unsuccessful conversion from epidural analgesia to anesthesia increases with the number of boluses of local anesthetic administered during labor, the degree of urgency of caesarean section, the duration of anesthesia, and the assistance provided by a “non-anesthesiologist”.

When epidural conversion fails, the use of spinal or combined spinal-epidural anesthesia is preferred over general anesthesia. There is no unambiguous approach in selecting a local anesthetic, its dosage, concentration and combination with different drugs when converting epidural analgesia to caesarean section anesthesia, which requires further research.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

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