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Modern methods of regional and postoperative anesthesia during cesarean section: a literature review

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ABSTRACT

The number of cesarean section (CS) deliveries increases annually in Russia. General anesthesia involves certain risks, including difficult or unsuccessful intubation, aspiration, and infectious and thromboembolic complications. Therefore, regional anesthesia is the method of choice for CS. To date, choosing the most effective method of regional anesthesia remains challenging, including in the postoperative period. Thus, this review aimed to compare the effectiveness of regional anesthesia methods used in CS and identify the most preferred ones for use in clinical practice. The authors conducted a literature search in the electronic databases PubMed (MEDLINE), eLibrary, and Google Scholar using the following keywords and their combinations in English and in Russian: «cesarean section», «neural morphine», «regional analgesia», «epidural analgesia», «peripheral nerve block», nerve block», «paravertebral block», «cesarean section», neuroaxial use of opioids», «regional analgesia», «epidural analgesia», «peripheral nerve blockade», «blockade», and «paravertebral blockade». The search results revealed 3 558 in the PubMed database, 94 in eLibrary, and 2 662 in Google Scholar. The results show that the neuroaxial administration of opioids remains the gold standard of pain relief after CS; however, information on the analgesic effectiveness of new blockades, such as anterior block of the quadratic lumbar muscle and block of the muscle straightening the spine, continues to accumulate.

Keywords: regional anesthesia; cesarean section; obstetrics; anesthesiology; neuroaxial anesthesia; peripheral nerve blockade; surgery.

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Современные методы регионарной анестезии и послеоперационного обезболивания при кесаревом сечении: обзор литературы

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АННОТАЦИЯ
В Российской Федерации ежегодно увеличивается число родоразрешений путём кесарева сечения (КС). Общая анестезия влечёт за собой определённые риски, включая сложную или неудачную интубацию, аспирацию, инфекционные и тромбоэмболические осложнения. Именно поэтому регионарная анестезия является методом выбора при КС. В настоящее время всё ещё существуют трудности с выбором наиболее эффективного метода регионарной анестезии, в том числе в послеоперационном периоде. Целью настоящего обзора было сравнение эффективности методов регионарной анестезии, используемых при КС, и выявление наиболее предпочтительных для использования в клинической практике. Авторами проведён поиск литературы в электронных базах данных и библиотеках PubMed (MEDLINE), eLibrary, Google Scholar с использованием следующих ключевых слов и их сочетаний: «cesarean section», «neuraxial morphine», «regional analgesia», «epidural analgesia», «peripheral nerve block», «nerve block», «paravertebral block», «кесарево сечение», «нейроаксиальное применение опиоидов», «регионарная аналгезия», «эпидуральная аналгезия», «блокада периферических нервов», «блокада», «паравертебральная блокада». По итогам поиска обнаружено 3558 источников в базе данных PubMed, 94 — в eLibrary и 2662 — в Google Scholar. В итоговый анализ вошло 65 источников. Результаты обзора показывают, что нейроаксиальное введение опиоидов по-прежнему остаётся «золотым стандартом» обезболивания после КС, однако продолжает накапливаться информация о лучшей обезболивающей эффективности таких новых блокад, как передняя блокада квадратной мышцы поясницы и блокада мышцы, выпрямляющей позвоночник.

Ключевые слова: регионарная анестезия; кесарево сечение; акушерство; анестезиология; нейроаксиальная анестезия; блокада периферических нервов; операция.

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BACKGROUND

In Russia, there is a steady increase in the incidence of cesarean section (CS), which reached 30.9% in 2021 [1]. Regional anesthesia is the method of choice for CS in 90% of cases [2], due to lower anesthesia-related morbidity compared to general anesthesia, which may be complicated by difficult or failed intubation, aspiration, infection and thromboembolism [3]. Additional benefits of regional anesthesia include postoperative anesthesia, reduced blood loss, and lower maternal morbidity and mortality [4].

Due to the increasing tendency towards a shorter length of postoperative hospital stay, neuroaxial anesthesia combined with ultrasound-guided peripheral nerve block techniques is actively used in obstetric anesthesiology [2], but there is still insufficient evidence to support its universal use in CS [2, 5]. More data on the type and efficacy of conventional nerve blocks compared with intrathecal or epidural morphine administration are needed.

AIM

Our aim was to analyze the literature on the use of regional anesthesia methods in CS, including neuroaxial administration of opioids and regional peripheral nerve blocks; to compare the efficacy of these methods during the surgery and postoperative period, and to identify the most preferable methods to be used in clinical practice.

RESEARCH METHODOLOGY

The literature search was conducted in the electronic databases and libraries PubMed (MEDLINE), eLibrary, Google Scholar using the following keywords and their combinations: "cesarean section," "neuraxial morphine," "regional anesthesia," "epidural anesthesia," "peripheral nerve block," "nerve block," "paravertebral block" in English and in Russian. The search results revealed 3558 sources in the PubMed database, 94 in eLibrary, and 2662 in Google Scholar. The review included the studies published predominantly in the last 10 years. The literature search was limited to randomized controlled trials (RCTs) and meta-analyses. Descriptive reviews, abstracts, and short reports were excluded. The authors independently analyzed the titles and abstracts of relevant studies and extracted the full text after establishing their eligibility. Inclusion criteria for the review:

- Description of the block technique in the study;
- Publication in English or Russian;
- CS performed using the Pfannenstiel incision.

The research algorithm is presented on Figure 1.

DISCUSSION

Specificity of anesthesia in cesarean section

There are several surgical approaches to delivery by CS. The techniques differ depending on the location and direction of the incision. The incision can be

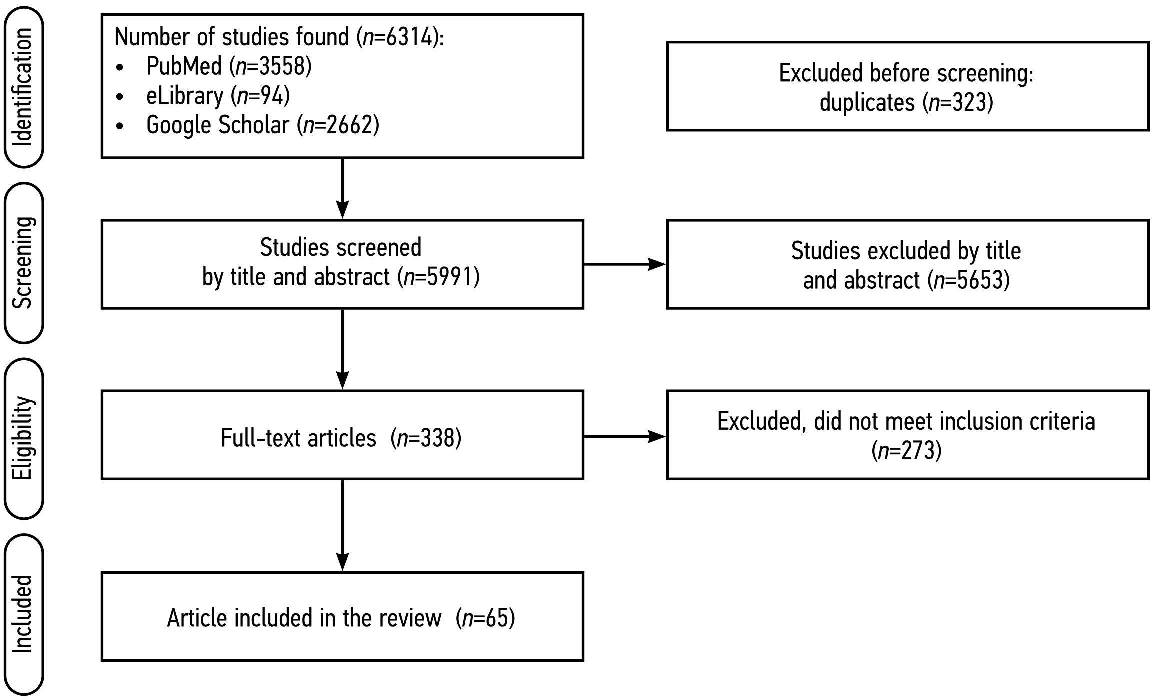

Fig. 1. Research algorithm.

vertical or horizontal and located at different sites. The present literature review is limited to the discussion of transverse lower segment CS with transverse skin incision, known as the Pfannenstiel method. Alternative methods are less common [5], so they were not the focus of our work.

While intraoperative CS using neuroaxial anesthesia usually requires a sensory block extending from the sacral dermatomes to the T_{IV} level, anesthesia after CS does not require such extensive coverage [6]. In Pfannenstiel incisions, somatic innervation of the skin often consists of the ilioinguinal and iliohypogastric nerves coming from the T_{XI}–L_{I} spinal nerve roots. The entire anterior abdominal wall and fascial layers are innervated by multiple nerves, including the thoracoabdominal (T_{VII}–T_{XI}), subcostal (T_{XII}), iliohypogastric (L_{I}), and ilioinguinal (L_{I}) nerves, most of which pass through the fascial plane between the internal oblique and transverse abdominal muscles. The uterus receives sympathetic innervation from the lower thoracic nerve roots T_{XI}–T_{XII} / upper lumbar nerve roots L_{I}–L_{III} via the hypogastric plexus, and parasympathetic innervation from the pelvic splanchnic nerve from the nerve roots S_{II}–S_{IV} [7]. Thus, the goal of regional anesthesia is the penetration of local anesthetic along these anatomical structures.

Regional anesthesia in cesarean section

Neuroaxial anesthesia

Neuroaxial anesthesia is the administration of a local anesthetic with or without adjuvants such as opioids or adrenaline into the epidural (epidural anesthesia) or subarachnoid/intrathecal space (spinal anesthesia). This method is commonly used for anesthesia of the chest, abdomen, and lower extremities, including anesthesia during and after CS [8].

For neuroaxial anesthesia, the patient is placed in a sitting or lateral position. After skin preparation and bandage application, the spinous processes are palpated or identified by ultrasound. Local infiltration is placed in the gap between the spinous processes in midline access or between the laminae in paramedian access. The needle is inserted into the epidural or intrathecal space gradually, depending on the technique of resistance reduction, with or without ultrasound. Spinal anesthesia (SA) is usually a single injection, while epidural anesthesia (EA) requires placement of a catheter for continuous anesthetic infusion. There is also a variant of combined spinal-epidural anesthesia (CSE) [9].

The use of ultrasound during the procedure might be helpful. Transverse scanning of the lumbar spine allows visualization of the posterior and anterior dura mater complex to control the depth of resistance loss. Sagittal scanning of the lumbar spine in the lamina region also allows visualization of the interlayer space and real-time placement of a neuroaxial block [10].

Neuroaxial anesthesia is commonly used in lower abdominal and lower extremity surgeries, including CS, to establish a tight surgical block [8]. In addition, neuroaxial techniques can be used for postoperative anesthesia either by single injection or by continuous infusion. Postoperative anesthesia does not require the same level of block density as surgical intervention.

Currently, neuroaxial administration of opioids (particularly epidural or intrathecal administration of morphine) is the gold standard of anesthesia after CS. It is also an important aspect of multimodal anesthesia supported by the clinical guidelines of the American Society of Anesthesiologists (ASA) [11]. More recent studies cited in the ASA guidelines demonstrate improved patient outcomes with the use of neuroaxial opioids compared to opioids administered intravenously or intramuscularly [12, 13]. This is true both in terms of pain control and adverse events associated with the use of opioids in post-CS pain management, such as pruritus, nausea, vomiting, and risk of respiratory depression [14]. However, in recent years, the development and improvement of the new methods of peripheral anesthesia, discussed below, has challenged the conclusions of these recommendations [15]. Early data showed that neuroaxial administration of opioids provides more effective anesthesia than peripheral nerve block [16, 17], and the combination of various regional anesthesia techniques, including block of the quadratus lumborum and transverse abdominal muscles, with neuroaxial administration of opioids does not appear to provide a significant additional analgesic effect [18]. Knowledge about the use of regional anesthesia techniques is continuously increasing; awareness of the physical and psychological adverse effects of postpartum pain on women in labor is growing, and special attention is being paid to early postoperative rehabilitation and minimization of persistent postoperative pain. Further studies are needed to continuously evaluate the efficacy of each individual peripheral nerve block in the absence of and in combination with neuroaxial opioid administration.

Paravertebral block

Thoracic paravertebral block (PVB) is widely used for anesthesia in thoracic and upper abdominal surgeries. It is performed by injecting anesthetic into the space bounded by the vertebral body medially, the pleura anteriorly, and the superior costotransverse ligament posteriorly. This is where the spinal nerve root is located after it exits the epidural space, and the sympathetic trunk is located nearby [19].

The thoracic paravertebral space ends at the L_I level with the upper attachment of the lumbar muscle [20]. The L_I nerve root enters another part of the lumbar muscle to form the lumbar plexus, and it is thought to be insufficiently blocked by the thoracic PVB [20]. Although PVB at the T_{XII}–L_I level is insufficient for the Pfannenstiel incision at the L_I level, it has the advantage of possible medial extension into the epidural space and blocking visceral pain at the surrounding epidural levels [21].

During PVB, the patient can be placed in a sitting, lateral, or prone position. A block is performed using anatomical landmarks or ultrasound guidance. The most common technique is ultrasound-guided paramedian approach. With paramedian sagittal approach, the level of the T_{XI} and T_{XII} vertebrae is determined using the inferior border of the thorax as a landmark. A low-frequency curvilinear ultrasound probe is placed in the sagittal plane along the midline and slowly moved laterally until transverse processes appear. With a slight lateral tilt, the pleura is usually exposed in the spaces between the transverse processes. In some cases, the costotransverse ligament may be visualized in the gap above the pleura. After local infiltration, the needle is inserted in the plane of the ultrasound beam. The goal is to insert the needle between the transverse processes and through the costotransverse ligament, if visible. The success of the block is determined by the pleura descending downward when the local anesthetic is injected [22] and (ideally) the absence of superficial spread toward the erector spinae muscle (ESM).

The widespread use of ultrasound allows accurate assessment of the efficacy and location of the PVB injection, as well as clear differentiation between paravertebral and erector spinae plane block. While direct comparison of PVB with and without ultrasound guidance is rare, the use of ultrasound guidance has been demonstrated to increase the likelihood of block success and postoperative pain control [23, 24]. Nevertheless, evidence for the efficacy of PVB for pain control after CS is still insufficient. Currently, there are no RCTs and no evidence beyond clinical case reports.

Erector spinae plane block

Currently, the erector spinae plane (ESP) block has been shown to be quite effective in the anesthesia of patients with multiple rib fractures, and also as an alternative to epidural block and PVB [25]. The ESP-block involves longitudinal distribution of local anesthetic in a fascial plane anterior to the ESM and posterior to the transverse processes [26]. Although only the dorsal branches are in this plane, the effectiveness of the block in anterior chest wall surgery suggests that sometimes, although unreliably, the ventral branches are also blocked. It is believed that local anesthetic diffuses anteriorly through ligamentous structures into the paravertebral space [27]. It is hypothesized that without the articulating rib, the ventral branches would have better extension at the level of nerve root L_I and below. The erector spinae plane is located posterior to the psoas muscle, and the local anesthetic is free to spread in a cranio-caudal direction. Studies have shown the possibility of anterior spread of local anesthetic into the lumbar plexus [27]. There is also the possibility of epidural spread, as local anesthetic that enters the paravertebral or lumbar plexus region can also spread into the epidural space [28].

The patient may be placed in a sitting, lateral or prone position when the ESP-block is performed. The procedure is almost always performed under ultrasound guidance. Depending on the patient's body habitus, a high-frequency linear or low-frequency curvilinear ultrasound probe is placed in the sagittal plane along the midline and scanned transversely until the transverse processes appear. A slight lateral tilt may help to expose the pleura, but it is not always necessary. After local infiltration, the needle is inserted in the plane of the ultrasound beam and pushed just behind the transverse process through the ESM. The success of the block is determined by the cranial and caudal spread of the local anesthetic in the plane between the transverse process and the ESM [26].

I.D.V. Ribeiro Junior et al. conducted a systematic review and meta-analysis consisting of 3 RCTs that focused on comparing ESP-block with other postoperative anesthetic interventions, including other types of abdominal wall block and intrathecal morphine [29]. The 2 RCTs included in the meta-analysis comparing ESP-block with transverse abdominis plane (TAP) block after CS yielded consistent results. The ESP-block provided a significantly better pain relief for a longer period; patients who underwent TAP-block used more additional opioids and sought emergency pain control earlier than the group of patients with the ESP-block [30, 31]. The third study showed no statistically significant differences between a low thoracic ESP-block and alternative methods of pain control [29]. A separate RCT involving 52 patients comparing the low thoracic ESP-block with the posterior quadratus lumborum muscle block (QLB) showed no significant differences in pain scores or block efficacy [32]. A similar result of equal analgesic effect was obtained in a RCT comparing the lower thoracic ESP-block with anterior QLB [33]. Further comparison between ESP and alternative peripheral nerve blocks in this group of patients is the subject of future studies.

Most RCTs evaluating the efficacy of the ESP-block after CS do not include neuroaxial administration of opioids. However, one RCT compared 140 patients, half of which received an ESP-block with bupivacaine without neuroaxial opioids and another half received intrathecal morphine and an ESP-block with saline. This study showed a significantly lower need for oral opioids, lower pain scores in the first 24 h, and longer time to first administration of additional pain control medication in patients who received a bupivacaine ESP-block [34]. These results suggest that the ESP-block may have a greater analgesic effect than intrathecal morphine, although they have yet to be replicated and studied in a larger population. It would also be worthwhile to evaluate the efficacy of the ESP-block in combination with intrathecal morphine administration and analyze whether this would have additional efficacy.

Lateral, posterior and anterior quadratus lumborum block

The quadratus lumborum block (QLB) targets the fascial planes surrounding the quadratus lumborum muscle (QLM), the posterior abdominal wall muscle that originates from below the posterior iliac crest and the iliolumbar ligament and is located above the X_{II} rib as well as the L_I–L_V transverse processes [35]. Posterior to the QLM is the ESM with the middle thoracolumbar fascia between them. Posterior to the QLM is the psoas muscle with the anterior thoracolumbar fascia between them. The fascial plane lateral to the QLM is in contact with the transverse plane of the abdomen. The lateral QLB targets the lateral border and provides local anesthetic distribution like that of transverse abdominis plane (TAP) block (type 1 QLB). The posterior QLB (type 2 QLB) targets the middle thoracolumbar fascia posterior to the QLM and may extend to the thoracic paravertebral spaces through this fascial plane. Anterior or transmuscular QLB (type 3 QLB), targets the anterior lumbosacral fascia and can extend to the thoracic paravertebral spaces [35]. Some studies report distribution of the drug to the Th_{VII} paravertebral space, while others report distribution only to Th_{IX}–T_X [36]. As for distribution in the lumbar region, there is a possibility of spreading to the upper roots of the lumbar nerves (up to L_{III}), but this was mainly observed in studies conducted on cadavers. It should be noted that the iliohypogastric and ilioinguinal nerves, branches of L_I, run along the anterior surface of the QLM on their way to the pelvis [37].

Depending on the patient's body habitus and the type of QLB selected, a high-frequency linear or low-frequency curvilinear ultrasound probe can be used to scan in the transverse plane. The probe is moved anteriorly from the mid-axillary line to identify the external oblique, internal oblique, and transverse abdominal muscles. The physician then focuses on the plane between the internal oblique and transverse abdominal muscles (transverse abdominal plane) and follows this plane posteriorly. The internal oblique muscle eventually narrows, and the transverse plane superficial to the transverse abdominal muscle joins the fascia deep to the transverse abdominal muscle. Both fasciae together are adjacent to the superficial posterior margin of the QLM [38].

Once the QLM is identified, a lateral QLB can be performed superficial to the QLM, and the local anesthetic spread transversely can be seen. To perform a posterior QLB, the needle can be placed at the posterior border of the QLM where it meets the ESM and inserted into the middle thoracolumbar fascia. To perform an anterior QLB, the needle must be placed deep into the muscle where the QLM borders the psoas muscle and inject local anesthetic into the anterior thoracolumbar fascia. The downward descent of the psoas muscle on ultrasound indicates successful transmuscular anterior QLB [38]. It should be noted that the QLM tends to be less echogenic than the psoas muscle.

The results of several RCTs have demonstrated that in the absence of neuroaxial opioid administration, lateral [39, 40], posterior [41], and anterior [42] QLBs are effective in reducing postoperative pain scores and opioid consumption in patients after CS compared with controls. In addition, one RCT in 2021 comparing anterior and posterior QLB in patients under neuroaxial anesthesia in the absence of neuroaxial morphine showed that anterior QLB resulted in significantly greater reductions in pain scores, 24-hour opioid consumption, and time to first additional pain control [43]. These results were confirmed in a 2022 RCT involving 104 patients who underwent CS under general anesthesia, further supporting the idea of the efficacy of anterior QLM as a superior pain control in the absence of neuroaxial morphine [44].

Many RCTs have focused on comparing different types of QLBs with TAP-blocks to determine whether one of them provides sufficient analgesia or reduced opioid consumption. K. El-Boghdadly et al. conducted a meta-analysis that included 31 RCTs. The authors compared all 3 types of QLBs with lateral and subcostal TAP-blocks in patients who did not receive neuroaxial morphine, and all types of compared blocks were found to be equal in their pain control effect [18]. However, many individual RCTs found evidence suggesting that QLBs do provide greater reductions in pain and opioid consumption compared with TAP-blocks, with 1 study suggesting a prolonged effect of QLBs compared with TAP-blocks [45–48].

While most studies have focused on assessing the early pain control efficacy of these blocks, M. Borys et al. used the Neuropathic Pain Symptom Inventory (NPSI) scale to assess postoperative pain months after the posterior QLB and TAP-block in the absence of neuroaxial opioid administration. The authors found significant reductions in pain scores at 1 and 6 months in the QLB and TAP-block groups compared to controls but did not note statistically significant differences in the analgesia efficacy of the compared blocks [49]. This unique study demonstrates that the benefits of regional anesthesia exceed the duration of the block itself, and future studies could further extend and quantify this effect.

The results of several meta-analyses demonstrated a significant analgesic effect of QLB compared to control in patients who did not receive neuroaxial opioids [50, 51]. However, in a meta-analysis conducted by H. Tan et al. including 10 RCTs, the authors found no significant improvement in pain control in patients who received QLB and neuroaxial opioids together compared to those who received neuroaxial opioids alone [51]. Similar results were obtained in a meta-analysis including 31 studies [18]. These data show that QLBs of all types have limited efficacy in patients already receiving neuroaxial opioids, one author directly compared the efficacy of posterior QLBs with intrathecal administration of morphine and found surprising results. E.R. Salama demonstrated that patients who underwent a single posterior QLB with 0.375% ropivacaine had significantly reduced pain scores at rest and with movement, decreased additional opioid consumption after 48 h, and had significantly fewer adverse events than those who received 100 μg of intrathecal morphine. In addition, the author demonstrated a 70% reduction in additional opioid intake in the QLB group compared to controls, whereas the intrathecal morphine group had an overall reduction in opioid intake of 30% compared to controls [52]. These results have not been reconfirmed.

Transversus abdominis plane block

There are several approaches to performing the TAP-block to target different dermatomes, but they all aim to injecting anesthetic into the fascial layer between the 2 muscles of the abdominal wall. The subcostal TAP-block, which targets the fascial plane along the midclavicular line just below the rib cage between the posterior rectus sheath and the transverse abdominal muscle, is thought to cover T_{VI}–T_{IX} dermatomes. The midaxillary TAP-block, formerly known as the lateral TAP-block, targets the fascial plane between the internal oblique and transverse abdominal muscles along the midaxillary line between the ribs and pelvis. The midaxillary TAP-block is considered to cover the T_X–T_{XII} dermatomes from the midline of the abdomen to the midclavicular line. The combined ilioinguinal-iliohypogastric nerve block (IINB) targets the same fascial plane as the midaxillary TAP-block but is performed medial to the anterior superior iliac spine to cover the ilioinguinal and iliohypogastric nerves [53]. It should be noted that these blocks do not reach the neuroaxial space or extend to the sympathetic trunk and thus do not cover visceral pain.

In CS with Pfannenstiel incision, IINB and/or midaxillary TAP-block is preferred given the specific features of their distribution. With the patient placed in the supine position, the high-frequency linear transducer is placed in a transverse orientation on the abdomen just above the iliac crest along the midaxillary line for the TAP-block or slightly medial to the anterior superior iliac spine for IINB. The 2 oblique muscles and the transverse abdominal muscle are identified, and the needle is inserted into the fascial plane between the internal oblique and the transverse abdominal muscles. The iliohypogastric nerve and the ilioinguinal nerve are located adjacent within this fascial plane and can be recognized by their hyperechogenic oval shape. Success of the block is determined by the downward descent of the transverse abdominal muscle and the underlying peritoneum [54].

It is well established that both midaxillary block and IINB do provide some postoperative pain control in patients who underwent CS. The subcostal TAP-block was infrequently investigated in this group of patients, probably due to the irrelevant localization. A meta-analysis of 17 studies involving 11 000 participants demonstrated pain control efficacy of a TAP-block compared with controls in the absence of neuroaxial opioid administration; patients receiving a TAP-block needed fewer oral opioid equivalents and had a longer period before requiring their first opioid [55].

The types of TAP-block have been compared with each other, as well as with many other peripheral nerve blocks, to assess their efficacy for pain control after CS. As mentioned above, RCTs comparing the TAP-block with the ESM-block demonstrated the superiority of the latter in reducing total opioid consumption as well as in increasing the time to first pain control administration [30, 31]. While the results of the meta-analysis showed no significant difference in the pain control effect of the TAP-block compared to different types of QLB, 24 independent RCTs demonstrated superiority of QLB compared to the TAP-block [45–48]. A systematic review including 5 RCTs demonstrated similar efficacy for post-CS pain control when comparing midaxillary TAP-blocks with IINB [55]. 2 meta-analyses failed to establish a statistically significant pain control benefit of the ultrasound-guided TAP-block compared with direct wound infiltration with local anesthetic in subcutaneous tissue in post-CS patients without neuroaxial opioid administration [56, 57].

Multiple meta-analyses including RCTs investigated post-CS patients receiving neuroaxial morphine as well as the ultrasound-guided TAP-block. An analysis of 524 patients in 2012 and 1100 in 2020 did not confirm that the addition of TAP-block to neuroaxial morphine had any additional pain control effect [55–59]. A meta-analysis comparing the efficacy of midaxillary TAP-block and lateral QLB showed that in the presence of neuroaxial opioid, there was no significant difference in pain control in patients receiving regional anesthesia compared to controls [18]. In 2022, S. Ryu et al. performed the largest meta-analysis to date, including 76 studies involving 6278 post-CS patients, comparing various regional techniques including neuroaxial, ESB, TAP-block, QLB, IINB, and others. Based on the results of the study, the authors concluded that only IINB combined with neuroaxial morphine provides additional pain control effect compared to isolated neuroaxial morphine administration [60].

Rectus sheath block

The rectus abdominis muscles are represented by 2 tracts, which are located in the fascial sheath. This is a fibrous section formed by the aponeurosis of the transverse abdominal muscle, internal and external oblique muscles. It contains the thoracoabdominal nerves after they pass through the transverse plane of the abdomen. After entering the posterior sheath of the rectus muscle, they branch off anterior cutaneous branches that supply the midline of the abdominal wall. It should be noted that this arrangement is present only above the arcuate line, which is located just caudal to the umbilicus. Below the arcuate line, there is no posterior sheath of the rectus muscle, thus the thoracoabdominal nerves run anterior to the rectus muscle. The classical technique of injecting anesthetic into the layer posterior to the rectus abdominis is unlikely to block the nerves below the arcuate line and thus does not provide sufficient block [61].

The linear probe is placed above the umbilicus to visualize the oval-shaped rectus abdominis muscles. There are 2 hyperechogenic lines under the rectus abdominis: the upper line is the posterior sheath of the rectus muscle, and the lower line is the peritoneum. The needle is inserted in a plane toward the gap between them, ideally in the lateral third of the rectus muscle, to block the thoracoabdominal nerve before entering the rectus muscle [61].

Several studies evaluated the pain control efficacy of rectus sheath block (RSB) in CS with Pfannenstiel incision. An RCT comparing RSB to control in the absence of neuroaxial morphine demonstrated no significant difference in pain scores or reduction in opioid consumption over 24 h, raising concerns about the efficacy of RSB in pain control for this procedure. In the same RCT, RSB was compared with the TAP-block, and a significant reduction in total opioid consumption as well as postoperative pain scores was noted in the TAP-block group [62].

Local infiltration anesthesia

At the end of the surgical procedure, the surgeon may inject the local anesthetic directly into the operative field at any location he or she chooses; there is no single standard location for this technique. The surgeon may also decide to inject the local anesthetic deep into the rectus fascia, in the plane between the subcutaneous fatty tissue and the rectus fascia, or into the subcutaneous tissue only. In addition, the surgeon may decide to perform a single injection or place a permanent catheter in a plane of his choice for continuous infusion of local anesthetic [21].

Both TAP-block and local infiltration anesthesia (LIA), whether by single injection or continuous infusion through the catheter, have been shown to reduce opioid consumption over 24 h and provide more sustained pain control compared to controls in the absence of neuroaxial opioid administration [55, 59, 63]. However, a meta-analysis comparing the efficacy of TAP-block and LIA found no statistically significant difference in 24 h opioid consumption, 24 h pain score, or time to first additional pain control medication [57]. A second meta-analysis replicated the same results: the TAP-block may have little or no significant benefit in reducing postoperative pain compared with LIA [58]. One RCT found that continuous administration of ropivacaine via catheter did not result in any reduction in pain scores or postoperative opioid consumption compared to a control group that received continuous infiltration of the wound catheter with saline [64].

An RCT comparing 24-hour opioid requirements and pain scores in patients receiving intrathecal morphine versus those receiving continuous wound infiltration with ropivacaine showed a significant reduction in postoperative opioid use during the first 24 h in the intrathecal morphine group [64]. Additional studies are necessary to clarify these preliminary results.

Discussion

Currently, most studies that directly compared neuroaxial opioid administration and individual peripheral nerve blocks favor neuroaxial morphine for postoperative pain control, regardless of the peripheral nerve block technique used. In fact, most of the literature data do not demonstrate a significant analgesic effect of peripheral nerve blocks in combination with neuroaxial morphine. The largest meta-analysis to date on this issue suggests that only IINB combined with neuroaxial morphine provides an additional analgesic effect. New data from separate RCTs, which are yet to be replicated, suggest that other types of blocks may have some analgesic effect (one is ESP-block, another is posterior QLB).

It has been conclusively demonstrated that most regional anesthesia techniques provide some analgesic benefit to the patient compared with placebo in the absence of neuroaxial morphine, with the TAP-block being the most frequently used regional anesthesia technique. While many individual RCTs have demonstrated an analgesic benefit of all 3 types of QLB compared with the TAP-block, the largest available meta-analysis comparing these 2 techniques refutes this conclusion. When comparing different types of QLBs, the newest technique, anterior QLB, appears to be the most effective. Although the ESP-block has been much less studied, preliminary evidence suggests that it may have a more pronounced analgesic effect compared with the TAP-block.

Despite the possible advantages of regional techniques performed closer to the spinal nerve root, such as anterior QLB and ESP-block, their technical difficulties, as well as the need to place the patient to the lateral or prone position immediately after open abdominal surgery under neuroaxial or general anesthesia, carry numerous risks and logistical problems that need to be carefully evaluated. It is possible that even if compelling evidence in favor of these blocks becomes available, the TAP-block may become the method of choice for anesthesia after CS, in part because it is less difficult to perform.

The aim of our paper was to provide guidance for clinical decision making in evidence-based practice based on the available evidence, which is limited in number and heterogeneous in study design. In addition, there are only sparse data on a continuous local anesthetic infusion through a catheter in the studied population; a study of continuous infusions through a peripheral nerve catheter may prolong the effects of regional anesthetics beyond that provided by neuroaxial morphine and reveal the analgesic effects of blocks, which are absent with a single infusion of injection of local anesthetics.

Regardless of the anesthetic or multimodal analgesic components selected for CS, there remains a high incidence of postoperative pain after intervention. In fact, inadequate control of postoperative pain is the main reason for low patient satisfaction with surgery. Adequate pain control in this patient group is crucial because it promotes mother-child bonding and leads to a reduction in the incidence of postpartum depression and maternal mortality [65].

CONCLUSION

Neuroaxial opioid administration remains the gold standard for post-CS anesthesia. The short-term benefits of a single regional anesthetic injection in patients who have already received neuroaxial morphine may be negligible regardless of the technique or location of peripheral nerve block. In cases where neuroaxial opioids have not or cannot be administered, there is compelling evidence that regional anesthesia techniques can improve post-CS pain control and reduce opioid consumption postoperatively. Neuroaxial administration of opioids currently has the greatest amount of evidence to support it, but information continues to accumulate on the better analgesic efficacy of newer blocks such as anterior QLB and ESP-block.

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