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Title: Overview of ultrasound-guided plan blocks performed within the scope of multimodal anesthesia applications in lower and upper abdominal surgeries.

Short title: Overview of plan blocks used in abdominal surgery.

Abstract

Effective acute postoperative pain management is essential to prevent chronic pain, preserve function, and enhance quality of life. Multimodal anesthesia protocols are widely recommended for effective control of postoperative pain. Due to the side effects of opioids, there has been an increase in the tendency towards non-opioid based analgesic approaches. Peripheral nerve blocks support this approach. Nerve blocks used in upper abdominal surgery include external oblique intercostal block and paravertebral block; nerve blocks used in lower abdominal surgery include transversalis fascia plan block. Nerve blocks used in upper and lower abdominal surgery include transversus abdominis plan block and bilateral erector spina plan block. Appropriate use of these blocks reduces opioid use, prevents chronic pain, and improves patient satisfaction.

Keywords: postoperative pain, plane block, multimodal general anesthesia.

Makale başlığı: Alt ve üst abdominal cerrahilerde multimodal anestezi uygulamaları kapsamında yapılan ultrason eşliğinde periferik sinir bloklarına genel bakış.

Öz

Kronik ağrıyı önlemek, fonksiyonu korumak ve yaşam kalitesini artırmak için etkili akut postoperatif ağrı yönetimi çok önemlidir. Postoperatif ağrının etkili bir şekilde kontrol edilmesi için multimodal anestezi protokolleri yaygın olarak önerilmektedir. Opioidlerin yan etkileri nedeniyle, opioid içermeyen analjezik yaklaşımlara yönelme eğilimi artmıştır. Periferik sinir blokları bu yaklaşımı desteklemektedir. Üst abdominal cerrahide kullanılan sinir blokları arasında eksternal oblik interkostal bloğu ve paravertebral blok; alt abdominal cerrahide kullanılan sinir blokları arasında transversalis fasya plan bloğu yer alır. Üst ve alt karın cerrahisinde kullanılan sinir blokları transversus abdominis plan bloğu ve bilateral erektör spina plan bloğu örnek verilebilir. Bu blokların uygun kullanımı, opioid kullanımını azaltır, kronik ağrıyı önler ve hasta memnuniyetini artırır.

Anahtar kelimeler: Postoperatif ağrı, plan bloğu, multimodal genel anestezi.

Introduction

Postoperative pain

The International Association for the Study of Pain (IASP) defines pain as “an unpleasant sensory and emotional experience associated with or defined in terms of actual or potential tissue damage”. Recognizing and understanding the value of pain classification systems in the pain assessment process and clinical decision-making is essential to provide appropriate care for every patient experiencing pain [1].

Pain is classified based on mechanism, duration, cause, and location [2]. Pain is divided into three categories according to its pathophysiologic mechanism: pain caused by tissue disease or damage (nociceptive pain such as osteoarthritis), pain caused by somatosensory system disease or damage (neuropathic pain) and the coexistence of nociceptive and neuropathic pain (mixed pain) [3].

Nociceptive pain is a normal bodily response to injury. It can be caused by damaged tissues such as internal organs, muscles and bones. Nociceptive pain is divided into somatic and visceral. Somatic pain occurs in injuries to the musculoskeletal system, including skin, muscles and bone. Visceral pain, also called reflected pain, is associated with visceral tissues and can be felt indirectly [1].

Various stimuli of nerve damage in the peripheral or central nervous system can lead to neuropathic pain. Any process that damages nerves, such as metabolic, traumatic, infectious, ischemic, toxic or immune-mediated pathological conditions, can cause neuropathic pain. In addition, neuropathic pain may be caused by nerve compression or abnormal processing of pain signals by the brain and spinal cord [2, 3].

Mixed pain neuropathic pain may coexist with nociceptive pain. In some disease states, patients may experience mixed pain consisting of somatic, visceral and neuropathic pain at the same time or at different times, each separately. The different pathophysiologic mechanisms described above may work together to produce mixed pain. Examples include trauma that damages tissue and nerves, burns and cancer that causes external nerve compression and damages nerves through infiltration.

In some painful conditions, the pathophysiological mechanisms of pain are not well understood and/or cannot be demonstrated. Such pain is often incorrectly labelled as psychogenic. Although psychological factors are known to influence pain perception, true psychogenic pain is very rare. Limitations in our current knowledge and diagnostic tests may also be reasons for not finding any underlying cause and therefore the term idiopathic is recommended instead [2].

One of the main reasons for placing a patient under general anesthesia is surgically induced nociception. Left untreated, nociceptive pain can trigger intraoperative hemodynamic responses and postoperative chronic pain. Opioids are effective antinociceptives but have notable side effects such as respiratory depression, nausea, urinary retention, and constipation [4].

Effective management of acute postoperative pain is essential to prevent the development of persistent pain in the postoperative period. Inadequate pain control after thoracotomy, breast, or abdominal surgery increases the risk of developing chronic postoperative pain [5].

Chronic postoperative pain is thought to be neuropathic pain as a result of long-term inflammation or surgical injury to large peripheral nerves [6]. Surgical injury activates neural and inflammatory responses, increasing the risk of organ dysfunction. More pharmacologic techniques need to be developed to modify surgical stress responses [7]. Preoperative administration of high-dose glucocorticoids (>15 mg dexamethasone) provides significant analgesia, reduces postoperative fatigue and adverse physiologic responses, and may enhance recovery [8-10].

New strategies to improve postoperative pain and reduce opioid consumption are under investigation. Psychological interventions to reduce stress, anxiety, negative emotions and depression through education, therapy, behavior modification and relaxation techniques can reduce postoperative pain and opioid use [11].

Multimodal anesthesia

The definition of “multimodal” or “balanced analgesia” in the treatment of postoperative pain was first used in 1993 [12]. Multimodal analgesia refers to the use of two or more drugs or non-pharmacologic interventions with different mechanisms. Its use has been shown to limit the amount of opioids consumed and provide more effective pain control than opioids alone [13].

Multimodal general anesthesia strategies should include: (1) administer combinations of antinociceptive agents, each selected to target a different circuit in the nociceptive system; (2) continuously monitor levels of antinociception and unconsciousness; (3) use the sedative effects of antinociceptive agents to reduce doses of hypnotic agents and inhaled anesthetics; and (4) continue multimodal pain control in the postoperative period in the hospital and after discharge [4].

Component therapies of multimodal analgesia with significant evidence supporting efficacy in postoperative patients include gabapentinoids, paracetamol, ketamine, nonsteroidal anti-inflammatory drugs (NSAIDs) and regional anesthesia [13]. Multimodal therapy for perioperative pain management is recommended for all postoperative patients.

Drugs such as paracetamol, non-steroidal anti-inflammatory drugs, gabapentin and pregabalin should be considered as part of postoperative multimodal pain management. Patients should receive a regimen of NSAIDs, Cyclooxygenase inhibitor (COXIB) or paracetamol unless contraindicated. Regional blockade with local anesthetics should also be part of a multimodal approach to pain management. Dosing regimens should be implemented to maximize efficacy while minimizing the risk of side effects; and the choice of drug, dose, route of treatment and duration of treatment should be individualized [14, 15].

In an American study involving approximately 800.000 patients, great variability was observed in the use of multimodal analgesia between hospitals. It has been shown that nonopioid analgesics are underutilized in many institutions. In fact, nonopioid analgesics offer a cost-effective strategy to improve outcomes and patient satisfaction with a superior side effect profile than opioids alone [13].

Opioid-free general anesthesia

Opioids are an integral part of perioperative care due to their high analgesic efficacy. They have well-known short-term side effects and the potential for long-term adverse effects for patients and society. Long-term oral opioid use, especially for chronic pain, contributes significantly to the ongoing opioid epidemic, particularly in North America [16]. To reduce the side effects and overdose of opioids, opioid-free anesthesia has emerged as an alternative analgesic [17].

Known nonopioid analgesic strategies include paracetamol, nonsteroidal anti-inflammatory drugs or cyclooxygenase-2 specific inhibitors, local/regional analgesic techniques and non-pharmacological adjuncts (acupuncture, transcutaneous electrical nerve stimulation, psychological modalities etc.). Drugs generally recognized as analgesic adjuncts include steroids, gabapentinoids, intravenous lidocaine infusion and ketamine infusion. Dexmedetomidine, magnesium and β-blocker infusions are also available. As an α_2 adrenoceptor agonist, dexmedetomidine exerts sedative and analgesic effects through the locus coeruleus center and the posterior horn of the spinal cord, and it has sympathetic neurolysis. Recommended opioid-free anesthesia practices include administration of several nonopioid analgesics and analgesic adjuncts, with infusions of dexmedetomidine, magnesium, and β-blockers in various combinations [16, 18].

Opioid-free anesthesia plays an important role, especially in patients with chronic pain who use opioids before surgery. These patients are at risk of more severe postoperative acute pain when they consume more opioids after surgery. It also increases the risk of chronic postoperative pain in these patients [19].

Additional analgesia models using local anesthetics such as intraoperative wound infiltration, plane blocks, postoperative wound, catheter, peripheral nerve blocks and continuous epidural infusions also reduce the need for postoperative opioids [20].

Plane blocks in analgesia for upper abdominal surgery

The external oblique intercostal plane block

The external oblique intercostal plane block (EOI) block was described as potentially covering the dermatomes T6-T10 in a study on cadavers and patients, which is ideal for surgeries on the gallbladder (Figure 1) [21]. Opioid-free analgesia has been advocated in various patient populations, including obese adults in whom neuraxial techniques may be challenging. Its use reduces the theoretical risk of opioid-induced central apnea and offers multiple advantages in pediatric patients, such as improved satisfaction and shorter hospital stays. Opioid-free analgesia is particularly recommended as part of the perioperative plan for upper abdominal surgeries [22].

The reliably superficial nature of the technique is also of advantage in obese patients, where neuraxial, transversus abdominus plane and erector spinae plane block techniques are more challenging. Placing a catheter outside the surgical field without complex positioning offers significant advantages in frail, acutely pained, or critically ill patients for whom advanced positioning is difficult or impractical [23]. Ultrasound guided EOI is used for postoperative analgesia in sleeve gastrectomy, cholecystectomy and liver surgery [24-26].

Paravertebral plane block

Paravertebral block (PVB) has been demonstrated as an effective analgesia for thoracic and abdominal surgery. PVB is associated with potential complications such as intraoperative hypotension, pneumothorax, and neurovascular injury [27].

Plane blocks in analgesia for lower abdominal surgery

Abdominal plane blocks applied within the scope of multimodal analgesia reduce opioid requirements and provide post-operative analgesia after surgeries such as inguinal hernia repair and cesarean section [28].

Caesarean section

Cesarean section accounts for approximately 20% of deliveries worldwide. Early pain after cesarean section limits the patient's physical activity and negatively affects quality of life. Furthermore, untreated acute pain can lead to long-term complications such as persistent pain and postpartum depression, as well as delays in breastfeeding and mother-baby bonding. Multimodal analgesia techniques that can accelerate the recovery of physical function and provide better neonatal care after cesarean section should be implemented.

In a randomized clinical trial conducted by Pinarbasi et al. [29] in 79 patients, transversalis fascia plane block (TFP) provided a better quality of recovery than transversus abdominis plane block (TAP) and also reduced opioid consumption.

Inguinal hernia

The inguinal region receives innervation from the ilioinguinal and iliohypogastric nerves, which arise from the lumbar plexus, pass laterally over the quadratus lumborum, and course within the transversalis plane via the transversus abdominis muscle. The course of these two nerves provides a variety of injection sites, including the ilioinguinal and iliohypogastric nerve block, the TAP, the quadratus lumborum block and truncal blocks between the fascial planes such as the TFP.

In a prospective randomized study by Priya et al. [28] with 60 patients, posterior transversus abdominis plane block with transversalis fascia plane block was equally effective in relieving postoperative pain with similar patient satisfaction scores.

Transversalis fascia plane block

The TFP was first introduced by Hebbard in 2009 [30], and has been used for iliac crest bone harvest, appendectomy, cecostomy and inguinal hernia repair. TFP block has recently gained attention for pain management after a caesarean section.

The local anesthetic is injected between the transversus abdominis muscle and the transversalis fascia. It is distributed to the inner part of the quadratus lumborum muscle. It will then block the proximal parts of the T12 and L1 nerves. TFP targets these nerves between the lumbar plexus block and the TAP block (Figure 2).

Plane blocks in analgesia for upper or lower abdominal surgery

Transversus abdominis plane block

The TAP block was first described by Rafi in 2001 [31]. TAP blocks are part of a multimodal approach for abdominal surgeries, providing analgesic benefits and reducing postoperative opioid requirements [32].

The TAP block involves injection of a local anesthetic solution into a plane between the internal oblique muscle and the transversus abdominis muscle. The thoracolumbar nerves originating from the T6 to L1 spinal roots extend into this plane and the sensory nerves supply the anterolateral abdominal wall. The resulting local anesthetic can provide analgesia to the abdominal skin, muscles and parietal peritoneum [33, 34].

The ultrasound-guided TAP block is placed in the mid-axillary line, in the transverse plane between the iliac crest and the lower end of the ribs. This block requires an ultrasound device with a 10-5 MHz high frequency probe and a 50 mm or 80 mm needle. The needle is advanced into the plane between the internal oblique muscle and the transversus abdominis muscle. 1-2 ml of saline is injected to confirm correct needle placement. Then 15-20 ml of local anesthetic drug solution is injected on each side. The TAP is visualized as it expands with the injection. If a catheter is placed, a dilute infusion of 7 to 10 ml of local anesthetic drug solution can be given per hour [34].

In the past decade, there has been growing evidence supporting the effectiveness of TAP blocks for a variety of abdominal surgeries, such as cesarean section, hysterectomy, prostatectomy, hernia repair and cholecystectomy [33, 35].

There are varieties such as subcostal TAP block, lateral TAP block, posterior TAP block, oblique subcostal TAP block [33, 36].

Subcostal TAP: The ultrasound probe is placed on the lower edge of the rib cage and local anesthetic is injected between the internal oblique muscle and the transversus abdominis muscle.

Anterior TAP: The ultrasound probe is placed in an oblique direction on a line connecting the anterior superior iliac spine and the umbilicus, just cephalad to the anterior superior iliac spine. Local anesthetic is injected between the internal oblique muscle and the transversus abdominis muscle, medial to the anterior superior iliac spine, near the deep circumflex iliac artery.

Lateral TAP: The ultrasound probe is placed transversely in the midaxillary line between the subcostal margin and the iliac crest. Local anesthetic is injected between the internal oblique muscle and the transversus abdominis muscle at the midaxillary line.

Posterior TAP: The ultrasound probe is placed similar to the lateral TAP block. The probe is then moved posteriorly. Local anesthetic is injected into the posterior border of the TAP between the internal oblique muscle and the transversus abdominis muscle [34].

Oblique subcostal TAP: The transversus abdominis is defined as the more hypoechoic muscle layer just below the rectus abdominis. Local anesthetic deposition begins between the transversus abdominis and rectus abdominis, medial to the linea semilunaris. It is recommended to inject from below the rectus abdominis towards the lateral side [33].

Bilateral erector spinae plane block

Local anesthetic is injected into the fascial plane between the erector spinae muscle (ESM) and the tip of the transverse process. Within this area, the local anesthetic spreads in a cranio-caudal direction along 3-6 vertebral levels. Medial-lateral spread is usually limited to the borders of the erector spinae muscle, the angle of the ribs and its attachment to the surrounding thoracolumbar fascia [27, 37].

In the study by Park et al. [38] ultrasound-guided ESPB using different concentrations of bupivacaine provided clinical analgesic effects and led to similar opioid consumption in both groups. A lower concentration of local anesthetic may reduce the risk of local anesthetic toxicity.

Rectus sheath block

The rectus sheath block is performed by injecting a local anesthetic between the rectus muscle and the posterior rectus sheath (Figure 3). It blocks the anterior cutaneous branches of the lower thoracic spinal nerves. It can be used for postoperative analgesia and to reduce opioid use in various upper or lower abdominal surgeries, including laparoscopic surgery [39,40]. Especially indicated for midline vertical incision surgeries. Studies have demonstrated the efficacy and safety of the rectus sheath block in the pediatric population [41].

In conclusion, the clinician's decision to use plan block should be based on a balance between risks and benefits. Risks should be assessed in terms of local anesthetic systemic toxicity, one of the most important life-threatening complications of regional anesthesia. Ultrasound-guided nerve blocks within a multimodal anesthesia approach reduce opioid use when used effectively in appropriate patients. We believe that plan blocks play a very important role in reducing opioid use and side effects. For the time being, more studies and clinical experience with plan blocks are needed.

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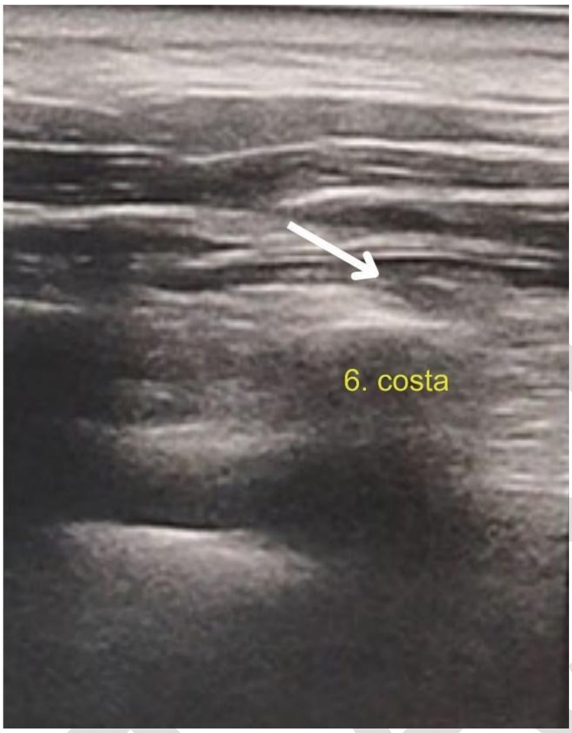

Figure 1. With the patient in the supine position, the ultrasound probe is placed in the sagittal plane at the level of the sixth rib between the midclavicular and anterior axillary lines. A paramedian sagittal oblique view is obtained with a short-axis view of the ribs approximately 1 to 2 cm medial to the anterior axillary line. The following structures were identified from superficial to deep: subcutaneous tissue, external oblique muscle, intercostal muscles between the ribs, pleura and lung. The skin entry point for injection is cranial to the level of the sixth rib, just medial to the anterior axillary line. The needle tip is advanced superomedially to inferolaterally along the external oblique muscle and finally reaches the tissue between the external oblique and intercostal muscles at the caudal end of the sixth rib and between the sixth and seventh ribs. Local anesthetic is injected into the area described and marked with a white arrow in the figure

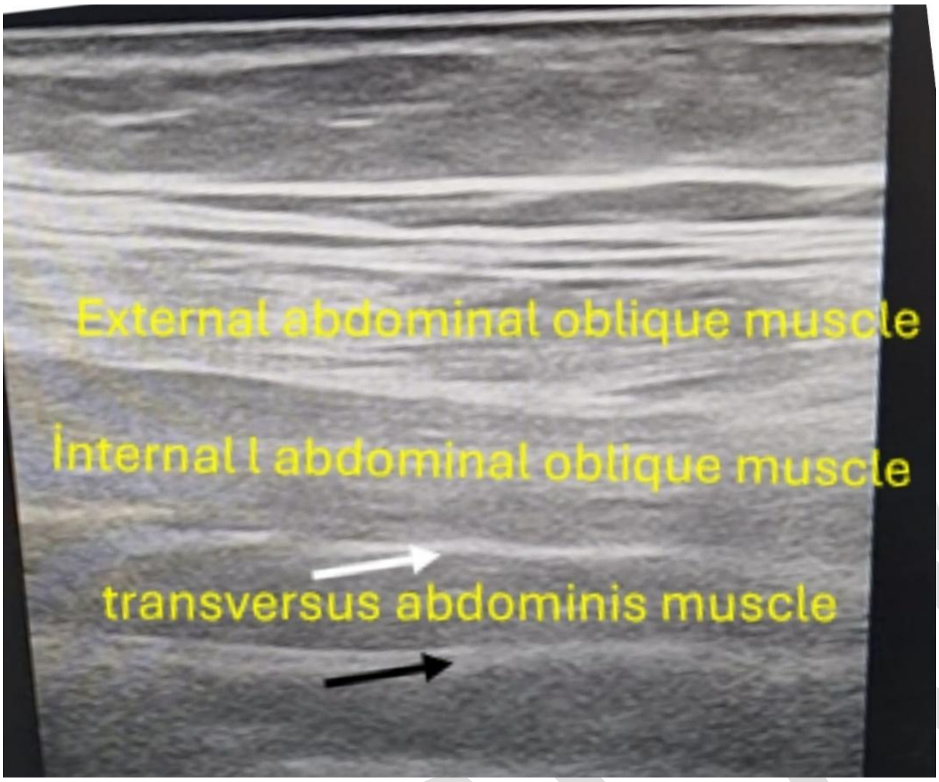

Figure 2. For the transversus abdominis plan block, local anesthetic is injected into the transverse fascia plane between the internal oblique muscle and the transversus abdominis muscle. For transversalis fascia plan block, the external-internal oblique and transversus abdominis muscles, quadratus lumborum muscle are visualized and local anesthetic is injected under the fascia where the internal oblique and transversus abdominis muscles meet. In the figure, the white arrow indicates the transversus abdominis plan block area and the black arrow indicates the transversalis fascia plan block area

Figure 3. Ultrasound identifies the rectus muscle and the posterior rectus sheath and fascia transversal, which appear hyperechoic on the skin. The needle tip is advanced posterior to the rectus muscle and over the underlying rectus sheath. Under local anesthesia, the rectus muscle is separated from the posterior rectus sheath by hydrodissection. In the figure, the posterior sheath of the rectus muscle is shown with a white arrow

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