ERECTOR SPINAE PLANE BLOCK FOR POSTOPERATIVE PAIN MANAGEMENT AFTER ABDOMINAL SURGERY: A SYSTEMATIC REVIEW

A Major Paper Presented

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Abstract

A fundamental component of healthcare delivery is providing comfort, including the minimization of pain with as few side effects as possible. Unmanaged postoperative pain continues to be a challenge in healthcare and is a frequently discussed and studied topic. Pain that is not controlled is associated with several negative sequelae involving multiple organ systems and an overall increase in morbidity. Using a multimodal approach to pain management has been emerging as a way of combatting not only unmanaged postoperative pain, but also the use of opioids. Peripheral nerve block administration is effective pain management technique anesthesia professionals are trained to administer. A newer peripheral nerve block, the erector spinae plane block has been shown to be an effective way of lowering postoperative pain scores and opioid consumption in a variety of surgeries. The purpose of this paper is to conduct a systematic review to determine if the administration of the erector spinae plane block (ESPB) will affect postoperative pain and opioid consumption after abdominal surgery when compared to the administration of the long-established transversus abdominus plane (TAP) block. This systematic review was created using both the preferred reporting items for systematic review and meta-analyses (PRISMA) framework and Critical Appraisal Skills Programme (CASP). A literature review was performed, and data was extracted and reported on each study. A cross study analysis was performed using data collection created the author of this review. The ESPB was found to be effective in reducing pain and opioid consumption when compared to receiving no block. The evidence comparing the ESPB to the TAP block suggest the ESPB may have superior pain lowering and opioid sparing abilities than the TAP block but would suggest more studies to confirm.

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Erector Spinae Plane Block for Postoperative Pain Management in Adults Having Abdominal Surgery: A Systematic Review

Background/Statement of the Problem

Pain is something we all experience in our lives, whether it is acute pain from an injury or surgery, or chronic pain which, often, develops from poorly controlled acute pain. A fundamental component of healthcare delivery is providing comfort, including the minimization of pain with as few side effects as possible. Unmanaged postoperative pain as well as the adverse outcomes of opioid exposure continue to be a challenge in healthcare (U.S. Department of Health & Human Services, Assistant Secretary for Health [HHS, ASH], 2018). Opioids are effective in treating pain but often come with undesirable side effects, the most harmful being dependence and addiction. This has led to large increases in overdoses and deaths from opioid use, creating a public health problem known as the opioid crisis. To combat this the Department of Health and Human Services developed a task force to establish best practices for pain management. Gaps in acute and chronic pain management practices were identified and recommendations were made (HHS, ASH, 2018).

One of the gaps identified was the underutilization of multimodal analgesia in the perioperative period. Multimodal analgesia can be defined as the administration of 2 or more drugs that act by different mechanisms for providing pain relief (Rosero & Joshi, 2014). For this gap, recommendations include the use of various nonopioid medications, preemptive analgesia, regional anesthesia, psychological, and integrative therapies (HSS, ASH, 2018). There is emerging evidence that a multimodal analgesia approach to

perioperative pain management in surgery using the novel erector spinae plane block may lead to lower pain scores and decreased opioid use in adults (Krishnan & Cascella, 2020).

The erector spinae plane blockade (ESPB) is a novel technique, first appearing in the literature in 2016 for the treatment of thoracic neuropathic pain. It is a peripheral nerve block that results in a multi-dermatomal sensory block of the thoracic and abdominal wall (Krishnan & Cascella, 2020). Since this technique was first reported it has been shown to be an effective part of postoperative pain management in various types of surgeries. This block has been described by many as safe and simple to administer with the use of ultrasonic guidance (Krishnan & Cascella, 2020). The purpose of this research is to conduct a systematic review to determine if the use of the ESPB will lower postoperative pain when compared to the transversus abdominis plane (TAP) block in adults having abdominal surgery as evidenced by decreased pain scores and postoperative opioid consumption.

Literature Review

Pain

Pain, as redefined by the *International Association of the Study of Pain* (IASP) in 2020, is "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage." It expands this definition by identifying some key points that should be included when identifying pain. Pain cannot be fully understood based on the activity of sensory neurons, but as a bigger picture including biological, psychological, and social factors. This varied and individual experience called pain, is learned throughout one's life. The inability to verbally report pain should not exclude that pain exists. Behavior is also an important aspect of pain expression and identification (IASP, 2020). Pain can be characterized as acute or chronic based on the length of time it exists. Acute pain usually resolves within a two-week period and is self-limiting while chronic pain lasts longer than 3 months in duration. Chronic pain has no biological value and can be triggered by poorly controlled acute pain (Nagelhout & Plaus, 2014).

Nociception

Nociception is the encoding and processing of a stimuli by the nervous system, that has caused or has the potential to cause tissue damage. This process starts with the stimulation of nociceptors, also known as pain receptors, which are located throughout the body. A noxious stimulus causes a localized release of inflammatory compounds/signal mediators that generate an action potential signal. This signal is transmitted through a three-neuron pathway, starting at the site of stimulation and traveling to the dorsal horn of the spinal cord by way of A-delta fibers and C-fibers. The

signal synapses with a second neuron in either the dorsal horn of the spinal cord or at a higher level and ascend the cord via the spinothalamic tract. As the signal moves toward the brain, synapses occur in the thalamus as well as the cerebral cortex and limbic system (Nagelhout & Plaus, 2014).

In contrast to this route, pain in the face via the trigeminal nerve goes directly to the brain. When the pain signal is transmitted to the dorsal horn of the spinal cord, the body can modulate this pain by enhancing it or suppressing it. The descending pain pathway plays an important role in the modulation of pain leading to suppression of signal. Substances released by the body in the dorsal horn, where the first and second neuron in the pain pathway synapse, cause suppression of pain signal. Interneurons located in the spinal cord also release substances that attenuate or inhibit the pain signal. Enhancement of pain occurs with repetitive stimulation that changes the way pain signal are conducted, decreasing the threshold for pain. In conclusion, the subjective translation of this stimuli by the cerebral cortex and limbic system is what we refer to as pain (Nagelhout & Plaus, 2014).

Acute postoperative pain

Pain occurring after surgery has been reported in over 80% of patients, with the majority reporting the pain as moderate, severe, or extreme despite the administration of analgesia. Pain in the first 24 hours after surgery varies by analgesia technique and severity. Predictors of severity have been identified and include type of surgery, age, gender, preoperative pain, anxiety, mood, incision size, and time since surgery (Gan, 2017).

Unmanaged, acute postoperative pain has been associated with a fair number of negative sequelae involving multiple organ systems. Pain activates the sympathetic nervous system causing a dysregulation of the cardiovascular system, gastrointestinal tract, urinary tract, immune system, and endocrine system. It can lead to fear, anxiety, depression, and decreased mobility from fear of worsening pain (Zubrzycki et al., 2018). Decreased mobility can lead to deep vein thrombosis, atelectasis, and pneumonia. There is an overall increase in morbidity, decrease in quality of life, prolonged recovery, prolonged opioid use, the development of chronic pain, increased medical expenses, and lost wages (Gan, 2017).

Postoperative pain measurement

The assessment and documentation of pain by a clinician is an essential first step in the treatment of post-operative pain. Self-reported pain is the most reliable way to measure pain because of the subjective nature of the experience. Scales including the numeric rating scale (NRS) and the visual analog scale (VAS) are helpful is assessing postoperative pain and guiding pain management (Nagelhout & Plaus, 2014).

The NRS measures pain intensity using an 11- number scale from 0 to 10. The patient chooses the whole number that best reflects their pain intensity. The scale represents a continuum of pain severity with the lowest intensity being '1' and the highest intensity being 10, and '0' representing no pain (Nagelhout & Plaus, 2014; Hawker, 2011). The NRS has been shown to have high reliability in both literate and illiterate patients, and validity with its high correlation with the VAS. Unlike the VAS, the NRS score can be administered verbally as well as graphically making it useful across languages and education level (Hawker, 2011).

The VAS measures pain intensity along a 100-mm horizontal line with “no pain” labeled on one end and “worst imaginable pain” at the opposite end. Like the NRS, it represents a continuum of pain intensity. Using the VAS, the patient is asked to identify on the horizontal line where their pain lies. Scores can be measured using a ruler between the point marked and the “no pain” end on the line. The higher the measurement, the worse the pain. The reliability of the VAS is good overall, but higher in those who are literate. The construct validity has shown to be highly correlated with the NRS. The VAS score is easy to administer and to respond to by most, however difficult to understand and complete in those with cognitive or visual impairment (Hawker, 2011).

Postoperative pain management

The management of post-operative pain can begin at any point in the perioperative period. Pre-emptive analgesia is given before incision and is administered in many different ways. Pre-emptive NSAIDs and local wound infiltrate have been shown to decrease analgesic consumption but not pain scores (Garimella & Cellini, 2013). Pre-emptive epidural analgesia on the other hand has shown to decrease pain scores as well as opioid consumption (Garimella & Cellini, 2013).

Opioids are typically used intraoperatively and postoperatively for postoperative pain management. They modulate nociception and are effective at reducing pain but can cause negative sequelae including respiratory depression, postoperative nausea and vomiting (PONV), pruritis, and post-operative constipation and ileus. Opioids can be administered via many routes and have a range of strength, onset, and duration. Patient controlled analgesia (PCA) administration of opioids has been shown to be superior in

terms of patient satisfaction and pain control when compared to as needed intramuscular (IM) administered opioids (Garimella & Cellini, 2013).

Neuraxial analgesia is used often in surgery involving the abdomen, pelvis, and thorax and involves depositing local anesthetics and/or opioids directly into the spinal canal (intrathecal) or surrounding the spinal nerve roots (epidural) to produce analgesia. While neuraxial analgesia can be an effective means of pain relief, it can also be technically challenging and can result in block failure and/or hypotension (Garimella & Cellini, 2013).

Nonopioid analgesics used for post-operative pain include selective and nonselective COX inhibitors and acetaminophen. Ketorolac, a mainly COX 1 inhibitor, has been shown to decrease opioid consumption and incidence of post-op ileus in patients having colorectal surgery. Acetaminophen and Paracetamol (IV acetaminophen) are thought to inhibit prostaglandins in the central nervous system and have been shown to be effective in post-operative pain management including the opioid sparing effects of paracetamol (Garimella & Cellini, 2013).

Peripheral nerve blocks are a way of providing pain relief to a specific area of the body by way of direct administration of an anesthetic. The advantages of this form of pain management include earlier patient discharge, decreased postoperative nausea and vomiting, and improved postoperative analgesia (Nagelhout & Plaus, 2014).

Peripheral nerve blocks used in abdominal surgery

Erector spinae plane block (ESPB). Since its emergence into the literature in 2016 for the treatment of thoracic neuropathic pain, the erector spinae plane block has been successfully used for a number of procedures involving the anterior, posterior, and

lateral thoracic wall as well as abdominal areas (Krishnan & Cascella, 2020). This form of regional anesthesia involves local anesthetic being injected into the paraspinal fascial plane between the erector spinae muscle and the thoracic transverse processes. In doing this, a multi-dermatomal sensory block occurs by way of blocking the thoracic and abdominal spinal nerves through cephalad and caudal spread of the anesthetic along the thoracolumbar fascia which extends across the abdomen and posterior thoracic wall (Krishnan & Cascella, 2020).

To the best of this author's knowledge, De Cassai et al. (2019) published the first systematic review involving the use of the erector spinae plane block. Because of the small number of randomized controlled trials (RCT)s in the literature and the heterogeneity of the data, a qualitative review of the studies was conducted examining pain scores, opioid consumption and related side effects, patient satisfaction, and complications. All non-RCT studies involving the use of the erector spinae plane block were appraised to determine technique, indication, advantages, and complication of the block (De Cassai et al., 2019).

Each RCT involved a different type of procedure and included cardiac surgery requiring cardiopulmonary bypass, unilateral breast cancer surgery, laparoscopic cholecystectomy surgery, and cardiac surgery requiring median sternotomy. Three out of four RCTs showed a lower opioid consumption in the ESPB groups compared to the control groups. The NRS and VAS were used in all four studies for pain evaluation. Three of the four studies showed significant reduction in pain scores at various time intervals. Patient satisfaction and block duration were not formally measured in any of the studies. Time to first analgesic requirement was measured by only one group and

therefore could not be compared. And finally, all the studies reported no block related complications (De Cassai et al., 2019).

For the second part of the review, 122 studies were included and consisted of studies with less than 10 participants per arm, abstracts, letters, editorials, case series, case reports, special articles, and expert reviews. The ESPB was identified to be utilized in a wide range of procedures involving surgery in the thoracic and abdominal cavity as well as amputations, hip surgery, and carotid endarterectomy. In addition, it has been indicated in the treatment of acute as well as chronic pain. The ESPB has been described as a single shot or continuous infusion. There have been four local anesthetics identified with usage in this block and include Lidocaine, Bupivacaine, Levobupivacaine, and Ropivacaine. The maximum anesthetic volume used for unilateral injection was 35 mL and for bilateral injection 60 mL. Two of the papers identified complications related to the block including pneumothorax, motor block, and block failure (De Cassai et al., 2019).

A meta-analysis of RCTs looking at the effect of the ultrasound guided ESPB on postsurgical pain was published by Kendall et al. (2020). It included thirteen RCTs across different surgical procedures all using the ESPB and evaluating its analgesic effectiveness on postoperative pain. Overall, pain scores and PONV were lower in patients who received ESPB compared to the control groups across multiple surgical procedures. Opioid consumption at 24 hours was significantly lower in patients who underwent surgical procedures of the chest and spine but not for abdominal surgery. Adverse events were either reported as none or none were reported.

A prospective randomized double blinded study published by Abu Elyazed et al. (2019) examined the analgesic efficacy and opioid consumption of the ESPB when used in adults having an open epigastric hernia repair. Both groups received ESPB injections, one group received the local anesthetic bupivacaine and the control group received sterile normal saline.

VAS pain scores were measured in both groups postoperatively and the ESPB with bupivacaine group had significantly lower scores between the hours of 2 and 12 postoperatively. At 18 and 24 hours there was no significant difference. Intraoperative fentanyl consumption was significantly higher in the control group. Time to first rescue analgesic dose was significantly shorter in the control group. Opioid consumption postoperatively was measured and there was a significant difference between the groups when looking at consumption over the first 24 hours postoperatively. The control group had significantly higher consumption of opioids during this time. There was no difference between the groups when comparing complications and PONV (Abu Elyazed et al., 2019).

A randomized controlled single blind study published by Aksu et al. (2019), examined the efficacy of the ESPB on pain scores and morphine consumption in adults having laparoscopic cholecystectomy surgery. The ESPB group received the local anesthetic bupivacaine, and the control group received no block. They found that morphine consumption was significantly lower in the ESPB group at the 6, 12, and 24 hour timepoints. Pain was measured using the NRS and there was a significant difference between the groups at the 12 and 24 hour timepoints but no difference at the 1 and 6 hour timepoints. The ESPB group had lower pain scores at the 12 and 24 hour

timepoints. There was no difference in incidence of PONV between the groups (Aksu et al., 2019).

Transversus abdominis plane block (TAP). The TAP block was first introduced in the literature in 2001 as a peripheral block of the abdomen (Garimella & Cellini, 2013). Its indications for use include unilateral analgesia to the skin, muscle, and parietal peritoneum of the anterior abdominal wall and have been reported to provide satisfactory analgesia following surgery of the lower abdomen, covering dermatomes T10 – L1. The TAP block is described as safe and effective if done properly (Farag & Mounir-Soliman, 2017). Studies have demonstrated the TAP block has opioid sparing benefit as well as earlier discharge from the hospital when compared with morphine (Garimella & Cellini, 2013).

Zhao et al. (2014) published the first systematic review and meta-analysis assessing the efficacy of TAP blocks after laparoscopic surgery compared to placebo. The data showed a decrease in pain and analgesic consumption when the TAP block was used versus the placebo. They did however find the TAP group to have an increase in post-operative nausea and vomiting.

Brogi et al. (2016) published a systematic review and meta-analysis on the analgesic efficacy and 24-hr morphine consumption after abdominal surgery when a TAP block is used. They included a wide range of abdominal surgeries and compared the TAP group to alternative analgesic techniques. The data showed a significant reduction in pain scores and opioid consumption except for the group that received intrathecal morphine which showed similar pain scores but a lower opioid consumption. Brogi et al. determined the types of abdominal surgeries that the TAP block was most beneficial in in

terms of reduction in pain and opioid consumption included gynecological surgery, bariatric surgery, appendectomy, inguinal hernia surgery, and cesarean delivery.

A variant approach of the TAP block, the oblique subcostal transversus abdominis plane block (OSTAP) has been shown to reduce pain scores and opioid consumption in adults having abdominal surgery. Its dermatomal coverage is like that of the tradition TAP block, covering T9 – T11. Basaran et al. (2015) published a randomized double-blind study looking at the effect of the OSTAP block on postoperative pain and respiratory function in adults having laparoscopic cholecystectomy surgery.

The OSTAP group received a block containing the local anesthetic bupivacaine, while the placebo group received no block. VAS scores were significantly lower in the OSTAP group at all time points at rest and with movement except for the 24-hour timepoint. Postoperative tramadol consumption was significantly lower in the OSTAP group. Respiratory function was better in the OSTAP group as evidenced by significantly higher FEV1 values in the OSTAP group. There was no significant difference between the groups when examining level of sedation, PONV, and prochlorperazine consumption (Basaran, 2015).

Another RCT examining the efficacy of the OSTAP block on postoperative pain in adults having laparoscopic cholecystectomy surgery, this time with the placebo group receiving a sham block containing sterile normal saline solution. The OSTAP group, again receiving the local anesthetic bupivacaine. Outcomes measured included VAS pain scores at rest and with movement, 24-hour opioid consumption, and length of stay in the post-anesthesia care unit (PACU). In the OSTAP group, compared to the control group, there was a significant difference in each outcome measured. Mean intraoperative opioid

consumption and 24-hour opioid consumption were significantly lower in the OSTAP group. VAS pain scores at rest and with movement were significantly lower at all time points up to 24-hours in the OSTAP group. And finally, PACU length of stay was lower in the OSTAP group (Breazu et al., 2016).

Peripheral nerve blocks like the ESPB and the TAP require training and time to perform. Administering opioids is easy and effective but as previously mentioned can have detrimental side effects. Regional anesthesia using the TAP block has been shown to produce opioid sparing analgesia after abdominal surgery since 2001. More recently the ESPB has shown to also have opioid sparing analgesia across surgical procedures. The importance of effective multimodal postoperative pain management is essential in lessening acute pain after surgery to decrease the incidence of the development of chronic pain and opioid dependence and addiction.

Framework

Systematic reviews are an important part of bringing evidence-based research into practice. Assessing the strength and validity of the available published research was done by identifying, selecting, and critically appraising randomized controlled trials surrounding the given topic, with the goal of contributing to the current pain management for this population of patients. To do this, the preferred reporting items for systematic review and meta-analyses (PRISMA) guidelines was followed as it is an evidence-based tool to standardize and improve the quality of data reporting and assess the strengths and weaknesses of the studies selected (Moher et al., 2009).

To lay out the literature search process, so all relevant studies can be found, the PRISMA four-phase diagram was used (Appendix A). This PRISMA diagram starts with the number of initial studies identified after the databases are searched. Followed by the number of studies left after screening for inclusion. All relevant articles were reviewed using the PRISMA 27-item checklist to identify all items to be included in the final systematic review (Appendix B). The checklist consists of seven main sections including title, abstract, introduction, methods, results, discussion, and funding; half of which have multiple related topics. A total of 27 items comprises the topics within these sections and are deemed essential in the reporting of a transparent systematic review, with as little bias as possible (Moher et al., 2009).

The quality of the studies was validated using the Critical Appraisal Skills Programme (CASP) for randomized control trials (RCTs). The CASP checklist for RCTs (Appendix C) contains eleven questions under three main sections addressing trial validity, results, and benefit of the study. The first three questions are used as a way to

quickly screen the study to assess whether it is worth proceeding with the remaining questions. Along with the question is also a hint, helping the reader identify why the question is important (Critical Appraisal Skills Programme, 2018).

Method

Purpose

The purpose of this research was to conduct a systematic review to determine if the use of the ESPB will lower postoperative pain scores and opioid consumption when compared directly to the transversus abdominis plane (TAP) block in adults having abdominal surgery as evidenced by lower pain scores and postoperative opioid consumption.

Inclusion/Exclusion Criteria

Inclusion criteria for study selection included randomized control trials comparing the ESPB to the TAP block in adults having abdominal surgery under general anesthesia. Exclusion criteria included studies published before 2010, articles not written in the English language, non RCTs, and studies involving the pediatric population (< 18 years old).

Search Strategy

The literature search was be performed using PubMed, MEDLINE, Google Scholar, and CINAHL databases. The key words include “analgesia” AND “abdominal surgery” AND “erector spinae plane block” AND “transversus abdominis plane”.

Data Collection and Appraisal

Select data was extracted from each study, included and organized into tables for comparison and further analysis. The first table compared data including author, year, type of surgery, method of anesthesia, number of patients, study group allocation, age range, gender, and ASA scores (Appendix D). The second table included variables that may have an influence on pain scores and opioid consumption within each study. These

variables include author, year, timing of block, block technique including local anesthetic used and dose, preoperative and intraoperative analgesia, postoperative analgesia (Appendix E). A third table displaying outcome measures, outcome results, and adverse events related to the blocks can be found in Appendix F.

The quality of the studies was critically appraised by using the Critical Appraisal Skills Programme (CASP) for randomized control trials (RCTs). The CASP checklist for RCTs contains eleven questions under three main sections addressing trial validity, results, and benefit of the study (Critical Appraisal Skills Programme, 2018).

Data Synthesis and Analysis

Compilation of data for this cross-study analysis was critical in allowing for the proposed problem statement to be answered. Comparison between studies including 24-hour pain scores, 24-hour opioid consumption, and study conclusion aimed at answering the question of whether the erector spinae plane block is superior to the TAP block in regard to postoperative pain scores and opioid consumption in this specific surgical population. The cross-study analysis can be found in Appendix G.

Implementation/Dissemination

Essential to communicating research finding is knowing your audience. The target audience for this information is healthcare professionals that work in the perioperative area. The findings will be communicated by way of electronic dissemination of a thesis via Rhode Island College Digital Commons database. There will also be oral and poster presentation at Rhode Island College upon completion of the review.

Results

The PRISMA flow diagram (Appendix A), along with the previously mentioned inclusion and exclusion criteria, were used to select full-text articles to be used for this systematic review. After searching the databases using keywords, 77 articles resulted. Two duplicate articles were eliminated resulting in 75 articles. These 75 articles were screened using inclusion and exclusion criteria, eliminating 70 articles and resulting in 5. These 5 studies were critically appraised using the CASP checklist and data was extracted and used in the creation of this systematic review.

The five studies are presented in the same order as they will appear in the data collection tables and cross-study analysis. Each study is summarized in data collection tables 1,2, and 3 (Appendix D, E, and F) and appraised using the CASP (Appendix C). A cross-study analysis is also formulated for evaluation (Appendix G).

Individual Study Summaries and Critical Analysis

The Altiparmak et al. (2019) trial, a prospective, randomized study, examined 68 adults age 18-65 years of age and categorized as being an American Society of Anesthesiology (ASA) physical status of I or II. The subjects were undergoing elective laparoscopic cholecystectomy surgery at a tertiary university hospital in Turkey. Patients were excluded if they had a coagulation disorder, infection at the injection site of the block, known allergy to local anesthetic, advanced hepatic or renal disease, chronic opioid consumption, or a body mass index (BMI) of 35 kg/m^2 or above.

Anesthetic management was standardized, and subjects were randomly allocated into two groups based on a computerized randomization table created by a researcher not involved in the study. Following intubation, both groups received either an ultrasound

guided ESPB or oblique subcostal TAP (OSTAP) block. Pain intensity was assessed in the postoperative period using the 11-point NRS scale while coughing. These scores were recorded at multiple time points up to 24-hours after completion of surgery by an anesthesiologist who was blinded to the group allocations.

Intraoperative fentanyl was given at induction of anesthesia at 1 mcg/kg for subjects in each group. Post-operative analgesia was the same in both groups and consisted of a tramadol patient-controlled analgesia (PCA) device that delivered 10 mg boluses and had a 20 minute lock out time and no basal infusion. Morphine, 4 mg intravenous (IV) was given when NRS scores were equal to or exceeded 4 while coughing. Outcomes measured included total tramadol consumption at the 24^{th} hour, intraoperative fentanyl need, morphine consumption, NRS scores at each time point, and incidence of complications. A p-value < 0.05 was considered statistically significant.

There were no significant differences in age, gender, height, weight, BMI, ASA score, and length of surgery between the two groups. Also, no significant difference in 24-hr morphine consumption, intraoperative fentanyl consumption, and NRS pain scores at all time points between the groups. There was however a significantly higher 24-hr tramadol consumption in the OSTAP group compared to the ESPB group ($p < 0.001$).

Intraoperative complications seen included bradycardia in two patients in the ESPB group and one in the OSTAP group and was not significantly different. Postoperative nausea was also documented and comparable between groups. The main limitation of this study is the lack of no-intervention group. In conclusion, findings from this study suggest that ESPB was an effective analgesia technique for laparoscopic

cholecystectomy study and reduced tramadol consumption significantly when compared to the OSTAP block.

The Tulgar et al. (2019) trial, a randomized, prospective, double-blinded, efficiency study done at a tertiary university hospital in Turkey, included 60 subjects, between the ages of 18 – 65, with an ASA score of I or II. These subjects were undergoing elective laparoscopic cholecystectomy surgery under general anesthesia. Exclusion criteria included patients who were unable to provide informed consent, had an allergy to local anesthetics, had bleeding conditions or on anticoagulants, had severe kidney or liver disease or psychiatric disorders, or a history of previous upper gastrointestinal surgery.

The sealed envelope technique was used to randomize subjects into three groups of twenty subjects each. Group C received the hospital's standard analgesia plan with no regional block, group ESPB and OSTAP received the same hospital's standard analgesia plan in addition to the block. Randomization and block administration was done by a provider not involved in data collection or analysis. Anesthetic management was the same for all subjects and ultrasound guided block placement was done at the completion of the surgery and before extubating and transfer to recovery.

Intraoperative remifentanil infusions were used on all subjects and titrated up to a max dosage based on hemodynamic parameters not specified. Postoperatively all subjects received 1 g of paracetamol and 20 mg of tenoxicam. Paracetamol was scheduled every 8-hr and skipped if NRS <2. Rescue analgesia included fentanyl 25 mcg for NRS >3 and a tramadol PCA delivering 10 mg every 20 min on demand only. Diclofenac NA IM 75 mg was also used as a rescue for NRS >3.

Pain was assessed using NRS pain scores at multiple time points up to 24-hr postoperatively at rest and when coughing. Postoperative analgesia requirement including paracetamol, tramadol, and rescue analgesics were measured. In addition, shoulder pain and PONV were noted. Descriptives of each group including age, gender, ASA score, surgical duration, and BMI were collected and were similar between groups. There was also no difference between time taken to perform OSTAP and ESPB. No block related complications were observed.

Pain measurements using the NRS at rest and with coughing showed no statistical significance at any time point when comparing ESPB and OSTAP groups. No statistically significant differences were seen in paracetamol, tramadol, and fentanyl consumption between the ESPB and OSTAP groups. The ESPB group had significantly lower pain scores at the 20-min, 40-min, 1 and 3-hr time points both at rest and with coughing compared the control group ($p<0.005$). The OSTAP group had significantly lower pain scores than did the control group at the 20^{th} minute ($p<0.005$). The control group had significantly higher paracetamol, tramadol, and fentanyl consumption compared to both block groups ($p<0.05$).

Limitations in this study included no data collection on sensorial coverage of block which could have resulted in missed block failures. In addition, the study was not large enough to determine block related complications namely nausea and vomiting. Overall, this study showed a decreased 24-h analgesia requirement in both ESPB and OSTAP groups compared to the control group but no difference between the two block groups.

The Ibrahim (2019) trial conducted in Saudi Arabia, was a double-blinded, randomized controlled trial, examined 63 adults age 20-60 years old. The subjects were categorized as being an American Society of Anesthesiology (ASA) physical status of I or II, have a BMI between 20-35, have trocar port sites at or above the T10 dermatome, and scheduled to undergoing elective laparoscopic cholecystectomy surgery. Patients were excluded if they had a coagulation disorder, infection at the injection site of the block, known allergy to local anesthetic, hepatic or renal insufficiency, chronic opioid consumption, a history of psychiatric or neurological disease, deafness, and previous open surgery.

Randomization and allocation into one of three groups was done by computer-generated random numbers and sealed envelopes. Patients and anesthetist responsible for data collection were blinded to the groups. Group I was the control group that received trocar site infiltration with bupivacaine, and group II and III received the ESPB and OSTAP blocks respectively, following induction of anesthesia. All surgical procedures were done by the same surgeon and the general anesthesia was standardized. The primary outcome measured in this study was 24-hr morphine consumption. Secondary outcomes included VAS pain sores at time points up to 24-hrs, intraoperative fentanyl consumption, and duration to first analgesic dose postoperatively, extubation time, PONV, block complications, and surgical duration.

Intraoperative analgesia for all groups included fentanyl 1 mcg/kg for induction followed by 10 mcg bolus every 5 minutes if mean arterial pressure and heart rate increased more than 15% of baseline. In addition, 1 g of paracetamol and 400 mg of ibuprofen given IV. Postoperative pain management was also the same for each group

and included either fentanyl 15-20 mcg, morphine 1-2 mg, or pethidine 15-30 mg IV while in PACU for moderate to severe pain. After discharge from the PACU to the surgical ward, the subjects could receive 1 g of paracetamol every 6-hrs for moderate to severe pain as well as a morphine PCA with 1 mg boluses every 12 minutes with a maximum of 5 mg per hour. Pain intensity was assessed at various timepoints up to 24-hr using the VAS at rest and with movement (flex leg against resistance).

Patient characteristics including age, gender, ASA scores, BMI, and duration of surgery were similar between groups. The mean 24-hr morphine was statistically significant between groups ($p<0.001$), except for between ESPB and OSTAP ($p = 0.173$). Intraoperative fentanyl consumption was significant between the control and both block groups ($p<0.001$), except for between the ESPB and OSTAP ($p = 0.95$). VAS pain scores were significantly higher in the control group compared to the ESPB and OSTAP groups at 6 and 12-h postoperatively ($p<0.05$). Time to first morphine dose was significantly shorter in the control group compared to the ESPB and OSTAP groups ($p = 0.001$), and no different between the two treatment groups. Secondary outcomes including PONV, block complications, surgical duration, and extubation time showed no significant difference between all three groups.

The Kamel et al. (2020) trial, a prospective, randomized, double-blinded, controlled trial done at a hospital in Egypt, included 48 women, between the ages of 40 – 60, with an ASA score of I or II, and BMI of 25-35 kg/m2. These subjects were undergoing elective open total abdominal hysterectomy under general anesthesia. Exclusion criteria included patients who had an allergy to study drugs (bupivacaine or

morphine), an altered mental status, chronic pain, infection at puncture site, bleeding conditions or on anticoagulants, or severe kidney or liver disease.

Subjects were divided into two equal groups using computer-generated randomization and placed in the ESPB or TAP block group. The ESPB group received an ultrasound-guided ESP block at the completion of the surgery and before neuromuscular reversal. The TAP block group received an ultrasound-guided TAP block at the same time. Induction, maintenance, and emergence of anesthesia was kept the same between subjects. Study outcomes included postoperative pain intensity, morphine consumption, time until first morphine dose required, and patient satisfaction of analgesia at the end of 24 hours.

Pain intensity was measured using the VAS scores at 30 minutes, 2, 4, 6, 8, 12, 16, 20, and 24 hours postoperatively. The subjects and outcome assessors were blinded to group allocation. Postoperative pain was managed with morphine, 3 mg IV for a VAS >3, followed by pethidine 1 mg/kg IV every 4-hrs with a maximum daily dose of 300 mg. VAS scores were significantly lower ($p<0.0001$) in the ES group compared to the TA group at all time points except the 4^{th}, 6^{th}, and 8^{th} hour. Time until first morphine dose was significantly longer ($p <0.0001$), and total 24-h morphine consumption was significantly lower ($p = 0.01$) in the ES group.

Patient characteristics including age, BMI, ASA score, and duration of surgery were similar between groups. Patient satisfaction with analgesia was measured and comparable between groups also. Nausea and vomiting were compared between groups and were not different. No adverse effects of either block was observed. Findings from this study suggest the ultrasound-guided ESP block provides more potent and longer

postoperative analgesia with less morphine consumption than the TAP block following a total abdominal hysterectomy.

The Abdelhamid et al. (2020) trial, a prospective, randomized, double-blinded, controlled study, examined 66 adults age 18-59 years of age, categorized as being an American Society of Anesthesiology (ASA) physical status of II or III, and having a BMI >40. The subjects were undergoing elective sleeve gastrectomy surgery at a hospital in Egypt. Patients were excluded if they had a coagulation disorder, a platelet count < 100,000, infection at the injection site of the block, known allergy to local anesthetic, advanced hepatic or renal disease, opioid addiction, preexisting neurological disease, or sepsis.

Using computer generated randomization, subjects were assigned to one of three groups. All subjects and the anesthetist involved in data collection were blinded to group allocation. The general anesthesia was standardized for all groups, but the postoperative analgesia was different. Each group received 100 mcg of fentanyl for induction of anesthesia followed by 50 mcg for any 20% increase in mean arterial pressure above baseline. Postoperatively, each subject received paracetamol 1 g IV every 8-hr for a VAS pain score of 3 and pethidine 50 mg IV for VAS of 5 or greater. The control group received this regime only, the ESP group received an ESBP after induction, and the TAP group received a TAP block after induction of anesthesia.

The main outcome of this study was assessment of postoperative pain using the VAS. Pain scores were recorded at 30 minutes after completion of surgery as well as 2, 4, 6, 8, 12, 18 and 24 hours. Secondary outcomes included intraoperative fentanyl requirements, intraoperative heart rate and mean arterial blood pressure, duration of

anesthesia, incidence of complications related to block, 24-hr pethidine consumption, and duration until first analgesia request postoperatively. Demographic and baseline characteristics were also collected and compared between groups.

When comparing characteristics including age, gender, BMI, ASA class, and surgery duration, there was no significant difference between all groups. Pain assessment using VAS revealed significantly less in ESP and TAP groups compared to control group throughout the first 12 hours ($p<0.001$). When comparing the ESP group to TAP group the data showed significantly lower VAS scores in ESP at the 2, 4, 6, 8, and 12 postoperative hours. And at the 24^{th} hour there was no difference between the three groups. Intraoperative fentanyl requirements were significantly higher in control group than in the TAP or ESP group ($p<0.001$). And significantly higher in the TAP group when compared to the ESP group ($p<0.001$). There was a greater incidence of PONV in the control group compared to the TAP and ESP groups ($p<0.003$), but no significant difference between the TAP and ESP groups. Cumulative 24-hr pethidine consumption was significantly higher in the control group than in the ESP and TAP group ($p<0.001$) and higher in TAP compared to ESP but not statistically significant. And finally, time until first rescue dose requirement was significantly delayed in ESP group compared to both the TAP and control groups ($p<0.001$).

Abdelhamid et al. (2020) study showed that the ultrasound guided ESPB resulted in lower postoperative pain scores, reduced intraoperative and postoperative opioid consumption compared to the subcostal TAP block and the control group. It was recommended that more studies be conducted with larger sample sizes to confirm findings. In addition, further studies should be done to investigate the optimal volume,

concentration, and type of local anesthetic for ESP when conducted for sleeve gastrectomy.

Cross-Study Analysis

The cross-study analysis table (Appendix G) shows the specific abdominal surgery performed in the study population including three elective laparoscopic cholecystectomy studies, an elective open total abdominal hysterectomy, and a sleeve gastrectomy. Each study measured pain scores in the first 24-hours postoperatively using either the VAS or NRS. In the three studies involving the elective laparoscopic cholecystectomy surgeries, no significant difference in pain scores were seen between the ESPB and TAP block groups. In the elective total abdominal hysterectomy study, the ESPB group had significantly lower pain scores in the first 24-hours than did TAP block group. In the sleeve gastrectomy study, pain was significantly lower in the ESPB group when compared to the TAP block group in the first 12 out of 24-hours.

All five studies measured 24-hour opioid consumption, however, they didn't all use the same opioid medication. In the elective laparoscopic cholecystectomy study by Altiparmak (2019), tramadol and morphine were used for analgesia and tramadol consumption was found to be significantly higher in the TAP block group compared to the ESPB group. There was no significant difference in morphine consumption between the two groups.

In the laparoscopic cholecystectomy study by Tulgar (2019), tramadol and fentanyl were the opioids used for postoperative analgesia. There was no significant difference seen between the ESPB group and TAP block group with either tramadol or fentanyl consumption. The laparoscopic cholecystectomy study by Ibrahim (2020), 24-hour

morphine consumption was the same between the ESPB and TAP block groups. In the open abdominal hysterectomy study by Kamel (2020), 24-hour morphine consumption was significantly lower in the ESPB group than in the TAP block group. In the elective sleeve gastrectomy study, pethidine consumption was compared and found to be no different between the ESPB and TAP block groups.

Three of the five studies used in this systematic review included a control group which received neither the ESPB nor TAP block. In all three studies, both the ESPB and TAP block showed significantly lower 24-hour pain scores and 24-hour opioid consumption when compared to the control groups that received no block.

Summary and Conclusions

Pain plays a significant role in the postoperative period and continues to be an unresolved healthcare problem (Gan, 2017). Inadequate acute pain management following surgery can lead to increased morbidity and mortality, slowed recovery, higher healthcare costs, prolonged opioid use, and the development of chronic pain (Gan, 2017). Because of this, postoperative pain control is a primary goal for patients and providers. Pain management throughout the perioperative period is critical to successful management of the surgical patient. The purpose of this paper was to conduct a systematic review to determine if the administration of the ESPB will affect postoperative pain when compared to the TAP block after abdominal surgery as evidenced by pain scores and opioid consumption in the first 24-hrs following surgery.

A literature review was completed focusing on nociception, pain, pain measurement, and postoperative pain management including the ESPB and TAP block. The PRISMA framework was utilized for this systematic review and included a 27-item checklist as well as a four-phase flow diagram. Available and applicable studies were identified, screened, and utilized for this systematic review.

Studies were selected and critically appraised by using the CASP checklist for RCTs to assess trial validity, results, and benefit of the study. Individual analysis was completed on each of the five studies and data was extracted from each study and placed into tables for further comparison. Finally, a cross-study analysis was completed to compare the outcome results of each study as it pertained to the original question of pain scores and opioid consumption.

This systematic review included five studies involving 305 adults having abdominal surgery, four studies which were laparoscopic, and one open procedure. The laparoscopic procedures included two cholecystectomies and a sleeve gastrectomy. The open abdominal procedure was a total abdominal hysterectomy. Each study included a group that received either an ESPB or a TAP block and three of the five studies included a control group that received no block. The total number of subjects in each study ranged from 48 to 68 participants, ages 18 to 70.

Intraoperative and postoperative pain management was discussed in detail in each study. Each group within a study were given the same non-block related pain management regimen. All studies used fentanyl intraoperatively, two of the studies used NSAIDS, one of which included Tylenol also. Postoperative pain regimens varied between studies. Three of the five studies used Tylenol, one of which also used tenoxicam, an NSAID. Three of the groups used a PCA, two with tramadol and one with morphine. All groups had non-PCA opioids as needed and to be administered for pain scores as low as 3/10 to as high as 5/10 depending on the study.

Outcome measures that were consistent across studies included pain scores and opioid consumption in the first 24-hrs following surgery. In the three studies involving laparoscopic cholecystectomy surgery, there was no significant difference in postoperative 24-hr pain scores between the ESPB and TAP block groups. Two of these three studies included a no-block control group. Both studies showed significantly higher pain scores in the control group than in either the ESPB or TAP block group. Pain scores in the laparoscopic sleeve gastrectomy study by Abdelhamid (2020), were significantly higher in the TAP block group when compared to the ESPB group for the first 12-hrs.

The no-block control group had significantly higher pain scores than either block group for the first 24-hrs postoperatively. The Kamel (2020) study demonstrated significantly higher pain scores in the TAP block group than in the ESPB group in the first 24-hrs after having open total abdominal hysterectomy surgery. There was no control group in this study.

All studies that included a no-block control group showed the ESPB and TAP block groups to be significantly opioid sparing in the first 24-hrs following surgery. In two of the five studies in this systematic review, the TAP block groups had significantly higher opioid consumption than did the ESPB groups. The study by Kamel (2020) was the only one to have both lower postoperative pain scores and opioid consumption in the ESPB group rather than in the TAP block group.

Limitations exist in this systematic review. Although the studies included in this review met the inclusion criteria, there were items that decreased the generalizability of the study. Because of the limited number of studies comparing these two types of blocks side by side, different surgical procedures of the abdomen were included in this study. Additionally, each study had different pain scores for which they gave pain medication for and different pain management regimens which may have affected the strength of the results. Overall, the results of this study implicate that both the ESPB and TAP block are superior in pain relief and opioid sparing ability compared to the no-block alternative. Two of the five studies showed superiority in pain relief with the ESPB, and two of the five studies showed the ESPB to be more opioid sparing than the TAP block. These results suggest the ESPB may be superior in controlling pain and lowering opioid use.

Additional studies are recommended comparing the two blocks in patients having abdominal surgery.

Recommendations and Implications for Advanced Nursing Practice

The Certified Registered Nurse Anesthetist (CRNA) aims to provide safe, evidenced based care to every patient through knowledge shared from research that has been conducted and disseminated. Systematic reviews provide a concise review and analysis of existing research regarding a subject, making them useful for bringing research to the bedside. CRNAs provide anesthesia to patients having abdominal surgery until care is transferred to a registered nurse in either a post anesthesia care unit or intensive care unit.

Despite the emergence of the opioid crisis and the knowledge of the ill effects, opioids remain a mainstay for acute pain management in the perioperative period. Essential to the CRNA's role is the prevention and treatment of pain. With the need to reduce opioid consumption and control pain, CRNAs are using a multimodal approach to the treatment of pain. One of the modes of pain management anesthesia providers are trained to do are peripheral nerve blocks, where local anesthetic is deposited surrounding a specific nerve(s), providing pain relief to a specific area of the body. Because of the unique role the CRNA plays in the management of pain, staying up to date with existing and emerging peripheral nerve blocks is essential for providing safe and effective care to our patients. It is also important to continue to evaluate and foster the use of multimodal pain control involving the entire healthcare team.

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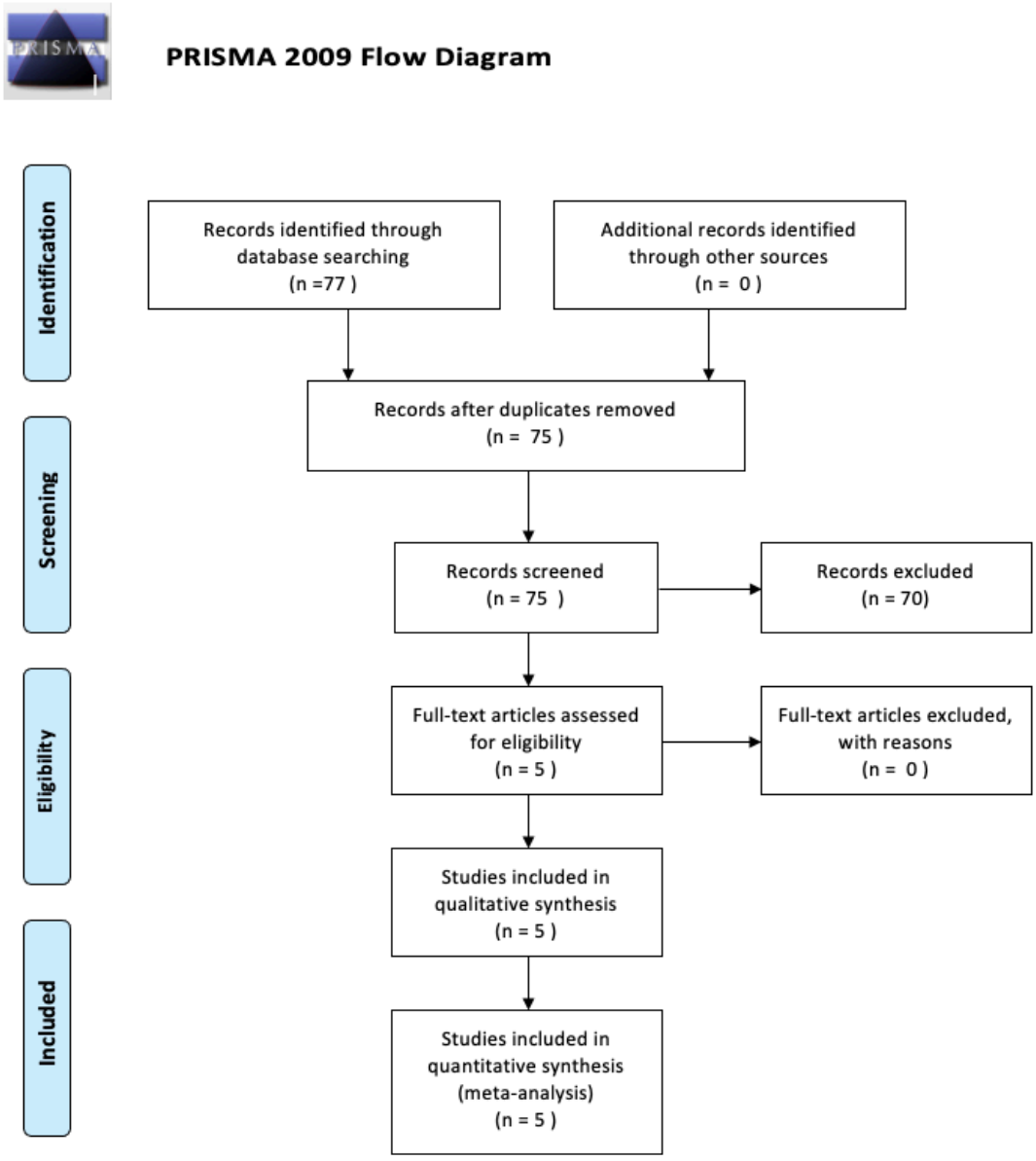
Appendix A


PRISMA 2009 Flow Diagram
Identification
Screening
Eligibility
Included
Records identified through database searching (n =77)
Additional records identified through other sources (n = 0)
Records after duplicates removed (n = 75)
Records screened (n = 75)
Records excluded (n = 70)
Full-text articles assessed for eligibility (n = 5)
Full-text articles excluded, with reasons (n = 0)
Studies included in qualitative synthesis (n = 5)
Studies included in quantitative synthesis (meta-analysis) (n = 5)

Appendix B

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org.

Appendix C

CASP checklist

Study title: Altiparmak, B., Toker, M.K., Uysal, A.I., Yagmur, K., & Demirbilek, S.G. (2019). Ultrasound-guided erector spinae plane block versus oblique subcostal transversus abdominis plane block for postoperative analgesia of adult patients undergoing laparoscopic cholecystectomy: Randomized, controlled trial. *Journal of Clinical Anesthesia, 57,* 31-36. https://doi.org/10.1016/j.jclinane.2019.03.012			
A. <u>Are the results of the trial valid?</u>	**YES**	**CAN'T TELL**	**NO**
1. Did the trial address a clearly focused issue? Evaluating the analgesic efficacies of the US-ESPB and US-OSTAP block for laparoscopic cholecystectomy surgeries.	X		
2. Was the assignment of patients to treatments randomized? Computerized randomization	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion? Attrition after start of study was 4. Two of those four converted to an open procedure, and two had a failed PCA in the postoperative period.	X		
4. Were patients, health workers and study personnel 'blind' to treatment? Pain evaluators and patients blinded.	X		
5. Were the groups similar at the start of the trial? Similarities between the groups include gender, age, height, weight, BMI, ASA score, and surgery length (minutes).	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		

B. <u>What are the results?</u> **7. How large was the treatment effect?** No significant difference in pain scores between groups. Significantly higher 24-hr tramadol consumption in OSTAP block group compared to ESPB group. No significant difference in 24-hr morphine consumption and intraop fentanyl consumption between groups. **8. How precise was the estimate of the effect?** Tramadol consumption $p < 0.001$			
C. <u>Will the results help locally?</u>			
9. Can the results be applied to the local population, or in your context?	X		
10. Were all clinically important outcomes considered?	X		
11. Are the benefits worth the harms and costs?	X		

(Critical Appraisal Skills Programme, 2018)

Study title:
Tulgar S., Kapakli, M.S., Kose, H.C., Senturk, O. Selvi, O., Serifsov, T.E., Thomas, D.T., & Ozer, Z. (2019). Evaluation of ultrasound-guided erector spinae plane block and oblique subcostal transversus abdominis plane block in laparoscopic cholecystectomy: Randomized, controlled, prospective study. *Anesthesia Essays and Researches, 13(1), 50-56.https://doi.org/10.4103/aer.AER_194_18*

A. <u>Are the results of the trial valid?</u>	**YES**	**CAN'T TELL**	**NO**
1. Did the trial address a clearly focused issue? Comparing the effectiveness of OSTAP block and ESPB in providing postoperative analgesia in patient undergoing laparoscopic cholecystectomy surgery.	X		
2. Was the assignment of patients to treatments randomized? Sealed envelope technique.	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion? Attrition rate was 0.	X		
4. Were patients, health workers and study personnel 'blind' to treatment? Patients and staff in recovery areas collecting data were blinded.	X		
5. Were the groups similar at the start of the trial? Similarities at the start of the trial included age, gender, and BMI.	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		

B. <u>What are the results?</u>

7. How large was the treatment effect? The US-guided ESPB and OSTAP block performed at the end of surgery in laparoscopic cholecystectomy patients significantly lowered NRS scores at rest and with coughing/movement in the first 3 hours and led to less analgesic requirement in the first 24-h when compared to the control group with no block.

8. How precise was the estimate of the effect? $p < 0.005$

C. <u>Will the results help locally?</u>			
9. Can the results be applied to the local population, or in your context?	X		
10. Were all clinically important outcomes considered?	X		
11. Are the benefits worth the harms and costs?	X		

Study title:
Ibrahim, M. (2020). Erector spinae plane block in laparoscopic cholecystectomy, is there a difference? A randomized controlled trial. *Anesthesia Essays and Researches, 14(1),* 119-126. https://doi.org/10.3103/aer_AER_144_19

A. Are the results of the trial valid?	**YES**	**CAN'T TELL**	**NO**
1. Did the trial address a clearly focused issue? Test the hypothesis that US-guided ESPB can produce less opioid consumption in the first 24-h after laparoscopic cholecystectomy when compared to OSTAP.	X		
2. Was the assignment of patients to treatments randomized? Computerized randomization	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion? Attrition rate 7.	X		
4. Were patients, health workers and study personnel 'blind' to treatment? Pain evaluators and patients blinded.	X		
5. **Were the groups similar at the start of the trial?** Similarities between the groups include gender, age, BMI, ASA score, and surgery duration (minutes).	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		

B. What are the results?

7. How large was the treatment effect? US-guided ESPB was found to be comparable to OSTAP block. Both blocks reduced intraop rescue fentanyl, 24-h morphine, and pain compared to the control group with no block.

8. How precise was the estimate of the effect? 24-h morphine - ESPB and OSTAP vs control p<0.001; intraop rescue fentanyl – ESPB and OSTAP vs control p<0.001; pain scores – ESPB and OSTAP vs control p<0.05			
C. <u>Will the results help locally?</u>			
9. Can the results be applied to the local population, or in your context?	X		
10. Were all clinically important outcomes considered?	X		
11. Are the benefits worth the harms and costs?	X		

Study title:
Kamel, A.A.F., Amin, O.A.I., & Ibrahem, M.A.M. (2020). Bilateral ultrasound-guided erector spinae plane block versus transversus abdominis plane block on postoperative analgesia after total abdominal hysterectomy. *Pain Physician, 23*, 375-382. Retrieved February 20, 2021 from https://www.painphysicianjournal.com/current/pdf?article=NzA3Ng%3D%3D&journal=128

A. <u>Are the results of the trial valid?</u>	**YES**	**CAN'T TELL**	**NO**
1. Did the trial address a clearly focused issue? To compare the ultrasound-guided ESPB versus the TAP block on postoperative analgesia after open total abdominal hysterectomy.	X		
2. Was the assignment of patients to treatments randomized? Computer generated randomization	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion? Attrition rate 0.	X		
4. Were patients, health workers and study personnel 'blind' to treatment? Patients and outcome assessors	X		
5. **Were the groups similar at the start of the trial?** Similarities between the groups include gender, age, BMI, ASA score, and surgery length (minutes).	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		

B. <u>What are the results?</u> **7. How large was the treatment effect?** Pain scores significantly higher in the TAP block group. Time to first morphine dose significantly shorter in the TAP block group. Total 24-h morphine consumption significantly higher in TAP block group. Patient satisfaction comparable. PONV comparable. **8. How precise was the estimate of the effect?** Pain scores p<0.0001, time to first morphine dose p<0.0001, total 24-h morphine consumption p=0.01			
C. <u>Will the results help locally?</u>			
9. Can the results be applied to the local population, or in your context?	X		
10. Were all clinically important outcomes considered?	X		
11. Are the benefits worth the harms and costs?	X		

Study title:
Abdelhamid, B.M., Khaled, D., Mansour, M.A., & Hassan, M.M. (2020). Comparison between the ultrasound-guided erector spinae block and the subcostal approach to the transversus abdominis plane block in obese patients undergoing sleeve gastrectomy: a randomized controlled trial. *Minerva Anestesiologica, 86*(8), 816-26. https://doi.org/10.23736 /S0375-9393.20.14064-1

A. Are the results of the trial valid?	**YES**	**CAN'T TELL**	**NO**
1. Did the trial address a clearly focused issue? To assess the analgesic efficacy of ultrasound guided ESPB compared to subcostal TAP block.	X		
2. Was the assignment of patients to treatments randomized? Computerized randomization	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion? Attrition rate 0.	X		
4. Were patients, health workers and study personnel 'blind' to treatment? Pain evaluators and patients blinded.	X		
5. **Were the groups similar at the start of the trial?** Similarities between the groups include gender, age, BMI, ASA score, and surgery duration.	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		

B. What are the results?

7. How large was the treatment effect? Ultrasound-guided ESPB resulted in lower postoperative pain scores, reduced intraoperative and postoperative opioid consumption compared to the subcostal TAP block and the control group. PONV higher in control group vs both block groups. Duration until first analgesia postop longer in ESPB group.

8. How precise was the estimate of the effect? Pain scores – ESPB and TAP vs Control and ESPB vs TAP (at timepoints 2h, 4, 6, 8, 12) $p<0.001$ Fentanyl consumption – control vs ESPB and TAP – $p<0.001$; TAP vs ESPB – $p<0.001$ PONV – $p<0.003$ Postoperative analgesia consumption – ESPB and TAP vs Control $p<0.001$ Time to first analgesia ESPB vs TAP & ESPB & control $p<0.001$			
C. <u>Will the results help locally?</u>			
9. Can the results be applied to the local population, or in your context?	X		
10. Were all clinically important outcomes considered?	X		
11. Are the benefits worth the harms and costs?	X		

Appendix D

Data Collection Table #1

	Author, Year	Procedure	Method of Anesthesia	# patients	ESPB Group	TAP Group	Control Group	Ages (yr)	M/F	ASA
a	Altiparmak, 2019	Elective Lap chole	General	68	34	34	NA	18 - 70	25/46	I - II
b	Tulgar, 2019	Elective Lap chole	General	60	20	20	20	18 - 65	22/38	I - II
c	Ibrahim, 2020	Elective Lap chole	General	63	21	21	21	20 - 60	20/43	I - II
d	Kamel, 2020	Elective open total abdominal hysterectomy	General	48	24	24	NA	40 - 60	0/48	I - II
e	Abdelhamid, 2020	Elective laparoscopic sleeve gastrectomy	General	66	22	22	22	18 - 59	32/34	II - III

Appendix E

Data Collection Table #2

	Author, Year	Timing of Block	TAP block	ESPB	Other/control group	Pre-op & Intraop. Analgesia	Post-op Analgesia
a	Altiparmak, 2019	After induction	Ultrasound guided OSTAP block with 20 mL 0.375% bupivacaine between the rectus abdominus and transversus abdominus muscle along the subcostal line of abdomen bilaterally	Ultrasound guided ESPB with 20 mL 0.375% bupivacaine at the T7 vertebral level		Dexketoprofen trometamol 50 mg, fentanyl 1 mcg/kg for induction	Tramadol PCA, no basal rate, 10 mg, 20 min lockout Morphine 4 mg for NRS pain score 4 or > while coughing
b	Tulgar, 2019	At completion of surgery under GA	Ultrasound guided OSTAP block with 10 mL of 0.5% Bupivacaine + 10 mL of 2% Lidocaine between the fascia immediately above the rectus abdominis muscle, bilaterally	Ultrasound guided ESPB with 10 mL of 0.5% Bupivacaine + 10 mL of 2% Lidocaine between the T8-T9 vertebral level bilaterally	No block, institution standard analgesia	Remifentanil gtt, fentanyl 100 mcg for induction	1 g Paracetamol, 20 mg Tenoxicam, Rescue fentanyl 25 mcg with NRS >3/10. Tramadol PCA 10 mg bolus 20 min lockout, 1 g paracetamol IV every 8 h for NRS >2 or patient refusal. Diclofenac Na IM 75 mg with NRS >3/10.
c	Ibrahim, 2020	After inductio	Ultrasound guided	Ultrasound guided	Direct visualizatio	Fentanyl 1 mcg/kg for induction, 1 g	For moderate to severe pain, patients were given either

		n and intubation	OSTAP block with 20 mL of 0.25% bupivacaine using oblique subcostal approach bilaterally	ESPB with 20 mL of 0.25% bupivacaine at T8 vertebral level, bilaterally	n of trocar sites with instillation of 0.25% bupivacaine, volume not specified	paracetamol, 400 mg ibuprofen both IV. Fentanyl bolus (10 mcg) every 5 min if MAP and HR increased more than 15% baseline	fentanyl 15-20 mcg, morphine 1-2 mg, or pethidine 15-30 mg all IV. After discharge to ward from PACU: 1g paracetamol every 6 hrs if pain moderate to severe. Morphine PCA with 1 mg bolus every 12 min with mx of 5 mg and no basal rate
d	Kamel, 2020	After surgery was complete and before reversal of NMB	ultrasound guided TAP block with 20 mL of 0.375% and 5 mcg/mL adrenaline (1:200000) between internal oblique and transnsversus abdominis muscle	ultrasound guided ESPB with 20 mL of 0.375% and 5 mcg/mL adrenaline (1:200000) at the T9 vertebral level, bilaterally		Intraoperative fentanyl 1 mcg/kg during induction followed by 0.5 mcg/kg/hr	Morphine 3mg IV if VAS >3. Once morphine given, pethidine 1 mg/kg IV every 4 hours with max daily dose of 300 mg
e	Abdelhamid, 2020	After induction	Ultrasound guided TAP block with 30 mL of 0.25% bupivacaine between the internal oblique and transversus abdominis muscles, bilaterally	Ultrasound guided ESPB with 15 mL of 0.25% bupivacaine at the T9 vertebral level, bilaterally	No block, opioid analgesia	Fentanyl 100 mcg for induction Fentanyl 50 mcg for any 20% increase in mean arterial pressure above baseline	1 g IV paracetamol every 8 hrs for VAS of 3 50 mg pethidine IV for VAS 5 or higher

Appendix F

Data Collection Table #3

	Author, Year	Adverse Events Related to Block	Outcomes Measured	Outcome Results	Study Conclusion
a	Altiparmak, 2019	None Reported	NRS pain scores with coughing at time points 15 min, 30 min, 60 min, 120 min, 12 hr, 24 hr. Tramadol consumption – first 24 hrs postoperatively Morphine consumption – first 24 h postop Intraoperative fentanyl consumption	Repeated measures analysis showed no statistically significant difference in NRS scores between groups. 24 hr Tramadol Consumption: significantly higher in the OSTAP group ESPB: 139.1 (±21.9); OSTAP: 199.9 (± 27.7) **p < .001 Morphine consumption: Higher in OSTAP group but not significant ESPB: 24 mg; OSTAP: 48 mg *p = .099 Fentanyl consumption: No difference between groups ESPB: 95.5 (± 23.3); OSTAP: 96.3 (± 30.8)**p = .821	Following laparoscopic cholecystectomy, US guided ESPB reduced tramadol consumption significantly when compared to the US guided oblique subcostal TAP block. Further studies should be done to evaluate the optimum volume and dose of local anesthetic solution.

b	Tulgar, 2019	None Reported	NRS pain scores at rest and with coughing at time points 20 min, 40 min, hours 1, 3, 6, 9, 12, 24. 24 hr Paracetamol consumption 24 hr Tramadol consumption	NRS scores: ESPB vs OSTAP No significant difference at any time point at rest and with coughing ESPB vs Control: ESPB group show significantly lower pain scores at time points 20, min 40 min, 1 h, & 3 h at rest and with coughing. OSTAP vs Control: OSTAP group had significantly lower pain scores at the 20th minute. *Ave. NRS score for all groups <4 at all times. Paracetamol consumption: significantly <0.05 higher paracetamol consumption in control group vs ESPB and control vs TAP. No significant difference between TAP & ESPB Tramadol consumption: Significantly higher consumption in the control group vs ESPB and TAP group during the first 12 hrs and 2nd 12 hrs. No significant difference in consumption between the two block groups.	The US-guided ESPB and OSTAP block performed at the end of surgery in laparoscopic cholecystectomy patients lead to decreased 24-h analgesia requirement when compared to a control group without a block. Further studies should be done to determine the effect, feasibility, and ideal volume and concentration.

			24 hr Fentanyl consumption Time to perform block	rescue fentanyl consumption: Significantly higher in the control group vs ESPB and TAP. No significant difference between the two block groups. Time (minutes) to perform block was not significantly different: ESPB: 6.65 ± 1.08; TAP: 5.7 ± 0.92 p = 0.491	
c	Ibrahim, 2020	None Reported	Pain intensity by VAS at rest and movement (flexion of leg against resistance) at time points 0, 2, 4, 6, 12, & 24 hr postoperatively 24 hr morphine consumption postoperatively Intraoperative fentanyl consumption	VAS pain scores at rest and with movement significantly higher in control group at hour 6 & 12 when compared to both block groups. 24 hr morphine consumption: no significant difference between the ESPB and OSTAP group. Consumption significantly higher in control group when compared to both ESPB and TAP block groups. Intraoperative fentanyl consumption was higher in the control group than either block group. No significant difference between the block groups.	US-guided ESPB was found to be comparable to OSTAP block. Both blocks reduced intraop rescue fentanyl, PACU morphine, 24-h morphine, and pain compared to the control group receiving no block.

			incidence of PONV	No significant difference in incidence of PONV	
d	Kamel, 2020	None Reported	Pain intensity using the VAS score at 30 min, 2, 4, 6, 8, 12, 16, 20, & 24 hrs postoperatively The time for requirement of first morphine dose Total morphine consumption in 24 hours postoperatively Patient satisfaction of analgesia at the end of 24 hours – verbal scale 1-3, 1 = unsatisfactory, 2 = satisfactory, 3 = excellent. Incidence of morphine related side effects: Nausea, vomiting, respiratory depression (RR<8/m), bradycardia (hr decrease >20% of baseline),	VAS scores at 30 min, 2, 12, 16, 20,24 hr were highly statistically ($p<.0001$) significantly lower in the ESPB group. Time to requirement of first morphine dose highly statistically significantly longer in the ESPB group. Total morphine consumption 24 h significantly lower in ESPB group. Patient satisfaction comparable between groups. N/V in both groups but not significantly different. No other morphine related side effects observed.	US-guided ESPB provides more potent and longer postoperative analgesia with less morphine consumption than TAP block after total abdominal hysterectomy.

			hypoventilation, cardiac arrest. Adverse effects of block technique: local infection, hematoma, bowel perforation, pneumothorax.	No adverse effects of either block observed.	
e	Abdelhamid, 2020		Severity of postoperative pain using the VAS at 30 min, and hours 2, 4, 6, 8, 12, 18, and 24. Total intraoperative fentanyl requirements PONV	VAS significantly lower ($p<0.001$) in ESP and TAP groups compared to control group throughout the first 12 hours. ESP vs TAP – significantly lower VAS scores in ESP at the 2^{nd}, 4^{th}, 6^{th}, 8^{th}, and 12^{th} postoperative hours. At 24 hrs there was no difference between the three groups. Significantly higher in control group vs TAP and ESP. Significantly higher in TAP vs ESP ($p<0.001$) Greater incidence in control group vs TAP and ESP ($p<0.003$). No significant difference between TAP and ESP. Significantly higher in control group (median 150) than in ESP	Ultrasound-guided ESPB resulted in lower postoperative pain scores, reduced intraoperative and postoperative opioid consumption compared to the subcostal TAP block and the control group. More studies with larger sample sizes should be done to confirm findings. Further studies should be done to investigate the optimal volume, concentration and type of local anesthetic for ESP when conducted for sleeve gastrectomy.

			Cumulative pethidine consumption during the first 24 hours Duration of time before the first request for rescue analgesia	(median 0) and TAP (median 50) ($p<0.001$) Significantly delayed in ESP group compared to TAP and control ($p<0.001$)	

Appendix G

Cross-Study Analysis

Study	Surgery	Lowest postoperative 24-hr pain scores	Lowest 24-hr postoperative opioid consumption	conclusion
a	Elective Lap chole	No significant difference in NRS scores between block groups.	Tramadol consumption significantly higher in OSTAP group. No significant difference in morphine consumption between groups.	ESPB reduced tramadol consumption significantly compared to OSTAP block.
b	Elective Lap chole	No significant difference in NRS scores between block groups. Pain scores significantly higher in control group.	No significant difference in tramadol and fentanyl consumption between block groups. Tramadol and fentanyl consumption significantly higher in control group than either block group.	ESPB and OSTAP block had comparable pain relief and opioid sparing ability. When compared to the control group, both ESPB and OSTAP groups were superior in decreasing pain and opioid consumption.
c	Elective Lap chole	No significant difference in VAS scores between block groups. Pain scores significantly higher in control group.	No significant difference in morphine consumption between groups.	ESPB and OSTAP block had comparable pain relief and opioid sparing ability. When compared to the control group, both ESPB and OSTAP groups were superior in decreasing pain and opioid consumption.

d	Elective open total abdominal hysterectomy	VAS scores in the ESPB group were significantly lower.	Morphine consumption significantly lower in ESPB group.	ESPB provides greater postoperative pain relief and less opioid consumption than TAP block.
e	Elective laparoscopic sleeve gastrectomy	VAS scores in the ESPB group vs TAP were significantly lower up to the 12^{th} hour. Pain scores significantly higher in control group compared to both block groups.	No significant difference in pethidine consumption between block groups.	ESPB resulted in lower postoperative pain scores when compared to the TAP block and the control group. Significant opioid sparing was seen in both TAP and ESPB groups compared to control group. No significant difference seen between two block groups.