Update on paravertebral blocks

Richa Wardhan

Purpose of review
The goal of this review was to update the reader on the developments and advancements that have transpired in the previous few years and to encourage an open dialogue amongst readers and researchers alike.

Recent findings
Tremendous progress has been made investigating the part paravertebral blocks play, not only in acute pain management but also in management of nonsurgical pain. It starts with discussing the recent advances pertaining to paravertebral blocks (PVBs) in breast, thoracic and cardiac surgery and then leads on to its evolving presence in pediatric surgery. The review also discusses utilization of thoracic paravertebral blocks in managing acute and chronic nonsurgical pain. Finally, it concludes with mention of new techniques and procedures to perform PVBs.

Summary
The impact of paravertebral analgesia on cancer pain and prevention of metastasis could be huge once enough data have accumulated. The steady influx of data on PVBs has led to the resurgence of this block in almost every area of acute pain management.

Keywords
chronic pain, fast track surgery, metastasis, paravertebral blocks, rib fractures, ultrasound

INTRODUCTION

Paravertebral blocks (PVBs) have gained immense popularity within the last 2 decades. Based on the current evidence, PVBs for surgical anesthesia at the level of the thoracic and lumbar vertebrae are associated with less pain during the immediate postoperative period, as well as less postoperative nausea and vomiting, and greater patient satisfaction compared with general anesthesia (GA) [1].

Thoracic paravertebral blocks for breast surgery

Thoracic paravertebral blocks (TPVBs) have shown to reduce postoperative pain and decrease opioid consumption in patients undergoing breast surgery. The focus is now on the role of TPVBs in prevention of chronic pain and possible prevention of metastasis after breast surgery.

Prevention of chronic pain

The role of TPVB in preventing chronic pain is still evolving. Kairaluoma *et al.* followed patients who received TPVBs for breast surgery for one full year. They found that the benefits of TPVBs were evident at every interview, with increasing benefits culminating at the 12-month interview, the PVB group had less motion-related pain and less pain at rest [2]. Karmakar *et al.* also shed more light on the impact of TPVBs in preventing and reducing the severity of chronic pain after breast surgery. In total, 180 women undergoing modified radical mastectomy were randomized to either a standardized GA, GA with a single-injection TPVB (or a placebo paravertebral infusion) or GA with a continuous TPVB. They concluded that even though there was no significant difference in the incidence or relative risk of chronic pain at 3 and 6 months when TPVB was used in conjunction with GA, nevertheless, patients who received TPVBs reported less severe chronic pain, exhibited fewer symptoms and signs of chronic pain, and also experience better physical and mental health-related quality of life [3]. Ilfeld *et al.* [4] also reported that only 14% of those who received TPVBs developed chronic pain as compared with 47% of those who did not.

Department of Anesthesiology, Yale University School of Medicine, New Haven, Connecticut, USA

Correspondence to Richa Wardhan, MD, Department of Anesthesiology, Yale University, 333, Cedar Street, New Haven, CT 06510, USA. Tel: +1 203 785 4488; fax: +1 203 785 6664; e-mail: richa.wardhan@yale.edu

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KEY POINTS

- Thoracic paravertebral blocks provide analgesia equivalent to thoracic epidurals but with less side effects.
- TPVBs for breast surgery have been used to provide surgical anesthesia and its role in evolving in preventing chronic breast pain and metastasis.
- TPVBs in thoracic and cardiac surgery have also shown to decrease incidence of chronic thoracotomy pain and can become valuable components of fast track thoracic and cardiac surgery.
- Their role in pediatric pectus excavatun repair is especially valuable because of their proven safety profile over thoracic epidurals.

Prevention of metastasis after breast surgery

The inhibition of the stress response to surgery by paravertebral anesthesia has shown to be associated with reduced risk of metastasis as evident from this retrospective follow-up of patients undergoing breast cancer surgery several years ago [5]. Recently, more data have poured in to define the exact mechanism by which TPVBs might work. There were two factors that came to light. First, for patients receiving TPVBs, opioids consumption is less. Opioids are notorious for their immunosuppressive role in cancer mediation. Second, the antimetastatic and anti-inflammatory effect of the amide local anesthetics used for TPVBs could play a major role [6].

Another study comparing the effect of cytokines and natural killer (NK) cells *in vitro* found that serum from patients who received TPVBs and propofol did not show altered normal NK marker expression or secretion of cytokines. Serum from GA patients reduced NK cell-activating receptor [7].

Single injection or infusion for breast surgery

More recently, researchers are trying to determine whether a continuous paravertebral block (CPVB) is superior to a single injection PVB for analgesia after breast surgery. In 2010, Buckemhier *et al*. conducted a randomized, double-masked, placebo-controlled study, in which 94 patients were assigned in a 1 : 1 : 1 ratio with early breast cancer to single injection PVB followed by CPVB infusion of 0.1% or 0.2% ropivacaine vs. placebo (saline) for 48 h postoperatively for unilateral breast cancer surgery without reconstruction. They concluded that patients who received 0.2% ropivacaine through their CPVB catheters did report a significant relative decrease in pain scores during the first postoperative week though total opioid use remained constant among all three treatment groups. They suggested that their study does not support the routine use of continuous paravertebral catheter anesthesia in patients undergoing operative treatment for breast cancer [8]. Conversely, in 2014, Ilfeld *et al*. [4] conducted a similar study and concluded that adding a multiple-day; continuous ropivacaine infusion to a single-injection ropivacaine paravertebral nerve block may result in a lower incidence of pain as well as pain-related physical and emotional dysfunction 1 year after mastectomy.

Thoracic paravertebral blocks for thoracic surgery

The primary factor that might influence post-thoracotomy pain is the severity of pain in the immediate postoperative period. Thus, inadequately controlled pain can increase postoperative morbidity, as well as reduce quality of life and patient satisfaction.

Chronic post-thoracotomy pain syndrome

The International Association for the Study of Pain has defined chronic post-thoracotomy pain syndrome as pain that recurs or persists along a thoracotomy incision for at least 2 months following surgery. Patients who experience post-thoracotomy pain at 3 months are at greatest risk for significantly decreased physical functioning and vitality [9]. A recent systemic review of literature pointed the evidence in favor of thoracic paravertebral block or thoracic epidural analgesia as the first-choice therapies for post-thoracotomy analgesia [10]. Given the lack of superiority of thoracic epidural analgesia over paravertebral analgesia and the potential risk of adverse effects, paravertebral analgesia may offer major advantages. What still remains unresolved, however, is the effectiveness of neuraxial analgesia techniques or paravertebral analgesia in reducing post-thoracotomy pain syndrome [10].

Fast track thoracic surgery

The three constituents that are vital for achieving the title of fast track surgery are minimally invasive surgery, optimal pain control and shorter hospital stay. Videoscopic-assisted thoracoscopic surgery qualifies as fast track surgery, but there is no consensus for the optimal postoperative pain management approach adopted following videoscopic-assisted thoracoscopic surgery [11].

In a retrospective study by Komatsu *et al.*, TPVBs were considered most suitable analgesic modality for fast track thoracic anesthesia for the following reasons. First, a majority of patients could tolerate

postoperative pain with an oral NSAID alone. Second, there were almost no pain-related postoperative pulmonary complications, and finally, all of the patients were able to participate in an aggressive physiotherapy program. Thoracic epidural was not considered ideal because of its multiple side-effects [12].

Thoracic paravertebral blocks for minimally invasive cardiac surgery

Minimally invasive mitral valve repair has been associated with reduced pain, time to extubation, and transfusion [13]. Over the years, only very few studies have reported utilization of TPVBs for cardiac surgery, especially the minimally invasive robotic procedures. A recent retrospective review of 200 patients who underwent robotic mitral valve repair focused mainly on early tracheal extubation and rapid recovery, the authors also wanted to confirm that the changes made to achieve these goals utilizing paravertebral blocks did not compromise patient safety or analgesia.

This study concluded that use of TPVBs allowed reduced intraoperative opioid administration, without compromising perioperative analgesia. Minimally invasive cardiac surgery through thoracotomy also carries increased risk of severe post-thoracotomy pain syndrome compared with median sternotomy [14] Again, the primary factor that might influence post-thoracotomy pain is the severity of pain in the immediate postoperative period. Thus, inadequately controlled pain can increase postoperative morbidity, as well as reduce quality of life and patient satisfaction [9].

Thoracic paravertebral blocks for pectus excavatum repair

In pediatric population undergoing pectus excavatum repair, the Nuss procedure has gained worldwide popularity. It involves sternal remodeling using a substernal bar alone, without cartilage resection, sternal osteotomy, or large visible scars; however, it can still be quite painful.

A recent retrospective trial by Hall Burton *et al.* was conducted to compare the efficacy of PVB catheters with TEA catheters for postoperative analgesia in pediatric patients undergoing the Nuss procedure. In this small series, bilateral PVB catheters resulted in equivalent opioid consumption and pain scores when compared with TEA for postoperative pain management in pediatric patients undergoing the Nuss procedure [15].

Epidural analgesia has long been the modality of choice for such a procedure like this; however, four cases of neurological deficits (one placed for Nuss procedure) likely from epidural analgesia have discouraged its use [16].

TPVBs seem to be a perfect fit for this procedure, especially in the pediatric population. To prove this point, Qi *et al.* conducted this first prospective randomized trial of its kind. Patients were allocated to either a TPVB group or an opioid analgesia group. In the BTPV group, 0.25% ropivacaine 0.5 ml/kg with 1 : 200 000 epinephrine was injected under ultrasound guidance on each side at the level of the fifth thoracic vertebra. Postoperative pain was evaluated in both groups for the first 48 h. Total opioid administered and cumulative attempts on the patient/parent-controlled intravenous analgesia pump were also recorded. The TPVB group had significantly low opioid consumption when compared with the opioid only group and better pain scores. No complications from placing TPVBs were noted in the study. They concluded that ultrasound-guided bilateral TPVBs provide improved postoperative analgesia for children undergoing the Nuss procedure as compared with intravenous parent-controlled intravenous analgesia and decreased the incidence of postoperative behavioral disturbance [17].

Lumbar paravertebral blocks for hip surgery

Lumbar paravertebral blocks are usually performed at L1,2 spinous level to target the nerve roots forming the lumbar plexus in an attempt to avoid quadriceps weakness and promote early discharge. Previous case reports [18] have discussed the advantage of lumbar paravertebral blocks in preserving quadriceps in hip arthroscopy. A recent study by Wardhan *et al.* compared quality of analgesia between continuous lumbar plexus block and continuous L2 PVB after total hip arthoplasty [19]. Even though the study demonstrated the equivalent analgesia between the L2 PVB and the lumbar plexus group, the L2 PVB failed to demonstrate motor preservation [19].

On the contrary, a recent case report again reports good efficacy of the block in a single patient along with motor preservation [20].

Thoracic paravertebral blocks for acute and chronic nonsurgical pain

An acute nonsurgical pain condition, whose adequate management has a significant role in reducing morbidity and mortality, is the management of rib fracture pain with TPVBs. Paravertebral analgesia has been shown to provide effective pain relief in patients with multiple rib fractures. Evidence supports the concept that paravertebral block is as effective as epidural blocks for perioperative

pain management without many of the side-effects of epidural analgesia [21]. Pulmonary complications, urinary retention, nausea, vomiting, and hypotension are less common with paravertebral block as compared with epidurals [22]. Per the guidelines published by the Eastern Association for the Surgery of Trauma in 2007, epidural analgesia is considered the gold standard for managing rib fracture pain. Epidural analgesia is, however, limited by its narrow applicability to rib fracture patients and related side-effects [23]. In addition, many trauma patients, for multiple reasons such as cervical neck fractures, lumbar–thoracic spine fractures, and altered mental status, are not candidates for epidural analgesia [24].

Chronic nonsurgical pain such as postherpetic neuralgia, cancer pain, or chronic pain after rib fractures can benefit tremendously from PVBs. The trial by Makharita *et al.* is probably the first of its kind comparing paravertebral blocks with traditional treatment for patients with active herpes zoster and postherpetic neuralgia. In total, 180 patients with acute thoracic herpetic eruption were randomly assigned to receive a paravertebral block using either 10 ml saline (placebo group) or 25 mg bupivacaine, and 8 mg dexamethasone in a total volume of 10 ml (active group). Significantly lower doses of pregabalin and acetaminophen were consumed in the active group. Incidence of postherpetic neuralgia was comparable in both groups after 3 months but significantly lower at 6 months [25]. A recent case report also describes the use of neurolytic paravertebral block for intractable cancer pain affecting ribs. Ultrasound was used to identify the space and plane of injection at the mid-thoracic level. Absolute alcohol was used to block the nerves at different segments. Both patients had great pain relief [26].

Recent advances in technique and anatomical study of thoracic paravertebral blocks

Ultrasound guided PVBs have gained popularity over a landmark technique within the last decade. A recent clinical study by Luyet *et al.* reconfirmed that ultrasound-guided TPVBs might be superior to a landmark approach. In this first ever MRI study of its kind, the authors evaluated the location of paravertebral catheters that were placed using the classic landmark puncture technique and correlated the distribution of contrast dye injected through the catheters with the extent of somatic block. In total, 29% of the patients had misplaced catheters and there was a discrepancy between the radiological spread of the dye and the observed distribution of loss of sensation [27]. This reconfirms the notion studies that ultrasound-guided TPVBs are more reliable and successful; however, the discrepancy between the spread of local anesthetic and somatic analgesia still exists [28]. There have been several hypotheses explaining this conundrum. Lundblad *et al.* [29] assumed a secondary spread following the primary visualization of caudally administered local anesthestic. Marhofer *et al.* found evidence of epidural spread of the local anesthetic through MRI at the time of MRI investigation in 25% of TPVB. A secondary epidural spread with possibly subsequent contralateral sensory effects is a reasonable explanation for the larger extent of somatic block compared with the spread of local anesthetic, which is in accordance with the literature [28].

There is even more paucity of literature when it comes to the spread of sensory block produced by continuous TPVBs. A recent clinical study by Yoshida *et al.* [30] has helped answer few of these questions. Their study indicated that there was no difference in dermatomal spread or pain scores between 0.2 and 0.5% Ropivacaine and for both groups only four segment spread was observed when continuous catheters were used.

CONCLUSION

In experienced hands, TPVB placement is a simple technique devoid of major complications and side-effects. Recent decades have seen an explosion in the data investigating all possible uses of TPVB analgesia. The purpose of this current review was to keep the reader updated and interested in exploring the applicability of TPBV analgesia in their clinical practice.

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