Review Article

The role of local anaesthetic techniques in ERAS protocols for thoracic surgery

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Abstract: The use of enhanced recovery after surgery (ERAS), as in other surgical specialties, is an emerging concept in cardio-thoracic surgery but there is still a lack of effective protocols to reduce the burden of surgery on the patient, shorten the period of postoperative recovery, and reduce the likelihood of chronic pain developing. The use of local anaesthetic (LA) techniques, such as thoracic epidural analgesia (TEA) and paravertebral blocks (PVB), as an adjunct to anaesthesia are considered key components, though there is little data for direct comparison of the techniques. This review aims to evaluate the role of LA techniques in a thoracic ERAS program through evidence from literature and considering aspects of clinical practice. We discuss how ERAS is adapting and evolving with the increasing use of video-assisted thoracoscopic surgery (VATS) is thoracic surgery. It also examines the advantages of multimodal, opioid-sparing analgesia in the post-operative period to minimise the inflammatory response and improve functional recovery. LA techniques within ERAS protocols have the potential to hasten recovery when managed appropriately and to their full potential.

Keywords: Enhanced recovery; epidural anaesthesia; paravertebral block (PVB); local anaesthetics (LA)

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Introduction

The concept of enhanced recovery after surgery (ERAS) was introduced by Wilmore and Kehlet in 2001 (1) and was originally introduced to facilitate enhanced recovery for patients after colorectal surgery. The medical care of patients should be optimised in the months before surgery takes place, and earlier mobilisation after surgery, so patients can resume their regular activities, and can be then safely discharged sooner than under conventional surgical protocols, without increasing the rate of complications. It relies on the idea of marginal gains, where each individual element of the ERAS protocols may just have a small effect, together though, they act to synergistically improve outcomes.

The absolute incidence of all thoracic procedures in the UK is hard to quantify, as no collected database exists. However, there is data from the Society for Cardiothoracic Surgery in Great Britain and Ireland (SCTS) on the number of lung cancer resections performed every year, showing that for the 2014–2015 audit period (the most recent year that data is available from) 7,228 lung cancer resections were performed, across 36 thoracic units in the UK. About 40% of these cases were performed by video-assisted thoracoscopic surgery (VATS), an increase from 30% the previous year (2). The resection of lung cancer is a major indication for thoracic surgery, and the incidence of lung cancer in the UK is currently increasing (3).

The application of ERAS ideas to thoracic surgery is

not a new concept, though there is little published data and evidence. A systematic review published by Fiore *et al.* in 2016 (4) identified six studies, only one of which was a randomised trial. These studies were inconsistent as to which elements of ERAS protocols were included, representing a lack of homogeneity across thoracic surgery units, which can be at least partly attributed to the lack of established guidelines in this area (5). In addition, there is a lack of data investigating the use of VATS due to the fact they were conducted before or while VATS developed as a mainstay of thoracic surgery (6). This is important as minimally-invasive surgery has always been considered an integral part of ERAS protocols, and its benefits have been widely demonstrated in other specialties (7).

ERAS in thoracic surgery involves multiple components and a multidisciplinary approach, including preoperative assessment, anaesthetic technique (including the use of regional anaesthetic techniques as an adjunct to anaesthesia), surgical technique (with a focus on the use of minimally-invasive techniques such as VATS), and postoperative care focusing on early mobilisation, management of post-operative pain, prevention of post-operative nausea and vomiting, early return to eating and drinking, and resumption of everyday tasks as soon as possible (6).

Regional local anaesthetic (LA) techniques have been shown to convey significant benefit in the management of acute postoperative pain when compared to systemic opioids alone (8), and it is thought that management of acute pain postoperatively has a significant benefit in the prevention of chronic pain (9). While the benefit of a single analgesic technique used in combination as part of multi-modal analgesia is difficult to prove, there is some evidence to suggest that regional techniques confer a morbidity benefit (10) compared to systemic opioids alone. They also provide a significant opioid sparing benefit, which helps to reduce opioid-related side effects and facilitate ERAS.

Cases demonstrations

The following cases represent typical scenarios in our institution and probably elsewhere. They reflect the patient pathway on the journey through different stages of perioperative care and highlight the multi-disciplinary nature of modern thoracic surgery and anaesthesia.

(I) A 62-year-old male patient who presents for thoracotomy upper lobe resection. He had a premedication that consisted of gabapentin and temazepam and was given dexamethasone iv on arrival to the OR. He is given a high thoracic epidural preoperatively by a consultant anaesthetist. The operation was successful and proceeded without complications and the patient was taken to high dependency unit (HDU) following a short stay in PACU. Post-op analgesia was a patient controlled epidural analgesia (PCEA) pump consisting of levobupivacaine and fentanyl, which was on for around 16 hours post-op before the patient was switched to a "plain" bag consisting just of levobupivacaine. In addition to this, the patient was prescribed regular paracetamol and several "as required" medications, including diclofenac and oxycodone IR. The patient was stepped down from HDU to a ward and pain was well controlled on post-operative day one (POD1). There was no use of any additional analgesics other than the epidural. He had started mobilising early under the guidance of the physiotherapists and had resumed eating and drinking several hours after his surgery. The epidural catheter was removed on POD3 and the patient started on tramadol in the short term for pain control. He was discharged 6 days after his operation.

(II) A 71-year-old male patient who comes in for a VATS lobe resection. The procedure was surgically challenging and the decision was made to convert from a VATS procedure to a thoracotomy. The rest of the procedure proceeded without further complications and two paravertebral blocks with catheters (PVBs) were placed by the consultant surgeon under direct vision prior to closure. Levobupivacaine boluses were delivered into both paravertebral catheters at the end of the procedure and the patient was taken to HDU where they were started on levobupivacaine infusions to maintain the PVB. In addition to this, the patient was prescribed regular paracetamol and several "as required" medications, including diclofenac and oxycodone IR. The patient was stepped down from HDU POD1 but was having ongoing issues with pain control. Overnight, they were given 10 mg of oxycodone IR, and the next day on review by the acute pain service (APS) the decision was made to give them a 20 mL top-up of LA. This improved the pain control significantly, enabling them to engage with the physiotherapists which they were unable to do prior to their APS review. They

continued to be reviewed by the APS but needed no further oxycodone or LA top ups, and had their paravertebral catheters removed on POD3. The patient was started on dihydrocodeine for pain control in the short term and was discharged seven days after their operation.

How are LA techniques used and what does the literature say about their efficacy?

The use of LA techniques is common in thoracic surgery, with 92% of cardiothoracic anaesthetists surveyed regularly using either a thoracic epidural analgesia (TEA) or a PVB as an adjunct to anaesthesia. A smaller percentage used intercostal nerve blocks, intrathecal opioids, other regional techniques, or did not use LA techniques regularly in their practice (11).

Insertion of a thoracic epidural normally happens prior to the induction of general anaesthesia, which allows the anaesthetist to confirm the epidural is functioning before proceeding. It is normally inserted at either the level of T3/4 or T4–5, the dermatomal distribution of which is set to achieve a block from T1/2 to T10, using either a paramedian or laminar approach (12).

The most common epidural solution used intraoperatively and in the immediate post-operative period is a combination of a long-acting LA (such as levobupivacaine or ropivacaine) and lipophilic opioid (such as fentanyl), which mostly spread into the systemic circulation and work there (13). This is often switched to a "plain" bag, containing just LA solution, during the recovery period as part of the management of post-operative pain.

Epidurals are commonly used in thoracic surgery as pain relief for patients but are not without their risks, including the possibility of epidural haematoma, epidural abscess, and meningitis (14) It is difficult to estimate a true incidence of these complications, but in one large single-centre study conducted by Christie and McCabe (15) covering a 6-year period, they recorded 12 major complications over 8,100 perioperative epidurals (these epidurals were provided for a variety of surgery, and are not solely thoracic epidurals), a complication rate of 1 in 675. A more recent metanalysis of the use of thoracic epidurals in cardiac surgery showed an even lower complication ratio, calculating the risk of epidural haematoma to be 1 in 3,552 (16).

PVB are the injection of LA into the paravertebral space, a potential space that exists lateral to the epidural space through which the spinal nerves travel, where infiltration of LA produces a unilateral nerve block. It is common to insert two (or more) paravertebral catheters a couple of vertebral spaces apart to ensure a unilateral block over the distribution of several dermatomes (17). There are various methods employed to achieve this. it can be done percutaneously through a loss of resistance technique, under thoracoscopic guidance, under ultrasound guidance, or under direct vision during thoracotomy (12). It is common to thread a paravertebral catheter into the space to allow for the infusion of LA into the space for maintenance of the block, and to allow top-ups of LA to be delivered into the space to facilitate pain control in the postoperative period (17).

There has been an increase in PVB use in thoracic surgery in recent years with recent studies suggesting that they have similar analgesic efficacy when compared to TEA, long been considered the gold-standard, but with a superior side-effect profile, less haemodynamic instability, and increased preservation of pulmonary function (18). However, PVBs are not without problems. There is the potential for failure of catheter placement in PVBs, though this has reduced in recent years with the advent of PVBs being placed under direct vision by the surgeons rather than inserted percutaneously by anaesthetists (19), the LA solution may remain localised, spread ipsilaterally into paravertebral spaces above and below, spread laterally into the intercostal space, or spread medially through into the epidural space, which means that if functions like an thoracic epidural with its accompanying side effects including sympathetic block (19). However, it is difficult to collate data on the failure rate of PVB, due to a difficulty in how to define and measure their efficacy, which varies between author, along with the variation in insertion techniques.

A recent Cochrane review investigated the use of TEA or PVB for thoracotomy and concluded that they were equally as effective in controlling pain in the postoperative period, without a difference in 30-day mortality, major complications, or length of stay (9). For VATS cases no studies have shown a clear advantage for the either the use of PVBs or TEA, but for both open thoracotomy and VATS cases there has been a trend in recent literature towards the use of PVB over TEA (20). The Cochrane review and the PROSPECT group investigated a variety of regional anaesthetic techniques for use as an adjunct in thoracotomy and came to the conclusion that PVBs were as effective

as TEA but it was associated with a lower incidence of hypotension and other minor complications (8,9), though they noted that the current evidence was of a low-quality.

Do VATS patients only need a PVB?

VATS is an emerging surgical technique in thoracic surgery, particularly for the resection of tumours in oncologic surgery. An advantage to VATS over open thoracotomy is the reduction in post-operative pain (21) and it is also thought to reduce the development of chronic neuropathic pain postoperatively when compared to thoracotomy (22). While both TEA and PVB are often considered "gold-standard" LA adjuncts in thoracotomy, there is no consensus on which technique is superior in VATS procedures, though both are commonly employed by anaesthetists, amongst other techniques such as intercostal block, and interpleural infusion.

There is very limited data available on choice on LA technique in VATS procedures. They are often thought of as low-risk interventions only requiring short stays in hospital and therefore have been the focus of far fewer studies when compared to thoracotomy procedures, however it has been shown pain following VATS procedures is significant and can develop into chronic pain (23).

Studies investigating the use of multi-level single-shot PVB conducted at the end of a VATS procedure provides effective pain relief, but only for the first six hours after the procedure (24), indicating that while a single-shot PVB may not be sufficient, there is evidence to suggest that continuous PVB through a catheter is necessary for VATS procedures. It has been shown that the use of PVBs provided considerably superior analgesia postoperatively following VATS when compared to sole opioid PCA, intrapleural LA spray & opioid PCA (25) and a study by Fibla and colleagues looking at the use of PVB and NSAIDs for the management of pain post-VATS showed lower pain scores in the PVB cohort compared to the use of NSAIDs alone, without any significant side effects recorded (23).

There have also been studies looking at the use of TEA as a LA adjunct in VATS patients, which resulted in significantly lower pain scores, though the use of lipophilic opioids in the epidural infusion led to side effects of systemic opioids, such as nausea and vomiting (N + V), pruritus, and vertigo, such that the recommendation of the authors was to discontinue TEA on POD2 and stepdown to oral analgesia (26).

There are currently no studies published which investigate the use of PVB against TEA in VATS patients, so it is difficult to draw comparisons between the techniques, though looking at the data available it is clear that PVB is a safe and effective technique to use for use in VATS.

Are we employing multimodal analgesia?

Postoperative pain control is a major factor in ERAS protocols (7) and the management of such pain is generally through a multi-modal approach, which combines systemic analgesia with regional LA techniques for a balanced approach while minimising side effects (12), the core concept being that multiple analgesic agents work synergistically in the treatment of acute pain (1). Systemic opioids have long been the primary means of postoperative analgesia though are well known for their side effects, such as nausea and vomiting, urinary retention, hallucinations, constipation, and respiratory depression (27), all of which are directly in opposition to the principals of enhanced recovery.

More recently, arguments have been made that opioid tolerance and opioid-induced hyperalgesia (OIH) are more frequent that previously thought (28) and can be induced in the perioperative period through the use of high-dose opioids, resulting in increased intensity of post-op pain perception. The increasing use of remifentanil, a short-acting, highly potent opioid analgesic often infused as an adjunct to anaesthesia is an important consideration as both tolerance and OIH have been shown to occur even with short-term infusions when high doses are used intraoperatively (27,29).

The use of LA techniques is well established in the field of thoracic anaesthesia, they decrease opioid requirement, blunt the stress response to surgery, and the use of LAs prevents the nociceptive input in the acute postoperative period which is thought to prevent central sensitisation, thought to lead to a decreased incidence of chronic pain. The use of TEA and PVB in the immediate postoperative period have been described earlier, but the use of LA boluses (top-ups) after this is not well studied in current literature.

The use of routine LA top-ups for the management of postoperative pain as an opioid-sparing technique has the potential to facilitate enhanced recovery after thoracic surgery. Currently in local practice, the use of LA top-ups is often not used as a first line analgesia, with the preference for the use of opioids and then the use of LA top-ups after this if the patient continues to experience pain. There are

multiple possible reasons for this.

Additional training is required for health practitioners to administer LA top-ups, they are not always available and often convenience and time constraints of the care team favours prescribing oral pain killers over more time consuming LA top-ups.

LA top-ups can provide a rapid and safe alternative to opioids in the management of post-operative pain while patients still have their paravertebral or epidural catheters in situ. For epidurals, the concept of patient-controlled analgesia via a demand hand-set operated by the patient is well established. On the other hand, a similar approach to PVBs has not yet emerged, most likely because of relatively high volumes of LA needed for each top-up.

The common side effects of opioids have the potential to stop the patient from engaging with the enhanced recovery protocols in place, potentially increasing their length of stay in hospital, and opioid-sparing alternatives should be used to their fullest extent.

Other systemic analgesia commonly used includes NSAIDs, which is thought to have opioid sparing properties and modulates the inflammatory response to surgery, though caution should be exercised in patients with renal impairment and/or a history of GI bleeding, and paracetamol, which often given as an IV infusion intraoperatively before patients are stated on regular paracetamol postop, which gives a constant low-state of analgesia proven to reduce opioid consumption in thoracic patients (10).

There has been an increase in the use of ketamine in the perioperative phase, as it prevents central sensitisation to pain, and is thought to combat the effects of hyperalgesia after the use of remifentanil infusions (27). Systemic reviews have shown that in thoracic surgery, it has significant opioid-sparing properties, improves lung function, improves patient satisfaction, and reduces the incidence of nausea and vomiting (30).

Patients perception of perioperative care, acute pain, and the development of chronic pain

Traditional measures of patient satisfaction focus on pain scores, nausea and vomiting, are well established in the literature and are commonly the only factors measured in the post-operative period. While there has been an increase in studies looking at patient satisfaction, which look at the speed at which a patient returns to their normal life, disability-free survival rates, and general quality of recovery, these are rare and not commonly done as they require a much longer follow up period which is logistically difficult and patients are often lost to follow up (31).

There is evidence to suggest that using more thorough means of investigating patient outcomes, such as the use of patient-reported outcome measures (PROMs) and patient-reported experience measures (PREMs), which look at how an intervention changes patients' view of their health and the patients' perceptions of the health care they received respectively (32). Used in tandem, they allow for insight into patients' perception of their care. Furthermore, it has been shown that there is a connection between patients experience and their health outcome (33).

An important factor in patient satisfaction is their pre-operative perceptions of pain and other post-op complications, and it is often thought that inaccurate perceptions of postoperative pain are a risk factor for the development of chronic pain (34). The development of chronic pain is a major consideration after thoracic surgery, and it is thought that prevalence of chronic pain after thoracotomy is up to 50–60% (22), a figure that patients often don't appreciate when considering surgery.

The risk factors for the development of acute postoperative pain in a general surgical population include female gender, patients who are younger, who have a history of anxiety and/or depression, and patients who are not informed about the strategies for managing post-op pain, though these risks have not been demonstrated in a population of thoracic surgery patients, and indeed there is no any available data looking at risk factors in this cohort (12).

Conclusions

Critical to the core principals of ERAS for thoracic surgery is the idea of perioperative pain management, though evidence has shown that post-operative pain continues to be undertreated, and the guidelines for treating said pain are unclear, broad, and difficult to apply to everyday practice (35), leading to wide variation in practice between clinicians.

The use of LA techniques in thoracic anaesthesia is well established for both open thoracotomy and VATS procedures, and while no strong evidence exists over the ideal technique to use, it can be said that both TEA and PVB are "gold-standard" techniques and while PVB are associated with fewer minor side effects, there is no association with either technique and serious

complications (36). They can provide excellent analgesia in the postoperative period and are essential to the idea of ERAS, with their ability to provide analgesia for patients to mobilise as early as possible and reduce consumption of opioids.

It is likely that LA infusions and in particular PVBs are still underutilized in the perioperative care of thoracic patients and efforts to make them more effective are welcome. This optimisation will also help to reduce opioid consumption and help to facilitate ERAS. It is the duty of multi-disciplinary care team to eliminate systemic barriers to improve practice and allow effective ERAS programs for thoracic surgery (37).

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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