Pain Management in the Surgical Correction of Chest Wall Deformities

11

Elizabeth M.C. Ashley

Abstract

The thoracoscopic placement of Nuss pectus bars for the correction of pectus excavatum is a painful procedure., which poses a challenge for the thoracic anaesthetist. Adequate pain management can expedite post-operative recovery and reduce complications. It may also prevent the development of chronic post-operative pain. Previously thoracic epidural analgesia has been favoured by centres in North America and Europe, but there is tendency to move away from this in favour of a multimodal approach to analagesia, including regional blockade, opiate infusions and patient-controlled analagesia, with non-steroidal anti-inflammatory drugs, paracetamol and other novel analgesics given in addition for their synergistic and opiate sparing effects

Keywords

Multi-modal analgesia • Opiates • Patient-Controlled Analagesia • Non-steriodal anti-inflammatory drugs • Novel agents • Regional Blockade • Thoracic Epidurals • Post-operative Care

Surgical Procedures

Surgery for the correction of chest wall deformities, the commonest of which is pectus excavatum, is becoming more frequently performed, as minimally invasive surgical techniques are developed. This poses a challenge for the thoracic anaesthetist to provide appropriate perioperative pain relief for thoracic surgery for benign disease and what in many cases is an ostensibly cosmetic procedure.

Pectus correction was originally carried out by the Ravitch procedure. This was major thoracic surgery, involving removal of costal-cartilages and elevation of the sternum using small steel bars. This has now been super-ceded by the Nuss procedure. The Nuss procedure involves the thoracoscopic placement of a concave pectus bar, from the right side of the chest which is placed

E.M.C. Ashley, BSc, MBChB, FRCA, FFICM
Department of Anesthesia and Cardiothoracic Intensive Care, The Heart Hospital UCLH, London, UK
e-mail: elizabethashley@doctors.org.uk

S.K. Kolvekar, H.K. Pilegaard (eds.), *Chest Wall Deformities and Corrective Procedures*,
DOI 10.1007/978-3-319-23968-2_11

beneath the intercostal muscles and then flipped into a convex position to elevate the sternum, within the chest. The procedure involves two small (approximately 2 cm) lateral incisions in the chest wall for each pectus bar. One or two bars are used during each corrective procedure [1]. Severity of pain is related to the severity of the pectus (greater Haller Index) and the amount of elevation that is required. Two bars are paradoxically often less painful than one.

The bars are removed after approximately 2 years. This involves a second anaesthetic and further perioperative pain management.

Other procedures for chest wall surgery include local plastic reconstructive surgery, plastic flaps and silicone implants.

The patient population is predominantly young males with body image issues or perceived shortness of breath on exertion due to restrictive lung function. They are generally a highly-motivated group, who actively seek out the surgery and surgeons and are therefore motivated and prepared for a degree of post-operative pain.

However, the surgery is extremely painful and inadequate pain management can exacerbate post-operative complications, cause bar displacement, limit early mobilisation, limit enhanced-recovery and prolong hospital stay.

There is also an incidence of chronic post-operative pain and the patient should be aware of this before undergoing the procedure.

Intra-operative Pain Management

The pain management options include thoracic epidural anaesthesia or an opiate based technique. Regional blocks also play a role.

A survey and review of pain management following Nuss procedure was carried out over 108 Paediatric Hospitals in North America, Europe, Asia and Australasia, and was published in 2014. Fifty-five institutions carrying out the NUSS procedure responded and were performing the operations on patients aged between 14 and 17 years of age. Ninety-one percent of institutions used thoracic epidural anaesthesia and otherwise intravenous patient-controlled analgesia was used. Sixteen percent of the paediatric hospitals said they were stopping epidurals, preferring opiate PCAs [2]. A meta-analysis comparing epidural analgesia and Intravenous patient-controlled analgesia was also published in 2014. Only three randomised-controlled trials and three retrospective studies met inclusion criteria. Epidural analgesia produced slightly lower pain scores immediately post-operatively and in the first 12–48 h post-surgery, compared with PCA, but this did not translate into significantly different secondary outcomes such as reduced length of hospital stay and reduced hospital costs [3].

Opiates

A standard anaesthetic technique involves a small dose of a short-acting opiate on induction of anaesthesia, such as fentanyl, followed by a longer-acting opiate such as morphine during the procedure. Immediate post-operative pain can be managed in the recovery room using protocolised incremental doses of intravenous fentanyl or morphine administered by recovery nurses, with assiduous respiratory monitoring, and sedation scoring, until the patient is comfortable.

Patient-Controlled Opiate Analgesia

Patient controlled opiate anaesthesia (PCA) with fentanyl or morphine is used in the post-operative period. Many studies report using PCA in addition to epidural analgesia. This requires careful monitoring of cardiovascular and neurological observations. Opiates should not be given via two different routes, i.e. by intravenous PCA and epidural infusion, to avoid opiate side effects. In younger children nurse controlled analgesia (NCA) can be used. This involves regular pain assessments by the nursing-staff, with a nurse-administered opiate bolus based on the patient's weight. A standard adult PCA protocol includes a bolus dose (e.g. 1 mg of morphine or 20 ug of fentanyl) and a 5 minute lockout period, with or without a low dose background infusion. This enables the patient

to titrate opiate consumption according to his or her individual requirements and expectations of post-operative pain. More severe pectus is associated with higher PCA morphine consumption. There was an increase in 6 % morphine usage with every 1 cm increase in pectus depth [4].

Non-steroidal Anti-inflammatory Drugs

Intra-operative opiate analgesia can be supplemented by drugs with different mechanisms of action, which act synergistically and have an opiate-sparing effect. Conventional non-steroidal anti-inflammatory drugs (Cox-1 inhibitors) that can be administered intravenously include diclofenac and ketorolac. They inhibit the cyclo-oxygenase system and prostaglandin synthesis and therefore usual contraindications apply such as asthma, renal dysfunction, peptic ulceration and bleeding. In 2005 The European Medicines Agency (EMA) review on cox-2 specific inhibitors such as rofecoxib and paracoxib identified an increased risk of thrombotic events such as myocardial infarction and stroke. This has led to an increased reluctance to use cox-2 inhibitors intra-operatively. However the pectus population are young and fit and so advantages outweigh the risks in these patients. Indeed cox-2 inhibitors may have advantages in patients at risk of increased bleeding and gastric ulceration (PROSPECT Website).

Paracetamol

Paracetamol is also a useful adjunct to an opiate-based technique. The mechanism of action of paracetamol has not been entirely elucidated but there is evidence that it also works on cox-2 receptors, predominantly in the central nervous system. Intravenous paracetamol is highly effective as it has 100 % bio-availability avoiding first pass metabolism in the liver in comparison with oral or rectal preparations. It can be given in conjunction with NSAIDs. One gram of intravenous paracetamol is said to have similar analgesic efficacy to 10 mg of Intra-muscular morphine [5].

Other Novel Agents

Other more novel analgesics can be used intra-operatively or in the recovery room in patients with refractory pain.

Ketamine

Ketamine is an N methyl D aspartate (NMDA) receptor antagonist which has profound anaesthetic and analgesic properties, in small doses administered either intra-venously or intra-muscularly. It is opiate-sparing, reducing opiate side-effects such as respiratory depression. It may also prevent spinal-sensitisation or 'wind-up' which is attributed to the development of chronic post-operative pain syndromes. Intra-muscular administration has some advantages in that the effects of the ketamine are more prolonged. It can also be given as an infusion in the post-operative period.

Clonidine

Clonidine is an alpha-2 adrenergic agonist and imidazoline receptor antagonist. It was originally used to treat hypertension, but has several off-licence uses which include sedation and the treatment of pain. It can be used in conjunction with opiates intra-operatively and in the recovery room and can also be given as an infusion. It works by an entirely different mechanism from opiates and therefore has a synergistic effect.

Gabapentin or Pre-gabalin

Gabapentin or Pre-gabalin were originally developed as anti-epileptic medications, but are now used in the treatment of neuropathic pain. They have similar structures to the neurotransmitter GABA and bind to voltage-dependent calcium channels, but their mechanism of action is unclear. There is limited evidence from other

areas of surgery that pre-operative gabapentin may confer advantages in the management of post-operative pain. They reduce opiate usages and decrease opiate side effects. They may also have a theoretical role in the prevention of the development of chronic post-operative pain [6]. There is currently no published evidence for their use in Nuss surgery.

Wound Infiltration with Local Anaesthetic

Local wound infiltration by the surgeon at the time of surgery is a useful, simple and safe adjunct in the management of post-operative pain. Longer-acting local anaesthetics such as bupivacaine or ropivacaine should be used and the inclusion of adrenaline can prolong the duration of action further.

Paravertebral Nerve Blocks and Intercostal Nerve Blocks

Paravertebral blocks have been suggested as an alternative to thoracic epidural analgesia and a small study comparing bilateral paravertebral blocks with thoracic epidurals was published in 2014. Paravertebral blocks are technically easier to perform and have less serious complications than central neuraxial blockade. They can be performed as a 'one-shot' technique, by the anaesthetist prior to surgery or indwelling paravertebral catheters placed for use with infusions of local anaesthetic in the post-operative period. The major risk with bilateral paravertebral blockade is bilateral pneumothoraces. Ultrasound-guidance for block placement may reduce this risk. A retrospective study comparing 10 thoracic epidurals with 10 bilateral para-vertebral blocks in 20 adolescent males undergoing the Nuss procedure, showed no difference in post-operative opiate consumption or pain scores between the two groups [7].

Two meta-analyses and systemic reviews comparing epidural analagesia with paravertebral blockade in thoracotomy patients, concluded that analgesic efficacy was similar. However the side effect profile, including urinary retention, nausea and vomiting and pulmonary complications were lower in the paravertebral group [8, 9].

Similarly bilateral intercostal blocks performed prior to surgery by the anaesthetist or during surgery by the surgeon may be an alternative to central neuraxial blockade [10]. A recent double-blind randomized controlled trial comparing single-shot intercostal blocks performed with levobupivicaine or saline in 60 patients, showed decreased morphine consumption at surgery and for the first 6 h post-operatively, with less nausea and vomiting and less urinary retention in the levobupiviaine group [11].

Thoracic Epidural Analgesia

Thoracic epidural analgesia has been considered to be the gold-standard in pain management in surgery for the correction of chest-wall deformities. Thoracic epidurals must be placed with the patients awake or only mildly sedated to minimise the risk of neurological complications. This is a challenge in the paediatric or adolescent population and requires a co-operative patient and a skilled operator. Epidural analgesia has major side-effects and sequelae including intra-operative and post-operative hypotension, urinary retention, delayed mobilisation, inadequate analgesia, missed segments and patchy block. Epidural haematoma or abscess and spinal cord ischemia are major life-changing sequalae that require prompt detection and immediate neurosurgical imaging and intervention. This is not always rapidly available in cardiothoracic centres. Epidurals require assiduous nursing care and observations and have to be nursed on high-dependency units in many hospitals. This has cost and man-power implications.

There is also controversy about thromboprophylaxis with an epidural catheter in situ. Timing of low-molecular heparin administration must be co-ordinated with epidural placement and catheter removal. Heparin should not be given until 6 h post catheter insertion. Catheter removal must take place at trough levels of low molecular weight heparin and the subsequent dose should not be given until 6 h

after catheter removal, to minimise the risk of epidural haematoma [12].

NAP3 (National Audi Project 3) carried out by the Royal College of Anaesthetists in the UK and published in January 2009 showed a major complication rate of 4.2 in 10,0000 central neuraxial blocks including spinals, epidurals and combine spinal-epidural techniques. This was a large study carried out over a 12 month period in the UK which included 70,0000 procedures. These broke down into 46 % spinals and 41 % epidurals. Forty-five percent of the epidurals were performed in obstetrics and 44 % for peri-operative analgesia. There were 30 permanent injuries of which 60 % were in patients with epidurals. Eighty percent of the permanent epidural injuries were in the peri-operative group. Although complications rates were low, they occurred predominantly with peri-operative epidurals and the prognosis for vertebral canal haematoma or spinal cord ischaemia is extremely poor [13]. This may have discouraged the use of epidural analgesia in major surgery in the UK. The lack of convincing evidence that epidural anaesthesia decreases morbidity and improves patient outcome has also lead to anaesthetists re-evaluating whether the risks of epidural catheter placement, justify the benefits of the procedure [14].

Further to this, the National Pneumonectomy Study was published in the Journal of Cardiothoracic Surgery in 2009. This looked at 312 pneumonectomies for lung cancer over a 12 month period performed in 28 thoracic surgical centres in the UK. Major complications included significant arrhythmias requiring treatment (19.9 %), unexpected ICU admissions (9.3 %), 30 day mortality (5.4 %), further surgery (4.8 %) and increased inotrope usage (3.5 %). Sixty-one percent of the patients had a thoracic epidural and 31 % a paravertebral block. Risk factors for major complications included epidural analgesia, pre-operative ASA status, age and pre-operative lung function (DLCO, Diffusion capacity of the lung for carbon monoxide). This may be explained by increased hypotension and increased pulmonary complications with epidurals as opposed to a unilateral paravertebral block [15].

However, despite the published studies and audits, epidural analgesia remains the mainstay of perioperative pain management for pectus surgery in European and North American centres. A large multi-centre survey published in the Scandinavian literature in 2014 reported 91 % of institutions used epidurals for primary pain management [2]. Other studies have shown epidurals to provide superior analgesia to PCA Opiates in the immediate post-operative period, with moderately lower pain scores up to 48 h post-operatively [3]. A randomised study of epidural versus patient controlled analgesia was published in 2012 and included 110 patients. Epidurals were failed to be placed or did not work in 22 % of patients and epidural insertion significantly prolonged operative time. It also demonstrated marginally improved pain scores in the epidural group, but also greater demands on hospital staff with more calls to anaesthesia. There was no difference in hospital stay between the two groups [16]. The assumption that epidural analgesia is the truly the best pain management strategy for Nuss surgery is therefore being questioned. Patients who do not have epidurals have a shorter operating room time, less urinary retention and catheterisation, a shorter transition to oral medication and shorter hospitalisation [17].

Thoracic Epidural Analgesia is certainly a good option in centres with experienced epiduralists, nursing staff and facilities that can successfully monitor and manage epidural infusions and complications on the wards, with the availability of 24 h neuro-imaging and neurosurgery to manage catastrophic complications. If this is not available there should be some reluctance to place epidural catheters in young fit patients, who do not have cancer and are undergoing surgery primarily for aesthetic and psychological reasons.

Lumbar Spinal Opiates

Lumbar spinal opiates are another potential method of pain relief for Nuss surgery. Spinal diamorphine or preservative-free morphine is used extensively in enhanced recovery protocols for other types of surgery including major gynaecology, colorectal and orthopaedic surgery.

A large meta-analysis of intrathecal morphine in cardiac, thoracic, abdominal and spinal surgery showed opioid requirements were decreased intra-operatively and up to 48 h post-operatively [18]. There is no data for the use of spinal morphine or diamorphine in pectus surgery.

Hypnosis

They have been reports that post-operative self-hypnosis can improve pain scores, decrease opiate usage and decrease hospital stay [19].

A multi-modal approach to post-operative analgesia using a combination of neuraxial blockade or peripheral nerve block and pharmacological agents is probably the most successful strategy. This reduces the total dose of a single agent (i.e. opiate sparing), therefore minimising side-effects. Different classes of analgesics work by different mechanisms on different receptors and therefore have a synergistic effect when used in combination.

Step-Down Analgesia

When the epidural or PCA is discontinued, multimodal regular analgesia should be prescribed. A combination of a non-steroidal anti-inflammatory drug, paracetamol and an oral opiate such as oromorph, is appropriate. The patient should be supplied with a similar combination of medication on discharge from hospital. The strong opiate can be replaced by a weak opiate such as codeine or tramadol.

Post-operative Care

Of equal importance to the post-operative analgesic technique is the ward environment, standards of observation, monitoring, and nursing care. Patients with epidural infusions need cardiovascular, neurological and respiratory observations to detect rising epidural block, respiratory compromise, hypotension and neurological complications. This requires nursing staff to be trained in the management of epidurals. This level of care can only be provided in a high dependency or intensive care environment in many institutions.

Patients with opiate patient controlled analgesia also need regular respiratory observations (respiratory rate and depth) and assessment of level of sedation. This should be achievable in a surgical ward environment. The analgesic technique therefore has implications for the acuity of post-operative care and high-dependency bed utilisation.

Chronic Pain Management

There is no published data on the incidence of chronic pain after the Nuss procedure. However we know that 67 % of patients develop chronic pain after thoracotomy, which persists in 25 % of cases [20]. Risk factors for the development of chronic pain included longer and more complicated surgical procedures and severe post-operative pain [21]. This provides further impetus to achieve excellent pain control in the peri-operative period. This patient group also needs access to anaesthetists trained in chronic pain management and a multi-disciplinary chronic pain service, in the event of the development of post-operative chronic pain syndromes.

References

1. Castellani C, Schalamon J, Saxena AK, Hoellwarth ME. Early complications of the Nuss procedure for pectus excavatum a prospective study. Pediatr Surg Int. 2008;24(6):659–66.
2. Muhly WT, Maxwell LG, Cravero JP. Pain management following the Nuss procedure: a survey of practice and review. Acta Anaesthesiol Scand. 2014;58(9):1134–9.
3. Stroud AM, Tulanont DD, Goates TE, Goodnev PP, Croitoru D. Epidural analgesia versus intravenous patient-controlled analgesia following minimally invasive pectus excavatum repair: a systemic review and meta-analysis. J Pediatr Surg. 2014;9(5):798–806.
4. Grosen K, Pteiffer-Jensen M, Pilegaard HK. Postoperative consumption of opioid analgesics following correction of pectus excavatum is influenced by pectus severity: a single-centre study of 236 patients undergoing minimally invasive correction of pectus excavatum. Eur J Cardiothorac Surg. 2010;37(4):833–9.

5. Van Aken H, Thys L, Veekman L, Buerkle H. Assessing analgesia in a single and repeated administrations or propacetamol for postoperative pain: comparison with morphine after dental surgery. Anesth Analg. 2004;98:159–65.
6. Clarke H, Bonin RP, Orser BA, Englesaki M, Wijeysundera DN, Katz J. The prevention of chronic postsurgical pain using gabapentin and pre-gabalin: a combined systemic review and meta-analysis. Anesth Analg. 2012;115(2):428–42.
7. Hall Burton DM, Boretsky KR. A comparison of paravertebral nerve block catheters and thoracic epidural catheters for post-operative analgesia following the Nuss procedure for pectus excavatum repair. Paediatr Anaesth. 2014;24(5):516–20.
8. Davies RG, Myles PS, Graham JM. A comparison of the analgesic efficacy and side-effects of paravertebral vs epidural blockade for thoracotomy – a systematic review and meta-analysis of randomized trials. Br J Anaesth. 2006;96:418–42.
9. Joshi GP, Bonnet F, Shah R, Wilkinson RC, Camu F, Fischer B, Neugebauer EA, Rawal N, Schug SA, Simanski C, Kehlet H. A systematic review of randomized trials evaluating regional techniques for postthoracotomy analgesia. Anesth Analg. 2008;107:1026–40.
10. Lukošienė L, Kalibatienė L, Barauskas V. Intercostal nerve block in pediatric minimally invasive thoracic surgery. Acta Medica Lituanica. 2012;19(3):150.
11. Lukosiene L, Macas A, Trepenaltis D, Malcius D, Barauskas V. Single shot intercostal block for pain management in pediatric patients undergoing the Nuss procedure: a double blind randomised controlled study. J Pediatr Surg. 2014;49 (12):1735–7.
12. Horlocker TT. Regional anaesthesia in a patient receiving antithrombotic and anti-patelet therapy. Br J of Anaesth. 2011;107(S1):96–106.
13. NAP3 Report and findings of the third National Audit Project of the Royal College of Anaesthetists. Pages 1–36. Published by the Royal College of Anaesthetists; 2009.
14. Wildsmith JA. Continuous thoracic epidural block for surgery: gold standard or debased currency? Br J Anaesth. 2012;109(1):9–12.
15. Powell ES, Pearce AC, Cook D, Davies P, Bishay E, Bowler GM, Gao F, UKPOS Co-ordinators. UK pneumonectomy outcome study (UKPOS): a prospective observational study of pneumonectomy outcome. J Cardiothorac Surg. 2009;30:4–41.
16. St Peter SD, Weesner KA, Weissend EE, Sharp SW, Valusek PA, Sharp RJ, Snyder CL, Hotcomb 3rd GW, Ostlie DJ. Epidural vs patient-controlled analgesia for postoperative pain after pectus excavatum repair: a prospective randomized trial. J Pediatr Surg. 2012; 47(1):148–53.
17. St Peter SD, Weesner KA, Sharp RJ, Sharp SW, Ostlie DJ, Hotcomb 3rd GW. Is epidural analgesia truly the best pain management strategy after minimally invasive pectus excavatum repair? J Pediatr Surg. 2008;43(1):79–82.
18. Meylan N, Elia N, Lysakowski C, Tramer MR. Benefit and risk of intrathecal morphine without local anaesthetic in patients undergoing major surgery: meta-analysis of randomized trials. Br J Anaesth. 2009;102(2):156–67.
19. Lobe TE. Perioperative hypnosis reduces hospitalisation in patients undergoing the Nuss procedure excavatum. J Laparoendosc Adv Surg Tech A. 2006; 16(6):639–42.
20. Perttunen K, Tasmuth T, Kalso E. Chronic pain after thoracic surgery: a follow up study. Acta Anaesthesiol Scand. 1999;43(5):563–7.
21. Katz J, Jackson M, Kavanagh BP, Sandler AN. Acute pain after thoracic surgery predicts long-term post-thoracotomy pain. Clin J Pain. 1996;12(1):50–5.