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Abstract

Background

Pectus excavatum (PE) is the most common congenital chest wall deformity, occurring in 1:1000 children with a male to female ratio of 4:1. Several procedures have been described to manage this deformity, including cartilage resection with sternal osteotomy (the Ravitch procedure) and a minimally invasive repair technique (the Nuss procedure). Whilst initially described as a non-thoracoscopic technique, the current surgical approach of the Royal Childrens Hospital (RCH) involves thoracoscopic assistance. Postoperative pain is significant in patients undergoing the pectus repair and multiple analgesic regimens have been advocated with continuous thoracic epidural infusions and opioid infusions the most common. Some authors have advocated patient controlled analgesia (PCA), paravertebral nerve blocks (PVNB) and wound infusion catheters as alternatives.

Aims

The primary aim of this study was to assess our experience with postoperative pain and analgesia requirements associated with the minimally invasive repair of pectus excavatum in children.

Methods

This is a retrospective cohort study with a contemporaneous comparison group examining patients treated between January 2005 and December 2015 for minimally invasive repair of pectus excavatum by the Nuss procedure.

Results

Two hundred and seventeen patients [mean age 14.9 (SD 1.9) years] with pectus excavatum treated at the Royal Childrens Hospital between 2005 and 2015 were identified. All patients were managed with thoracic epidural analgesia and intravenous morphine infusions. The epidural was effective in the post anaesthesia care unit (PACU) in 97.3% (failure to place an epidural rate was 4 (1.9%) no block on awakening 0.9%). A further 4 (1.8%) were removed within 24 hours. The mean morphine equivalent dose (MED) in the first 24 hours was 0.8mg.kg.day^{-1} . PCA was continued for a mean of 3.8 days and the total mean MED dose was $2.2\text{ mg.kg.day}^{-1}$. Minor complications occurred in 67 (30.9%) with postoperative nausea and vomiting (PONV) in 36 patients (16.6%) and urinary retention requiring an indwelling catheter in 40 patients (18.4%).

Conclusion

An epidural based analgesic regime is associated with low pain scores and few acute complications. The continuation of morphine analgesia after the first postoperative day is common but associated with an increased incidence of urinary retention and PONV.

Key words: Funnel Chest, Thoracic Surgery, Thoracoscopy, Pediatrics, Anaesthesia.

Clinical implications:

What is already known about the topic?

Pain associated with pectus excavatum repair is severe and there is no consensus as to the optimum analgesic regime. An analgesic approach involving continuous regional analgesia and intravenous morphine is the most frequently reported technique.

What new information this study adds:

Postoperative complications following pectus excavatum repair especially PONV and urinary retention are correlated with post operative morphine use rather than epidural local anaesthetic bolus or epidural adjuvants. Limiting the duration of postoperative morphine infusions when epidural infusions without adjuvants are used may further reduce postoperative complications.

Background and Significance

Pectus excavatum (PE) is the most common congenital chest wall deformity affecting between 1 in 400 and 1 in 1000 people, predominantly teenagers and young adults (1-3). It often becomes more apparent during puberty (4). Several procedures have been described to manage this deformity but the minimally invasive repair of PE technique (Nuss repair) is currently the first-line approach for PE in many centres (5). It is regarded as a much less radical operation with better cosmetic results than open sternochondroplasty. Several modifications to the original Nuss procedure have been described including the use of thoracoscopy to guide bar placement (6). The current surgical approach at RCH involves thoracoscopy despite an earlier outcome paper which described a non-thoracoscopic technique with low complication rates (7). The change occurred as the risk of major cardiac injury was thought to be less with a thoracoscopic approach (8).

Repair of pectus excavatum has been associated with severe postoperative pain lasting up to 4 days postoperatively. Despite this, there is no universally accepted approach to postoperative analgesia. Continuous thoracic epidural analgesia (TEA) is common but the desired level of placement, optimal bolus volume, use of adjuvants and other aspects of multimodal analgesic are inconsistent (9-12). Recent publications have advocated patient controlled analgesia, paravertebral nerve blocks and wound infusion catheters as alternatives to TEA (13-18). This is partly due to decreasing use of paediatric neuraxial blocks and partly due to concerns about neurological complications associated with epidural analgesia (19, 20). Whilst the use of paravertebral nerve catheters (PVNB) catheters for controlling postoperative pain in thoracotomy patients may have equal efficacy to epidural nerve blocks (21), many other techniques are of limited value. Reports describing single shot techniques may have a role but cannot be relied upon to treat pain, which often extends to more than 4 days (22, 23). Our aim was to examine our own practice to determine which analgesic combinations are associated with good pain relief and minimal complications.

Methods

This was a retrospective study of all patients with pectus excavatum consecutively managed at the Royal Children's hospital over an 11 year period between January 2005 and December 2015 inclusive. Patients were identified by searching the hospital administrative dataset and surgical clinic records. The Royal Children's Hospital Ethics Committee granted approval for this study (HREC 35175A). Data was obtained from a hospital electronic medical record and paper histories where these had not been scanned.

All surgical cases were managed by one of two surgeons. Two surgical approaches have been used in the time frame, a non thoracoscopic (or classical approach) and a thoracoscopic guided approach. In the classical approach a transverse incision 2.0-2.5 cm long was made in each lateral chest wall, between the anterior axillary and medial axillary lines, in line with the deepest point of the depression. Selected stainless steel Nuss bars (Biomet Australia) were bent into a curved or convex shape to conform to the patient's thoracic shape. A skin tunnel was raised anteriorly and the intercostal space was entered with a 30 cm long curved Kelly clamp. The Kelly clamp was slowly advanced across the mediastinum immediately under the sternum until it emerged on the opposite side. A strand of umbilical tape was pulled through the tract, tied to the surgical steel bar and then used for traction as the bar was advanced. In the thoracoscopic approach the initial incision was similar and after dissecting the subcutaneous tissues and muscles, blunt dissection was carried out along the rib surface. Right-sided thoracoscopy was performed by insertion of a 5-mm port through the right lateral chest wall just above the estimated level of the diaphragm in the anterior axillary line. The intrathoracic placement of the port was confirmed by observing lung tissue with a 5-mm scope after which a pressure of 4 to 5 mm Hg was used for insufflation. Under careful thoracoscopic guidance a curved steel bar was inserted behind the ribs and sternum with its concavity facing anteriorly. In both approaches, the bar was then rotated through 180° using a 'flipper' device, so that its convexity faces anteriorly, pushing out the sternum and correcting the deformity. For long depressions two bars were used. Lateral stabilisers were attached to the bars and ribs using sutures.

All epidurals were placed in the lateral position after induction of general anaesthesia and intubation, and prior to surgery. The local anaesthetic used, initial bolus volume and epidural adjuvants added were at the discretion of the treating anaesthetist. Intraoperatively, patients received intravenous paracetamol, fentanyl, ketolorac and two anti emetics (dexamethasone, granisetron). The effectiveness of the epidural was assessed on awakening in the post anaesthesia care unit by patients' assessments, mapping of dermatome cover with ice and visual analog scores.

Postoperative pain control was managed with continuous thoracic epidural infusion (0.125% levobupivacaine at 0.1-0.2 ml.kg.hr⁻¹) and supplemented with morphine patient controlled analgesia (PCA). Oral analgesics included regular oxycodone, paracetamol and nonsteroidal anti-inflammatory drugs (NSAIDs), with tramadol added to decrease PCA use. A ketamine infusion (100-400 µg.kg.hr⁻¹) was used in addition to morphine infusions as a rescue in the event of inadequate epidural analgesia. Patients were discharged on paracetamol, NSAIDs and tramadol 1-2 mg.kg⁻¹ or oxycodone 0.1-0.2 mg.kg⁻¹.

Daily and total opioid administration was converted to morphine equivalent dose/kg (MED.kg^{-1}) for each patient using a validated opioid conversion tool (24). Morphine equivalents were then divided by the patient's duration of morphine use and weight in kilograms, yielding the morphine equivalence dose per kilogram (MED.kg^{-1}). Doses of opioid other than morphine were converted to morphine equivalents using standard equi-analgesic dose conversion ratios (i.e. morphine 10mg equals fentanyl 100 micrograms) and calculated as $\text{mg kg}^{-1} \text{ day}^{-1}$. Epidural opiates were converted to intravenous (IV) morphine equivalents using epidural dose conversion ratios (epidural morphine 1 mg equals 10mg IV, epidural fentanyl 1 micrograms equals 3 mcg IV and 1mg epidural hydromorphone equals 5 mg IV). Adverse events were classified as major if they required bar removal, further interventional procedures, unplanned intensive care admission or delayed discharge. All other adverse events were considered minor. Analgesic side effects assessed included respiratory depression, PONV, pruritus and urinary retention. The University of Michigan Sedation Score (UMSS= 0 awake and alert, 1 = minimally sedated, 2=moderately sedated, 3= deep sedation and 4= unrousable) was used to score the level of sedation, continuous oximetry and respiratory rate to assess respiratory depression and a numeric rating scale for pain. Pain scores were assessed 1 hourly whilst the patient was awake (using developmentally appropriate scale e.g. Wong-Baker Faces scale, Numeric scale, FLACC scale or PAT score). Median pain scores were recorded both at rest and during periods of activity including ambulation and coughing.

Statistics

Parametric data are presented as mean (SD), non-parametric as median (IQR), and categorical as proportions. A two sample t-test was used to compare the ages and weights of the two groups. The Pearson's chi squared test was used to establish if there was an association between the confounders (gender, surgeon), the outcomes (early and late complications) and predictors (classic vs thoracoscopic). Multivariate logistic regression was used for all independent variables found to be associated with complications on univariate logistic regression with a two-tailed significance set at a p -value less than 0.05. Results were expressed as odds ratio (OR) with 95% confidence intervals. Data from patients with missing values were not analysed.

Results

Of the 217 patients repaired during the eleven-year period, 122 patients underwent classical Nuss repair (two of whom underwent open sternochondroplasty and Nuss bar stabilization) and 95 underwent thoracoscopic assisted repair (Table 1). The 122 classical repairs were primarily performed between January of 2005 and December of 2008, and are used for comparison purposes. The degree of pectus excavatum deformity was classified as severe in 23% and asymmetrical in 25% of patients undergoing the Nuss procedure. The mean (SD) age at the time of repair was 14.6 (2.3) in the classical group and 15.4 (1.2) years in the thoracoscopic group.

A thoracic epidural anaesthesia was attempted in all cases. The epidural was effective in PACU in 97.2% [4 failure to place an epidural (1.9%), 2 no blocks on awakening (0.9%)], a further 10 (4.6%) were removed within 24 hours (Table 2). There was one dural puncture (0.5%). The thoracic level chosen was T7, 8 in 56.7% of cases, T6, 7 in 22.1% and T8, 9 in 14.7%. The mean (SD) volume of

local anaesthetic bolus solution used to initiate epidural anaesthesia was 0.27 (0.09) ml.kg⁻¹. Levobupivacaine was used in 188 cases (86.6%), racemic bupivacaine in 11% and ropivacaine in 0.9%. Epidural adjuvants were used in 27.6% of all cases with fentanyl (18.4%) and clonidine (7.8%) being the most common. Combinations of local anaesthetic, opiates and clonidine were used in 2.7% of cases.

Morphine PCA was used in all patients and changed to fentanyl PCA in 16 (7.4%) due to PONV or pruritus. The mean morphine equivalent dose (MED) in the first 24 hours was 0.8mg.kg.day⁻¹. PCA was continued for a mean (SD) of 3.2 (1.0) days and the total MED dose was 2.2 mg.kg.day⁻¹. There was no linear relationship between age and MED doses (Fig 1). There were however significant differences between age groups. The mean (SD) first day MED in children less than 12 years of age was 27% higher than children 13-15 years of age [1.08 (0.67) vs.0.85 (0.54) mg.kg⁻¹, p=0.04]. The total MED in children less than 12 was 7.7% higher but not significantly different [2.50 (1.96) vs.2.32 (2.2) mg.kg⁻¹, p=0.37] to the older age groups. The thoracic level at which the epidural was placed had no significant effect on day 1 or total MED (Fig 2). Ketamine was used as a rescue infusion in 23 patients (10.6%) either in response to inadequate epidural analgesia or to facilitate transition from epidural to oral analgesia.

Significant intraoperative events occurred in 2 patients (0.9%), both in relation to turning of the pectus bar. One patient developed bradycardia, hypotension and a drop in end tidal CO₂. The hypotension was unresponsive to 10 mcg.kg⁻¹ adrenaline so internal cardiac massage via an extended thoracotomy incision was performed. A brief period of ventricular fibrillation was cardio reverted and an adrenaline infusion was commenced. Extensive postoperative investigation failed to find a cause but echocardiography demonstrated a mildly dilated aortic root. In the other case a sudden drop in ETCO₂ and hypotension during bar rotation required repeated metaraminol boluses. An intra-operative transesophageal echocardiogram demonstrated good ventricular function and a small apical pericardial effusion without tamponade. A chest X-ray demonstrated bilateral large pleural effusions and the patient required postoperative inotropes overnight.

Perioperative complications occurred in 67 patients (30.8%), primarily PONV and urinary retention (Table 3). Urinary retention occurred frequently in the first 24 hours postoperatively with 40 (18.4%) requiring urinary catheter. Other transient anaesthetic complications occurring in PACU included Horner's syndrome (11%), high epidural blocks (12%) and bradycardia (7.8%). Overall, the most common non anaesthetic related postoperative complication in our series was pneumothorax which was noted in 12% of patients (Table 3). The vast majority of pneumothoraces were incidental findings, as only five patients (2.3%) required intercostal catheter drainage.

Median (IQR) day 1 pain scores recorded at rest were low [2 (2-3)] with the highest daily value corresponded mainly with periods of activity including ambulation, physiotherapy and coughing [3 (2-5)]. The highest pain scores [median (IQR) 3.2 (3-4) thoracoscopic vs 3.3 (1-4) non thoracoscopic] occurred on day 3 consistent with cessation of epidural infusion. Significantly higher day 3 pain score were reported in the non thoracoscopic group (Kruskal Wallis p=0.02) but not the thoracoscopic group (p= 0.21). Six patients were re-admitted for pain control and a further 9 (4.1%) presented to the

emergency department with pain issues. The median (IQR) length of hospital stay was 4 (2-5) days with two patients having a prolonged admission with loss of weight as well as pain. Three of the presentations were for an acute increase in pain following trauma (e.g. fall). All were able to be managed with increasing oral analgesia and early outpatient follow-up. Seven patients were referred to the chronic pain team for ongoing issues with pain post hospital discharge. Two of these patients had their bar removed early one due to infection, another due to suspected allergic reaction to the bar. One further patient with ongoing pain was later noted to have significant reaction to the bar on removal, raising the suspicion of an allergic reaction.

Univariate regression analysis was used to determine factors associated with anaesthetic complications (Table 4). Morphine use in the first 24 hours was correlated with age and epidural success but not with preoperative assessment of pectus severity, asymmetry, surgical technique or epidural adjuvants. Urinary retention was not associated with age, day 1 morphine dose, or epidural bolus dose. In contrast indwelling urinary catheter was correlated with age and morphine but not epidural level or bolus volume. Epidural adjuvants did not significantly reduce pain on day 1 ($p=0.68$), day 3 ($p=0.99$), urinary retention ($p=0.89$) or PONV ($p=0.06$) compared to plain solutions.

Discussion

This series describes an epidural infusion, intravenous morphine PCA based analgesic regimen with low rates of significant complications but an unexpected high incidence of analgesic related complications especially urinary retention and PONV. Postoperative urinary retention is multifactorial and age, anxiety, thoracic epidural analgesia and morphine all play a role. In this series, urinary retention requiring catheterisation correlated with morphine equivalent doses (MED) on day 1 postoperatively but not with epidural insertion level, epidural opiates or local anaesthetic dose. Morphine dose was not related to surgical approach, intraoperative or postoperative analgesia. Day 1 MED was highest in children under 12 years of age but the incidence of morphine related complications was not significantly increased compared to older children. PONV correlated best with day 1 and total MED. Studies in which PCA opiates are compared to epidural analgesia support the premise that higher morphine analgesic use is associated with higher rates of PONV and urinary retention (14, 17, 25). The daily and total MED reported in our series is lower than that reported in other series (ranges from $0.6\text{-}5\text{mg.kg.day}^{-1}$) and PONV and urinary retention rates are lower (15-17, 25). The implication is that analgesic protocols that aim to reduce MED would be effective in reducing morphine related complications in pectus excavatum repair. Ketamine infusions were used to provide analgesia in the setting of ineffective epidural analgesia or to aid the transition phase following cessation of epidural infusions. The morphine sparing effect of ketamine may have confounded the association between morphine doses and complications.

Post pectus repair pain is multifactorial and includes outward pressure from the Nuss bar, incisional pain, muscle spasms, and release of inflammatory mediators from the primary surgical insult (17). In addition, a CT biomechanical simulation study has demonstrated age related differences in postoperative pain (26). Postoperative pain tends to occur in the anterior part of the thorax for paediatric patients and in the posterior part of the thorax for adult patients. The distribution of

mechanical stress to the rib is concentrated primarily around the growth zones in the costochondral junctions and the connection between rib and vertebra and is dependent of the stage of ossification (27, 28). In our series children less than 12 years of age had a 27% higher morphine use on day 1 postoperatively which decreased with time. The relationship between age and postoperative pain is in contrast to previous series where patients 13-18 years of age had 75% higher MED requirements than children 7-12 years of age (17). The age factor confounds comparisons of papers from centres where both adults and children undergo pectus repair (17, 25, 29).

The epidural local anaesthetic and adjuvants used were at the discretion of the treating anaesthetist and as such a number of combinations were observed. The incidence of high blocks and bradycardia was higher in the thoracoscopic approach and is related to slightly higher initial epidural bolus volumes perhaps as a response to avoidance of epidural adjuvants. In our series there were no significant differences in morphine associated side effects such as PONV or urinary retention between patients with epidural opiates and those without. There was a trend over time in the series to avoiding epidural adjuvants as it was believed there was greater flexibility in postoperative analgesic options if epidural adjuvants were not used. This is in agreement with other series where epidural clonidine and fentanyl as adjuvants are additive to the incidence of pruritus and nausea without improving analgesia or reducing opioid requirements (17, 30).

There is no consistency in the approach to postoperative analgesia for pectus excavatum repair with a recent survey of 58 paediatric institutions (mainly from the USA) finding multiple analgesic combinations. Epidural analgesia was used in 91% of units but the desired level of placement was variable and the adjuvants used included fentanyl, hydromorphone and clonidine. PCA morphine or hydromorphone was used only if the epidural failed in 60% of respondents and concurrently with the epidural in 30% (9). In a multi-institutional review of 284 minimally invasive repairs (52% from a single institution) where epidural anaesthesia was not routine, analgesia was poor with patient reported pain scores of 7 while resting quietly and 8 while moving around (31). Epidural analgesia for pectus repair has been the subject of 9 retrospective cohort studies (11, 16, 17, 21, 25, 30, 32-34), three prospective randomised studies (10, 14, 35), 1 survey and 1 systematic review. The prospective randomised trials compared continuous epidural analgesia alone versus intravenous opioids (IVPCA) after the Nuss procedure and demonstrated epidural superiority with pain control better immediately, at 12 hours and at 24 hours (10, 14, 35). A subsequent meta-analysis of 6 studies confirmed epidural analgesia is associated with a small improvement in pain scores through to 48 hours after surgery, without significant differences in secondary outcomes (36). Two of the papers reviewed provided 73% of patients and confounded comparisons because of high epidural failure rates (22 and 35%). A recent retrospective cohort study compared TEA to continuous infusion of ropivacaine through bilateral anterior chest wall catheters. The wound catheter group received a hydromorphone PCA, gabapentin and a clonidine patch and was discharged home after 48 hours but continued to receive local anaesthetic infusion at home for up to 7 days(18). The meta-analysis highlighted the marked heterogeneity in outcome measures, potential for bias and recommended further research.

The use of TEA is heavily influenced by local experience, excessive failure rates (37) and rare complications. Three cases of spinal cord injury following TEA for PE have been reported (6, 20) of

which anaesthetic details are available only for one. The mechanism of injury is unclear and anterior spinal artery syndrome could not be excluded in any of these cases. Several institutions no longer recommend epidural analgesia as an option for pectus excavatum repair (38).

Limitations

This study had a number of limitations. Firstly, as with many retrospective studies, it is not possible to adequately generate matched comparator groups of patients with similar pectus excavatum severity. The classical Nuss approach as used by one of our surgeons was associated with significantly more lung and tissue trauma which confounds the comparison of analgesic techniques. Similarly the variability in local anaesthetic epidural adjuvant combinations confounds morphine requirements. Although 14 anaesthetists provided anaesthetic care in this series 75% of cases were managed by one of 3 consultant anaesthetists. The use of ketamine as a rescue analgesic in the face of failed or inadequate epidural analgesia also impacts on morphine requirements. Undoubtedly, patient's pain experiences are determined by baseline state anxiety and other factors which cannot be controlled (39). Although not seen in this series a history of chronic pain (chest wall or other) requiring use of analgesia prior to the procedure could impact on the patients perception of postoperative pain.

Conclusion

Thoracic epidural analgesia and morphine PCA is an effective postoperative analgesic regime but does not completely blunt the unpleasant sensation of chest wall pressure following the Nuss procedure. Higher morphine doses to treat this sensation were associated with a greater incidence of urinary retention and PONV.

Disclosures:

Ethics; HREC 35175A RCH Human Research Ethics Committee, The Royal Children's Hospital, 6th August 2015.

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Table 1. Demographics of patients undergoing repair of pectus excavatum as either non thoracoscopic (Classical Nuss procedure) or thoracoscopic assisted repair.

		Classic Nuss n=122	Thoracoscopic Nuss n=95	p value	Pectus Symmetry
Gender	Male (%)	100 (82%)	83 (87.4%)	0.28	y
Age	Yrs mean (sd)	14.6 (2.3)	15.4 (1.2)	0.01	describes
Weight	Kg mean (sd)	55.5 (11.9)	58.8 (8.9)	0.02	objective
Pectus severity	Moderate (%)	67 (55%)	20 (21%)	0.01	assessment
	Severe (%)	36 (29.5%)	14 (14.7%)	0.01	of
Pectus Symmetry	Asymmetrical (%)	34 (27.9%)	20 (21%)	0.25	symmetry
Co-Morbidities	Marfan's Syndrome	0	2		of
	Marfanoid	11 (9%)	0		anterior
	Scoliosis	10 (8.2%)	9 (9.5%)	0.74	chest
Surgery duration	Minutes	84.3 (79.5-89.2)	119.2 (115.2-123.3)	0.01	wall. LOS
Hospital LOS	Days	4.8 (2.1)	5.0 (1.2)	0.55	length of
					stay.

Table 2. Description of combined thoracic epidural and patient controlled analgesic (PCA) postoperative analgesic regime. Thoracic Epidural Analgesia is described as thoracic level (T5,6) of placement , bolus of local anaesthetic prior to infusion and any additive used in conjunction

			Classic Nuss	Thorascopic	p
			n=122	Nuss n=95	value
Epidural	Level	T5,6	3	5	ns
		T6,7	21	27	0.07
		T7,8	70	53	0.92
		T8,9	25	7	0.01
		T9,10	0	1	ns
		T10,11	1	1	ns
		Bolus (ml.kg ⁻¹)	0.24 (0.1)	0.3 (0.1)	0.01
	Local Anaesthetic	Bupivacaine 0.25%	21 (17.2%)	3 (3.2%)	0.01
		Levobupivacaine 0.25%	99 (81.1%)	91 (95.8%)	0.01
		Ropivacaine 0.25%	1	1	ns
	Adjuvants	Morphine	3	0	0.01
		Fentanyl	35	5	0.01
		Clonidine	16	0	0.01
		Fentanyl Clonidine	3	0	ns
		Morphine Clonidine	2	1	ns
PCA Morphine	First day(mg.kg ⁻¹)	0.76 (0.68-0.84)	0.85 (0.74-0.97)	0.31	
	Total(mg.kg ⁻¹)	2.24 (1.89-2.59)	2.08 (1.75-2.41)	0.09	
	Days	4.1 (3.9-4.2)	3.5 (3.3-3.7)	0.01	
Ketamine	Total (mg.kg ⁻¹)	131.8 (134.4)	125.2 (64.4)	0.88	

with local anaesthetic (adjuvants). All values are mean(sd) or totals (%).

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Table 3. Perioperative complications associated with repair of pectus excavatum. Surgery was either non thoracoscopic (Classical Nuss procedure) or thoracoscopic assisted repair. pectus excavatum repair. PDPH postdural puncture headache, PCA patient controlled analgesia, PONV postoperative nausea and vomiting.

		Classic Nuss n=122	Thoracoscopic Nuss n=95	p value
Epidural related	Failure	3 (2.4%)	2(2.1%)	0.77
	Epidural removal within 24hrs.	3 (2.5%)	8 (8.4%)	0.05
	Dural Puncture/PDPH	0	1 (1%)	0.89
	High Block	10 (8.2%)	15 (15.8%)	0.01
	Unilateral block	7 (5.7%)	8 (8.4%)	0.01
	Horners syndrome	12 (9.8%)	10 (10.5%)	0.72
	Bradycardia	3 (2.5%)	14 (14.7%)	0.002
PCA related	PONV	23 (18.9%)	13 (13.5%)	0.31
	Urinary retention	32 (26.2%)	34 (35.8%)	0.13
	Urinary catheter	18 (14.7%)	22 (23%)	0.11
	Itch	2(1.6%)	5 (5.3%)	0.26

Table 4. Univariate regression analysis of factors associated with anaesthetic complications. Post-operative nausea and vomiting (PONV). For factors with a binary outcome (Urinary retention urinary catheter, PONV, Horner’s syndrome) the Odds ratio represents the presence or absence of the factor. For continuous data the estimate is the odds ratio for a unit increase for the factor (e.g. per year). *Epidural insertion level above

Variable	Odds Ratio	Std.Error.	P value	95% CI
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T7, 8; # Excessive Morphine use was defined as $>1\text{mg.kg}^{-1}$ morphine equivalent dose (MED) on postoperative day1.

Urinary retention	Age	1.12	0.09	0.16	0.96-1.32
	Morphine day 1	1.33	0.36	0.30	0.90-3.09
	Epidural bolus	1.80	2.79	0.70	0.08-37.7
Urinary Catheter	Age	1.32	0.15	0.02	1.06-1.64
	Morphine day 1	1.67	0.52	0.05	1.01-3.09
	Epidural level*	0.72	0.31	0.43	0.31-1.65
	Epidural bolus	7.60	14.5	0.29	0.18-317.3
PONV	Age	0.90	0.07	0.19	0.78-1.05
	Morphine	1.11	0.29	0.69	0.66-1.86
Horners syndrome	Epidural level*	1.9	0.9	0.18	0.74-4.8
	Epidural bolus (>0.3ml.kg ⁻¹)	1.21	0.54	0.42	0.50-2.92
Morphine#	Age <15	1.2	0.38	0.56	0.5-2.22
	Severity	0.83	0.37	0.68	0.35-1.97

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