

Received: 2010.12.13
Accepted: 2011.05.20
Published: 2011.11.01

Authors' Contribution:

- A** Study Design
- B** Data Collection
- C** Statistical Analysis
- D** Data Interpretation
- E** Manuscript Preparation
- F** Literature Search
- G** Funds Collection

Epidural and opioid analgesia following the Nuss procedure

Malgorzata Walaszczyk^{1ABCDEF}, Piotr Knapik^{2ACDEFG}, Hanna Misiolek^{1ACDEFG},
Wojciech Korlacki^{3ABCF}

¹ University Department of Anesthesiology and Intensive Therapy, Medical University of Silesia, Zabrze, Poland

² Department of Cardiac Anaesthesia and Intensive Therapy, Medical University of Silesia, Silesian Centre for Heart Diseases, Zabrze, Poland

³ Department of Paediatric Surgery, Medical University of Silesia, Zabrze, Poland

Source of support: Departmental sources

Background:

Summary

Parents have the right to decide on behalf of their children and deny consent to regional anaesthesia. The investigators decided to investigate quality of postoperative analgesia in adolescents undergoing epidural and opioid analgesia following the Nuss procedure.

Material/Methods:

The study subjects were 61 adolescents aged 11–18 years who underwent pectus excavatum repair with the Nuss procedure. Patients were divided into epidural (n=41) and opioid (n=20) groups, depending on their parents' consent to epidural catheter insertion. Intraoperatively, 0.5% epidural ropivacaine with fentanyl or intermittent intravenous injections of fentanyl were used. Postoperative analgesia was achieved with either epidural infusion of 0.1% ropivacaine with fentanyl, or subcutaneous morphine via an intraoperatively inserted "butterfly" cannula. Additionally, both groups received metamizol and paracetamol. Primary outcome variables were postoperative pain scores (Numeric Rating Scale and Prince Henry Hospital Pain Score). Secondary outcome variables included hemodynamic parameters, additional analgesia and side effects.

Results:

Heart rate and blood pressure values in the postoperative period were significantly higher in the opioid group. Pain scores requiring intervention were noted almost exclusively in the opioid group.

Conclusions:

Denial of parental consent to epidural analgesia following the Nuss procedure results in significantly worse control of postoperative pain. Our data may be useful when discussing with parents the available anaesthetic techniques for exceptionally painful procedures.

key words:

pectus excavatum • Nuss procedure • epidural analgesia • ropivacaine • opioids

Full-text PDF:

<http://www.medscimonit.com/fulltxt.php?ICID=882032>

Word count:

3055

Tables:

2

Figures:

3

References:

29

Author's address:

Piotr Knapik, Silesian Centre for Heart Diseases, Szpitalna 2 Str., 41-800 Zabrze, Poland,
e-mail: pknapi@sum.edu.pl

PH

BACKGROUND

Pectus excavatum is the most common (>80%) congenital wall deformity [1,2]. For many years the classic operative treatment of pectus excavatum involved the method originally described by Ravitch [3]. In 1987, Nuss performed his first minimally invasive operation, and 10 years later his technique was first described in the *Journal of Pediatric Surgery* [1]. Since then, the popularity of this technique has grown dramatically [4]. Interestingly, long-term clinical and health-related quality of life outcomes following the Nuss and Ravitch procedures appear to be similar [5].

The Nuss procedure is minimally invasive, but this applies only to the surgical technique. A stainless steel bar is slipped under the sternum, under thoracoscopic guidance, through 2 small incisions made on the side of the chest. The bar is then reversed, and the sternum restored to the normal anatomical position [1]. Protopapas and Athanasiou, who recently assessed all the available data of 1,949 children who underwent the Nuss operation, revealed that although the operation has a zero mortality rate and very few complications, it is considered to be as painful as open thoracotomy [4,6,7]. The pain is located mainly in the anterior part of the thorax and the use of a double-bar (instead of just 1) tends to decrease the pain [7]. It is recommended that patients receive epidural analgesia to achieve effective pain relief [4]. Alternatively to epidural analgesia, administration of subcutaneous or intravenous morphine and nurse-controlled analgesia is still considered a method of choice in pediatric patients [8].

While conducting research focusing on a prospective comparison of epidural analgesia for the Nuss procedures with the use of various local anaesthetic agents, we noticed that despite the advantages of epidural analgesia following the Nuss procedure, some parents denied consent for regional blockade. The clinical implications of such decision for the children involved were not clear to us; we therefore decided to investigate the effect of denying consent for epidural analgesia for Nuss procedure and obtain evidence-based arguments to discuss these issues with the parents in future.

Parents have the right to decide on behalf of their children; however, the requirements for consent to regional anaesthetic procedures in children vary from country to country. This may present a significant future problem for clinicians due to the tendency to tighten consent procedures and legislation even further [9], as has been the case in our centre.

The aim of this study was to compare the postoperative course of adolescents who received epidural analgesia to those who received opioid analgesia following the Nuss procedure. Patients in the opioid group were recruited from adolescents whose parents denied consent to epidural analgesia.

MATERIAL AND METHODS

This study was not initially planned; it was rather created in the course of another research program focusing on a prospective comparison of epidural analgesia for the Nuss procedures with the use of various local anesthetic agents.

The study was performed in 61 adolescents, aged 11–18 (mean 15.5 ± 2.0 years) who underwent pectus excavatum repair with the Nuss procedure. The study protocol as a whole (including the protocol for children whose parents denied consent for epidural analgesia) was approved by the local Ethics Committee and the parents of each child signed an informed consent to participate in the study and a separate consent to perform epidural anaesthesia. The principles of epidural analgesia and their expected benefits were explained to the parents and children in detail.

Two groups were identified, depending on their parents' consent to epidural catheter insertion. As the refusal of epidural anaesthesia is relatively rare (<10%) in our centre, to achieve a comparable number of subjects in each group, every fifth consecutive child whose parents gave consent to epidural analgesia was qualified to the epidural group. In total, 41 patients were recruited to the epidural group and 20 consecutive patients to the opioid group.

All patients were premedicated with oral midazolam (Dormicum, Roche, Switzerland) 1 hour before the arrival to the anesthesia room. The insertion of the epidural catheter was performed under local anesthesia, with additional sedation (0.02 – 0.05 mg kg⁻¹ midazolam), in a sitting position (patients were accompanied by a nurse). The epidural catheter was inserted with the hanging drop technique. Initially, we aimed to approach the Th6-Th7 interspace. The unsuccessful identification of the epidural space on the desired level resulted in approaching the epidural space on neighboring levels (Th5-Th6, Th7-Th8 or even Th4-Th5 interspace). The epidural catheter was advanced 3–4 cm into the epidural space and a test dose (consisting of 20% of the loading dose) of local anaesthetic was administered to confirm the correct position of the epidural catheter.

For intraoperative analgesia, a mixture of 0.5% ropivacaine with 1:200,000 adrenaline and 7.5 µg ml⁻¹ of fentanyl was used in the epidural group. The loading dose was calculated based on the modified Bromage formula [10], which had been tested in a pilot group and then locally modified. A sensory blockade of 7 spinal segments was required to provide sufficient analgesia. The loading dose was therefore calculated as follows: 0.8 ml/segment ± 0.05 ml/segment for each 5 cm of height above (or below) 150 cm. If the epidural space could not be reached directly towards the most prominent deformity, the dose was increased to achieve a blockade of 8 spinal segments.

The onset of sensory blockade was assessed by a loss of cold sensation. Paracetamol (Perfalgan, BMS, New Zealand) 30 mg kg⁻¹ was then administered intravenously in both groups. Anesthesia was induced with propofol (Diprivan, Astra Zeneca, UK), and maintained by either propofol infusion or sevoflurane (Sevorane, Abbott Laboratories, USA). Fentanyl (Fentanyl, Polfa, Poland) was used to provide analgesia, while muscle relaxation was achieved by vecuronium (Norcuron, Organon Technika, Hungary).

In the epidural group, intraoperative analgesia was achieved with ropivacaine. The infusion was started 1 hour after the administration of a loading dose at a rate of 0.8 ml/segment/hour, adding (or detracting) 0.05 ml/segment/hour for each 5 cm of height above 150 cm (or below, respectively).

Table 1. Demographic and baseline clinical data.

Parameter	Epidural (n=41)	Opioid (n=20)	
Age (years)	15.6±1.9	14.4±2.4	
Height (cm)	174±13	162±15	
Body weight (kg)	54.3±10.0	49.5±11.8	
BMI (kg/m ²)	18.4±1.8	18.4±2.3	
Male sex	32 (78%)	15 (75%)	
Heart rate (bpm.)	78.5±12.4	82.4±10.0	
Before induction	Systolic pressure (mmHg)	118±15	117±18
	Diastolic pressure (mmHg)	76.2±6.6	74.9±7.5
	Oxygen saturation (%)	96.6±1.2	97.2±1.8
Spirometry	VC (l)	3.2±0.4	3.3±0.3
	FEV1 (l)	3.0±0.5	3.1±0.4
ASA status	I	25 (55%)	13 (65%)
	II	16 (45%)	7 (35%)
Number of bars	Single	30 (80%)	15 (75%)
	Double	11 (20%)	5 (25%)

In the opioid group, intraoperative analgesia was achieved with intermittent intravenous doses of 1–1.5 µg kg⁻¹ fentanyl, injected every 20–30 minutes.

The Numeric Rating Scale (NRS, range 0–10) and Prince Henry Hospital Pain Score (PHHPS, range 0–5) were used to assess postoperative analgesia [11]. Postoperative analgesia in the epidural group was achieved with an epidural infusion of 0.1% ropivacaine mixed with fentanyl 6 µg ml⁻¹. The infusion was initially started at a rate of 0.8 ml/segment/hour, adding (or subtracting) 0.05 ml/segment/hour for each 5 cm of height above 150 cm (or below, respectively). If postoperative pain achieved 3 points in the NRS and/or 2 points in the PHHPS, rate of epidural infusion was increased and patients were given 10 mg kg⁻¹ of intravenous metamizol (Pyralgin, Polpharma, Poland). In cases of persistent lack of sufficient analgesia (defined as 0–2 points in the NRS and 0–1 points in the PHHPS), normal opioid protocol for the opioid group was initiated. Epidural analgesia was administered for 3 postoperative days.

In the opioid group, a subcutaneous “butterfly” cannula was inserted into the subclavian region during the course of general anaesthesia. A standard loading dose of 0.1 mg kg⁻¹ morphine (Morphinum hydrochloricum, Polfa, Poland) was administered towards the end of the procedure. Postoperatively, 0.1 mg kg⁻¹ of morphine was administered every 5 hours. This was combined with an intravenous dose of 10 mg kg⁻¹ of metamizol, given on admission to the recovery room, and every 8 hours thereafter. If the postoperative pain achieved 3 points on the NRS and/or 2 points in the PHHPS, the patients were given repeated intravenous doses of 0.5 mg of morphine every 2 minutes until the pain reached acceptable

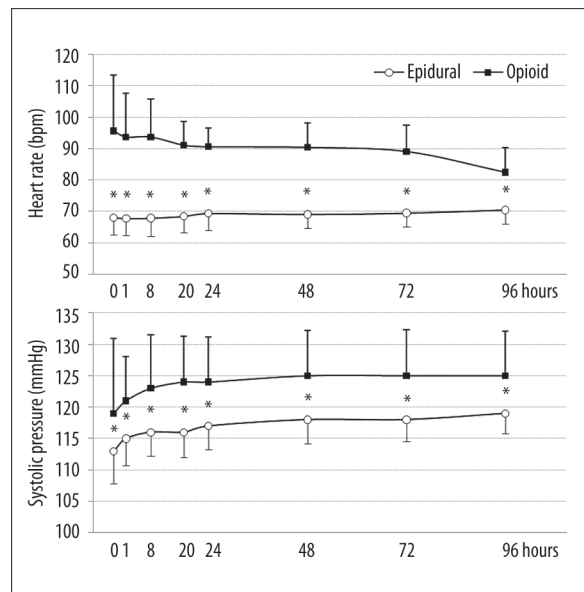


Figure 1. Heart rate and systolic blood pressure in the postoperative period.

levels. This procedure enabled us to estimate the required supplemental doses of morphine (50% of this dose was added to every standard dose of morphine). Intravenous injections of midazolam (0.5 mg kg⁻¹) and ketamine infusion (0.5 mg kg⁻¹ h⁻¹) were reserved for unbearable pain.

Heart rate and systolic blood pressure were registered for 96 hours, while depth of sedation and pain scores (Numeric Rating Scale and Prince Henry Hospital Pain Score) were registered directly after awakening and 1, 8, 20 and 24 hours after awakening from general anaesthesia. Adverse effects and the use of additional medications were also registered. Numeric Rating Scale scores of more than 2 and Prince Henry Hospital Pain Score more than 1 were considered as pain requiring intervention. Sedation was assessed with the Ramsay score.

Pain scores were the primary outcome variables. The size of the sample was calculated based on locally collected data to detect a 20% difference in the percentage of patients with pain scores requiring intervention, giving the trial a power of 0.8 for p=0.05. Secondary outcome variables included: hemodynamic parameters, sedation scores, need for additional analgesia and adverse effects in the postoperative period.

The results were expressed as mean ±SD, percentages and the number of occurrences. Patients’ initial data were compared using Mann-Whitney U test and chi-square test, depending on the type of data (numerical or binary). Postoperative hemodynamic data were compared with 2-tailed ANOVA. Ranked postoperative quantitative data were compared with Kruskal-Wallis test. Nominal data were compared with chi-square test (with Yates correction if necessary). P value below 0.05 was considered statistically significant.

RESULTS

The demographic data of patients in both groups were similar, as were their spirometry, initial hemodynamics and

PH

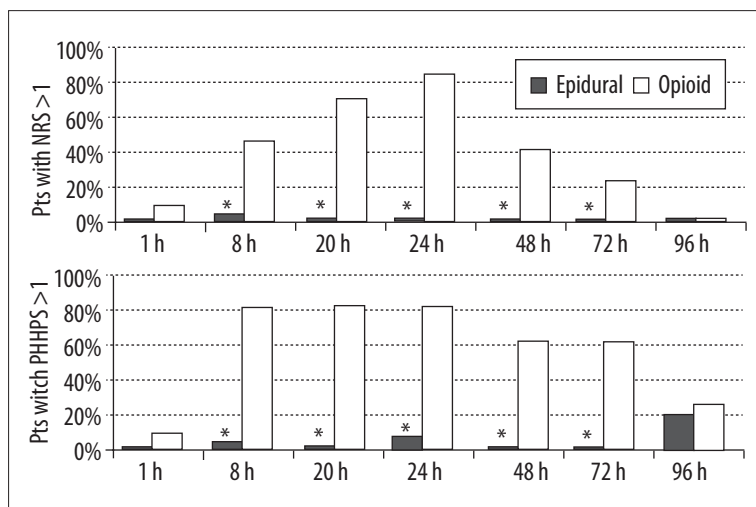


Figure 2. Percentage of patients with Numeric Rating >2 (top) and Prince Henry Hospital Pain Score >1 (bottom) in the postoperative period.

oxygenation (Table 1). The epidural catheter was inserted into the Th6-Th7 level in 32 patients. Insertion of epidural catheter while awake was well tolerated in all patients. Other locations included: Th5-Th6 (7 cases), Th4-Th5 (1 case) and Th7-Th8 (1 case).

The duration of the procedure was similar in both groups (58.7 ± 6.8 vs. 56.2 ± 8.2 min. in the epidural and opioid groups, respectively). The extubation time was shorter in the epidural group (8.8 ± 5.2 vs. 30.4 ± 15.6 min., $p < 0.01$).

Postoperatively, significantly higher values of heart rate and systolic blood pressure were noted in the opioid group (Figure 1). Pain scores requiring intervention according to the Numeric Rating Scale and Prince Henry Hospital Pain Score were decidedly more frequent in the opioid group (Figure 2).

In the epidural group, no patients required opioids. An adjustment of the epidural infusion rate was necessary in 1 child. In another child (with the catheter inserted at Th4-Th5), a further increase in the rate resulted in Horner syndrome; accordingly, the infusion was not increased further but non-opioid analgesic agents (metamizol) were administered intravenously, restoring sufficient analgesia.

In the opioid group, metamizol and morphine were used routinely, as part of the study protocol. The mean daily dose of metamizol and morphine, calculated for the entire postoperative period, was 12 mg/kg and 0.16 mg/kg, respectively. In 6 patients (30%), the standard dose of morphine was exceeded and in 2 patients (10%) there was a temporary need to administer midazolam and ketamine infusions on the second postoperative day. Sedation scores exceeding 2 in the Ramsay scale were more frequent in the opioid group (Figure 3).

The frequency of adverse effects did not differ significantly between the 2 groups (Table 2).

DISCUSSION

Thoracic surgery is exceptionally painful [4,6,7,12]. The Nuss procedure is not a classic thoracotomy; however the severity of postoperative pain is comparable to open thoracotomy.

Painful stimuli are particularly intense, sometimes unbearable for patients and therefore very difficult to control [4,6].

Comprehensive information given to parents before their children's operation can enhance their knowledge and reduce anxiety [13]. There is a tendency among anesthesiologists to disclose only those risks that are benign in nature and occur frequently; however, no data are available from pediatric anesthesiologists [14]. In the adult population, a minority of anesthesiologists described risks of paralysis (43%), seizures (20%), cardiac arrest (14%) and death (29%) in patients undergoing epidural analgesia; however, the available data in the literature are inconsistent [15].

What are the facts then? A prospective audit of children receiving epidural infusion analgesia (EIA) in Great Britain and Ireland and the data collected over a 5-year period revealed that incidents occurred in 96 out of 10,633 epidurals performed. Serious incidents were very rare – in fact, only 1 child had persistent problems 1 year after catheter insertion [16].

Information given to parents can have a profound impact on their consent to regional anesthesia for their children. Most parents seek to safeguard the welfare and best interests of their children; however, physicians must focus on the goal of providing appropriate care. Therefore, the doctrine of "informed consent" is of limited direct application in pediatrics [17]. Parents' anxiety about their children's anaesthesia may adversely affect the children's outcomes and compromise the quality of informed consent [18].

It is possible that the authors were not able to obtain consent from the parents due to the detailed information that was given to the parents during the preoperative visit. The anesthesiologist is legally obliged to inform patients (or parents in case of children) about all potential complications of the epidural blockade. The authors did not obtain consent to regional anesthesia from some parents mainly due to the fear of neurological complications (epidural abscess or hematoma).

Lönnqvist et al. [9] point out that there are situations where we should refrain from choosing methods of treatment

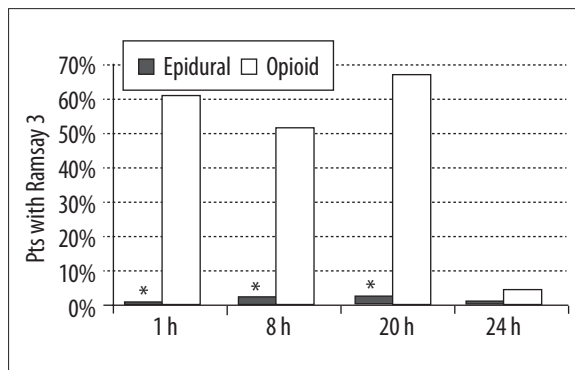


Figure 3. Percentage of sedation scores over 2, according to the Ramsay scale on the first postoperative day.

under pressure from the parents. As an example the authors present a case of pectus excavatum repair or fundoplication, where a regional anesthetic technique is clearly the best alternative and yet the parents do not give their permission for this procedure [9].

Does it really make such an important difference to our patients? The available evidence seems to indicate it does. A large retrospective study was performed on 155 consecutive patients who underwent elective open fundoplication, where only 72 patients received thoracic epidural analgesia (TEA). The postoperative complication rate was significantly lower in the epidural group (5.5% *vs.* 20%, $p < 0.001$) [19]. Postoperative epidural analgesia also improved the postoperative course following pediatric renal transplantation [20]. Among adolescents scheduled for scoliosis repair, a recent meta-analysis of all available studies (1966–2008) revealed that the administration of epidural local anesthetics plus intravenous opioids *vs.* intravenous opioids only was clearly associated with beneficial effects [21]. Adding local anesthetics to a standard anesthesia regimen generally tends to improve control of pain for various procedures [22,23]. Our study also supports these findings. This draws our attention to situations in which parental anxiety about anesthesia may adversely affect the outcomes, causing unnecessary pain and suffering.

For pectus excavatum repair, most authors used continuous thoracic epidural infusion of 0.125% bupivacaine with an opioid, supplemented with intravenous opioids and NSAIDs [4]. We used 0.5% ropivacaine intraoperatively, a concentration which is higher than usual dosing in children undergoing general anesthesia. This was based on a fact that Nuss procedure is exceptionally painful intraoperatively. In the postoperative period, however, we used extremely low concentrations of ropivacaine, which proved to provide satisfactory postoperative analgesia. To our knowledge such concentrations have not yet been described in the literature for Nuss procedures for postoperative use.

It is difficult to compare adverse effects with so few patients in 1 of the groups. One would expect nausea and vomiting to be significantly higher in the opioid group, but this cannot be measured significantly with these small numbers. Also, the loading dose of 0.1 mg kg⁻¹ morphine used in our study appears to be quite low; however, it should be taken into account that there were other analgesic agents administered

Table 2. Frequency of side effects in the postoperative period.

Side effect	Epidural (n=41)	Opioid (n=20)	P
Nausea	3 (7%)	3 (15%)	0.38
Vomiting	1 (2%)	2 (10%)	0.25
Urine retention	1 (2%)	1 (5%)	0.81
Bradycardia (60 bpm)	2 (5%)	0 (0%)	0.81

in these patients in parallel, according to the rules of multimodal analgesia. Metamizol, which was a part of this technique, is an analgesic agent commonly used in Poland; however, we are aware that it is not available in many countries.

The tendency to use very low concentrations of regional anesthetics is not new. It enables more selective blockade, with minimal adverse effects and comparable efficacy. The volume of regional anesthetic may also be increased safely and this could result in a lower percentage of unsuccessful blocks. In our study most patients had satisfactory analgesia during the administration of 0.1% ropivacaine. The original ropivacaine solution was diluted 8-fold, still providing sufficient analgesia.

Early studies proposed the use of ropivacaine only in children over 12 years of age; however, currently this could be extended also to younger children [24,25]. Lönnqvist et al. [26] suggested that pharmacokinetic properties of ropivacaine in children are not different from those observed in adults and the concentration of unbound fraction of ropivacaine in plasma is far below toxic levels.

The lack of consent for regional analgesia may not be the sole reason why epidural analgesia is not used. Sometimes the epidural catheter cannot be inserted or it can migrate and leave the epidural space, as was the case in 5.7% [27] and 7.0% of patients in 2 available studies [28].

In our study we used 2 pain scoring systems. The commonly used Numeric Rating Scale was supplemented with the PHHPS, which aims to assess dynamic pain experienced during chest wall movements. This score is often used following thoracic surgical procedures [11]. Similarly to other studies, the intensity of pain was generally maximal on the second postoperative day and subsequently decreased [6]; however, the scores achieved were significantly lower in the epidural group. Most of the catheters were removed on the third postoperative day, which resulted in comparable pain scores in both groups.

McBrige et al. [29] observed that 53% of children who received epidural infusion of bupivacaine following pectus excavatum repair did not require additional analgesia. The excellent analgesia in our epidural group was therefore predictable. The opioid group represents patients who could not be offered postoperative epidural analgesia due to lack of parental consent. Accordingly, our data may be a useful tool in informing parents of the anesthetic options available for exceptionally painful procedures.

Our study has certain limitations. It is always possible that data may be biased when the providers clearly feel 1 method of pain management is better than another and are not blinded to it. It was also difficult to obtain a single focus in this study, as this is not a classical scientific comparison between 2 groups, but rather a form of audit, indicating the postoperative course when epidural analgesia for Nuss procedure cannot be provided.

CONCLUSIONS

In conclusion, denying parental consent to epidural analgesia following the Nuss procedure results in significantly worse control of postoperative pain. Our data may be useful when discussing with parents the available anesthetic techniques for exceptionally painful procedures.

REFERENCES:

- Nuss D, Kelly RE Jr. A 10-year review of minimally invasive technique for the correction of pectus excavatum. *J Pediatr Surg*, 1998; 33: 545-52
- Molik KA, Engum SA: Pectus excavatum repair: Experience with standard and minimal invasive technique. *J Pediatr Surg*, 2001; 36: 324-28
- Haller JA Jr: History of the Operative Management of Pectus Deformities. *Chest Surg Clin N Am*, 2000; 10: 227-35
- Protopapas AD, Athanasiou T: Peri-operative data on the Nuss procedure in children with pectus excavatum: independent survey of the first 20 years' data. *J Cardiothorac Surg*, 2008; 3: 40
- Lam MW, Klassen AF, Montgomery CJ et al: Quality-of-life outcomes after surgical correction of pectus excavatum: a comparison of the Ravitch and Nuss procedures. *J Pediatr Surg*, 2008; 43: 819-25
- Pilegaard HK, Grosen K: Editorial comment Postoperative pain location following the Nuss procedure – what is the evidence and does it make a difference? *Eur J Cardiothorac Surg*, 2010; 38: 208-9
- Nagaso T, Miyamoto J, Kokaji K et al: Double-bar application decreases postoperative pain after the Nuss procedure. *J Thorac Cardiovasc Surg*, 2010; 140: 39-44, 44.e1-2
- Chadha M: Pharmacological pain relief in pediatric patients. *Middle East J Anesthesiol*, 2008; 19: 1255-90
- Lönnqvist PA, Morton NS, Ross AK: Consent issues and pediatric regional anesthesia. *Paediatr Anaesth*, 2009; 19: 958-60
- Bromage PR (eds.), *Epidural Analgesia*. Philadelphia: Saunders, 1978
- Torda TA, Hann P, Mills G et al: Comparison of extradural fentanyl, bupivacaine and two fentanyl-bupivacaine mixtures for pain relief after abdominal surgery. *Br J Anaesth*, 1995; 74: 35-40
- Salomäki TE, Leppäluoto J, Laitinen JO et al: Epidural versus intravenous fentanyl for reducing hormonal, metabolic and physiologic responses after thoracotomy. *Anesthesiology*, 1993; 79: 672-79
- Franck LS, Spencer C: Informing parents about anaesthesia for children's surgery: a critical literature review. *Patient Educ Couns*, 2005; 59: 117-25
- Brull R, McCartney CJ, Chan VW et al: Disclosure of risks associated with regional anesthesia: a survey of academic regional anesthesiologists. *Reg Anesth Pain Med*, 2007; 32: 7-11
- Domino KB: Informed consent for regional anesthesia: what is necessary? *Reg Anesth Pain Med*, 2007; 32: 1-2
- Llewellyn N, Moriarty A: The national pediatric epidural audit. *Paediatr Anaesth*, 2007; 17: 520-33
- Committee on Bioethics. Informed consent, parental permission, and assent in pediatric practice. *American Academy of Pediatrics. Pediatrics*, 1995; 95: 314-17
- Miller KM, Wysocki T, Cassady JF Jr et al: Validation of measures of parents' preoperative anxiety and anesthesia knowledge. *Anesth Analg*, 1999; 88: 251-57
- McNeely JK, Farber NE, Rusy LM et al: Epidural analgesia improves outcome following pediatric fundoplication. A retrospective analysis. *Reg Anesth*, 1997; 22: 16-23
- Coupe N, O'Brien M, Gibson P et al: Anesthesia for pediatric renal transplantation with and without epidural analgesia—a review of 7 years experience. *Paediatr Anaesth*, 2005; 15: 220-28
- Taenzer AH, Clark C: Efficacy of postoperative epidural analgesia in adolescent scoliosis surgery: a meta-analysis. *Paediatr Anaesth*, 2010; 20: 135-43
- Dabbagh A, Elyasi H: The role of paravertebral block in decreasing postoperative pain in elective breast surgeries. *Med Sci Monit*, 2007; 13(10): CR464-67
- Inanoglu K, Ozbakis Akkurt BC et al: Intravenous ketamine and local bupivacaine infiltration are effective as part of a multimodal regime for reducing post-tonsillectomy pain. *Med Sci Monit*, 2009; 15(10): CR539-43
- Ivani G: Ropivacaine: is it time for children? *Paediatr Anaesth*, 2002; 12: 383-87
- Hansen TG, Ilett KF, Lim SI et al: Pharmacokinetics and clinical efficacy of long-term epidural ropivacaine infusion in children. *Br J Anaesth*, 2000; 85: 347-53
- Lönnqvist PA, Olsson GL: Paravertebral vs epidural block in children. Effects on postoperative morphine requirement after renal surgery. *Acta Anaesthesiol Scand*, 1994; 38: 346-49
- Dolin SJ, Cashman JN, Bland JM: Effectiveness of acute postoperative pain management. *Br J Anaesth*, 2002; 89: 409-23
- Tsui SL, Tong WN, Irwin M: Epidural catheter direction and local anesthetic dose. *Reg Anesth*, 1993; 18: 308-11
- McBride WJ, Dicker R, Abajian JC et al: Continuous thoracic epidural infusions for postoperative analgesia after pectus deformity repair. *J Pediatr Surg*, 1996; 31: 105-7