



Initial surgical and pain management outcomes after Nuss procedure

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Abstract

Purpose: The purpose of this article was to report surgical and pain management outcomes of the initial Nuss procedure experience at the Children's Hospital of Wisconsin (Milwaukee) and to place this experience in the context of the published literature.

Methods: The initial 118 consecutive Nuss procedures in 117 patients were retrospectively reviewed with approval of the Children's Hospital of Wisconsin human rights review board. Patient, surgical, complication, and pain descriptors were collected for each case. Statistical methods for comparison of pain strategies included the Kolmogorov-Smirnov test for normality, 1-way repeated measures analysis of variance, and paired *t* tests.

Results: Patient, surgical, and complication descriptors were comparable to other large series. Complication rates were 7% early and 25% late. Epidural success rate was 96.4%. There was 1 episode of recurrence 2 years postbar removal (n = 114).

Conclusions: The institution of the Nuss procedure provides a highly desired result with significant complication rates. The ideal approach would deliver this result with lower risk. A pain service-driven epidural administration of morphine or hydromorphone with local anesthetic provides excellent analgesia for patients after Nuss procedure. The success of epidural analgesia is independent of catheter site and adjunctive medications. Ketorolac was an effective breakthrough medication.

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Pectus excavatum is the most frequent congenital deformity of the anterior chest wall, affecting 0.8% to 0.14% of the population [1,2]. Because of asymmetric

cartilaginous growth, this condition results in a concavity of the precordium with a resultant restrictive pulmonary defect and decreased aerobic capacity when compared to age-matched controls [2-5]. The role of surgery in reversal of these defects remains controversial; however, many patients perceive improvement [4,6-12]. Surgical correction has been correlated with positive outcomes and improvement of body image [13,14]. With the demand for minimally invasive

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surgical approaches increasing, the surgical repair of pectus excavatum has largely shifted away from the Ravitch repair. Recent innovations have included the use of substernal magnets, vacuum lifters, and the Nuss procedure [15-18]. The Nuss procedure is the most common minimally invasive repair of pectus excavatum and corrects the point of maximal concavity using a thoroscopically directed transthoracic convex substernal bar. Although patients undergoing the Nuss procedure enjoy a smaller scar, significant postoperative pain results from an instantaneous substernal correction.

Successful management of post-Nuss procedure pain is a priority as pain decreases patient satisfaction and increases complication rates [19]. Pain management strategies have included systemic opioids via patient-controlled analgesia (PCA), nonsteroidal antiinflammatory medications, hypnosis, and regional anesthesia (opioid, local anesthetic, and α -blockade) [19-27]. Although large series demonstrate that modern pain control strategies are adequate, the optimal technique has yet to be clearly determined [3,27,28]. Two small prospective randomized trials have been completed in children examining the efficacy of morphine or fentanyl PCA vs fentanyl/local anesthetic epidural analgesia. One study demonstrated no significance difference in visual analog pain scores or complication rates between fentanyl PCA and fentanyl/bupivacaine epidural treatment in 28 children [21]. A second study randomized 40 children between morphine PCA and fentanyl/ropivacaine epidural treatment. The results of this study demonstrate lower visual analog pain scores in the epidural group [29]. Given the lipophilic nature of fentanyl and its rapid dissemination into a large volume of distribution, the results of fentanyl epidural catheter treatments do not use the specificity of the epidural space afforded by other opioids. Adult thoracotomy pain studies have shown equivalent pain control with fentanyl treatment independent of site of administration [30].

The purpose of this review was to summarize the initial surgical outcomes and detail the pain management strategy used at the Children's Hospital of Wisconsin (Milwaukee). This experience is useful for other institutions building experience with the Nuss procedure given the significant learning curve described by other groups [27,31-36].

1. Materials and methods

After approval from the Children's Hospital of Wisconsin Human Rights Review Board, a retrospective chart review was conducted for patients undergoing the Nuss procedure for pectus excavatum repair at between 1999 and 2004. All consecutive cases of Nuss procedure were included in this interval. Patient data were collected 2 years after removal of the Nuss bar. Using anonymous case numbers, the following data were collected: patient descriptors (age, weight, sex, race, pulmonary function, and Haller index), surgical descriptors (number of bars, use of stabilizers, operative

time, estimated blood loss, adjunct cartilage resection, length of stay, and cost), complications (early vs late; < vs > 30 postoperative days), and pain management descriptors (PCA or epidural, epidural level, PCA/epidural formulary, number of pain interventions required, medication changes, use of ketorolac, use of clonidine, and pain scores).

A specialized team of pediatric anesthesiologists and an advanced practice nurse forming an acute pain management service delivered comprehensive pain management. Patients were transitioned to oral analgesics before hospital discharge. Nursing staff assessed pain scores using the 0 to 10 verbal numeric rating scale (VNRS; 0 = no pain; 10 = worst imaginable pain). Per guidelines, vital signs, pain, and sedation scores were recorded every 2 to 4 hours. All pain descriptors were collected as timed data points.

Available Haller indices were calculated from computed tomographic scans by dividing the widest intrapleural coronal chest diameter by the sagittal distance between the point of maximal concavity and the anterior vertebral column at the same level.

Statistics were included to examine sample characteristics. Numerical variables were examined for normality using the Kolmogorov-Smirnov test. One-way repeated measures analysis of variance was used to examine pain scores over time. Numerical variable comparisons (eg, ketorolac and clonidine effects) were examined using a paired-samples *t* test. Significant results used a *P* value less than .05 for all analyses. Statistical analysis was completed using SPSS, version 11.5 (SPSS Inc, Chicago, Ill).

2. Results

2.1. Patient descriptors

Charts of 117 consecutive patients undergoing 118 Nuss procedures were reviewed. The mean age at Nuss bar placement was 12.9 years (SD, 4.8). Mean weight was 46.7 kg (SD, 17.4). Seventy-five percent of patients were male. The ethnicity of our cohort was 93% white, 3% Hispanic, and 4% "other." There were no African American, Asian, or American Indian patients. Preoperative pulmonary function tests were completed in 28 patients (24%). These tests demonstrated a forced expiratory volume in 1 second of 89% of predicted (SD, 13), an forced vital capacity of 92% of predicted (SD, 13) and forced expiratory volume in 1 second–forced vital capacity ratio of 0.9 (SD, 0.1). The average Haller index was 4.0 (SD, 1.5; *n* = 65). Three patients had previous chest surgery, 4 had connective tissue disorders, and 2 patients had ulcerative colitis treated with 6-mercaptopurine.

2.2. Surgical descriptors

This patient series was the experience of 9 surgeons, all trained in either pediatric or pediatric cardiothoracic

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