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Anesthetic management for the minimally invasive Nuss procedure in 21 patients with pectus excavatum

Koichi Futagawa[1], Ichiro Suwa[1], Takahiko Okuda[1], Hiromichi Kamamoto[2], Junko Sugiura[1], Ryuji Kajikawa[1], and Yoshihisa Koga[2]

[1] Department of Anesthesiology, Nara Hospital, Kinki University School of Medicine, 1248-1 Otoda, Ikoma 630-0293, Japan
[2] Department of Anesthesiology, Kinki University School of Medicine, Osakasayama, Japan

Abstract
The aim of this study was to assess the anesthetic management and postoperative analgesic effect of continuous epidural infusion for the minimally invasive Nuss procedure. A total of 21 operated cases were analyzed retrospectively. Thoracoscopy was used in all cases. General anesthesia with endotracheal intubation was induced and maintained with oxygen, air, sevoflurane, and fentanyl in all cases. Thoracic epidural anesthesia was performed after induction at the level between Th4 and 12. When the bar was placed via insertion under the sternum, six patients exhibited sinus tachycardia and one showed premature atrial contraction for 2–4 beats before recovering spontaneously within 1 min. Operations were uneventful. The mean operating time was 115 min and anesthetic time was 193 min. In X-ray findings, residual pneumothorax and pleural effusion were found in seven (33.3%) and eight (38.0%) patients, respectively. In all cases, these symptoms were resolved spontaneously within 5 days. Epidural fentanyl ($0.3\,\mu g \cdot kg^{-1} \cdot h^{-1}$) in 0.125% bupivacaine ($0.15\,ml \cdot kg^{-1} \cdot h^{-1}$) or 0.2% ropivacaine ($0.15\,ml \cdot kg^{-1} \cdot h^{-1}$) were used for 3 days to relieve postoperative pain. Postoperatively, 12 (57.1%) patients required no additional analgesics, and 4 (19.0%) patients required a single dose of dicrofenac sodium or pentazocine. Although the Nuss procedure is minimally invasive, we should pay attention to the possibility of many intra- and postoperative complications. Continuous epidural infusion of fentanyl with local anesthetics provides effective postoperative pain relief and prevents complications such as bar displacement after the Nuss procedure.

Key words Anesthetic management · Pectus excavatum · Nuss procedure

Introduction

The minimally invasive Nuss procedure for pectus excavatum involves the insertion of a convex stainless steel bar under the sternum through a small lateral thoracic incision. The Nuss procedure has quickly gained significant popularity among patients and surgeons owing to the attenuation of operative invasiveness and its excellent cosmetic results. The optimum patient age for repair of the deformity is between 4 and 12 years, when the chest wall is flexible. Although the Nuss procedure is associated with a shorter operating time, smaller incisions, and less dissection, several complications, including pneumothorax, pleural effusions, pericarditis, and bar displacement, have been reported [1–5]. In the postoperative period, the patient should maintain bed rest with sedation and pain control to prevent postoperative lung complications or bar displacement. The present study attempted to analyze anesthetic management and the usefulness of postoperative epidural analgesia in our experience with the Nuss procedure.

Materials and methods

A total of 21 operated cases at the Nara Hospital of Kinki University from June 2000 through July 2005 were analyzed retrospectively. The patient preoperative evaluation was based on history, physical examination, X-ray findings, and selective computed tomography (CT) scans in all cases. General anesthesia with endotracheal intubation was induced, and epidural anesthesia was performed after induction at the level between Th4 and 12. The Nuss procedure was performed as previously described [1]. The Nuss procedure involves making two small incisions in the lateral chest wall, which permits an appropriately shaped convex metal bar to be secured inside the anterior chest hemicircumference. This results in elevation of the sternum, with remodeling of the ribs and costal cartilages. In all patients, a single bar was inserted. We used two-lung ventilation and thoracoscopy in combination in all cases. The procedure was performed under thoracoscopic guidance

Address correspondence to: K. Futagawa
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with artificial pneumothorax (4 mmHg) with carbon dioxide (CO_2). Direct visualization of the mediastinal structures with routine thoracoscopy has made the procedure much safer. At the end of the procedure, after fascia closure of the thoracic incisions and before removal of the thoracic trocar, the CO_2 insufflation was stopped, and the accumulation of CO_2 was expelled with positive pressure ventilation. X-ray evaluations were followed up to monitor the progress of postoperative pneumothorax, pleural effusion, or bar displacement. A continuous epidural infusion was started at the end of the operation. An epidural infusion of fentanyl in 0.125% bupivacaine ($0.15\,ml \cdot kg^{-1} \cdot h^{-1}$) or 0.2% ropivacaine ($0.15\,ml \cdot kg^{-1} \cdot h^{-1}$) was used to relieve postoperative pain. The continuous infusion dose of fentanyl was $0.3\,\mu g \cdot kg^{-1} \cdot h^{-1}$. Supplemental analgesics (dicrofenac sodium or pentazocine) were administered if necessary. A scoring system based on the patient's request for pain relief during the first 24 h following surgery was developed as follows: no analgesics = 0; a single dose of analgesics = 1; and two or more dose of analgesics = 2. The collected data on clinical symptoms, operative management (blood loss, duration of operation, and anesthesia), anesthetic techniques, postoperative analgesic treatments, and intra- and postoperative complications were evaluated.

Results

Characteristics of the 21 patients are shown in Table 1. The male to female ratio in patients was 15:6. The median age was 6.3 years (range, 3.4–15 years), and the median body weight was 26.2 kg (range, 12.8–59 kg). The preoperative evaluation showed that cardiac compression was noted via echocardiography or CT scan in 19 (90.9%) patients. Cardiac compression with mitral valve prolapse (MVP) was noted in one patient. Although three patients were treated for asthma, asthmatic symptoms ceased after surgery. General anesthesia was maintained with oxygen, air, sevoflurane, and fentanyl ($5–10\,\mu g \cdot kg^{-1}$) in all cases. When the bar was placed via insertion under the sternum, six patients exhibited sinus tachycardia and one patient showed premature atrial contraction for 2–4 beats before recovering spontaneously within 1 min. Respiratory complications such as hypoxemia and hypercapnea were not encountered, and the intraoperative view was sufficient for surgeons to operate. Blood loss in most patients was within 30 ml. The mean operating time was 115 min, and the mean anesthetic time was 193 min. Postoperative X-ray findings showed residual pneumothorax and pleural effusion in 7 (33.3%) and 8 (38.0%) patients, respectively. In all cases, these signs were resolved spontaneously without drainage by chest intubation within 5 days. The median hospital stay was 6.5 days. The percentage of patients requiring postoperative pain relief is shown in Table 2. For postoperative analgesia, 12 (57.1%) patients required no additional analgesics and 4 (19.0%) patients required a single dose of dicrofenac sodium. Five (23.8%) patients required two or more doses of analgesics such as dicrofenac or pentazocine.

Table 1. Characteristics of patients ($n = 21$)

Sex (M:F)	15:6
Age (years)	6.3 ± 4.8 (3.4–15)
Weight (kg)	26.2 ± 6.6 (12.8–59)
Cardiac compression on CT	19 (90.9%)
Asthma	3 (14.3%)
Duration of operation (min)	115 ± 26 (95–200)
Duration of anesthesia (min)	193 ± 38 (145–265)
Length of stay (days)	6.5 ± 2.3 (5–10)

Results are presented as means ± SD and range, or number (%)
CT, computed tomography

Discussion

The principal advantage of the Nuss procedure is that the approach is minimally invasive. The Nuss procedure was developed as an alternative to the standard open repair, involving an anterior chest wall incision, lifting of the pectoral muscle flaps, and resection of rib cartilage [1].

In the preoperative evaluation, cardiac compression was noted with echocardiography or CT scan in 19 (90.9%) patients. A previous study also found that the incidence of cardiac compression was 89.5% of patients, with MVP noted in 20.8% [3]. The rate of MVP was higher than that in the general population. MVP in patients with pectus excavatum is probably caused by cardiac compression. Early postoperative evaluation detected resolution of cardiac compression in 45% of these patients [3]. It has been reported that 17% of these patients are treated for asthma, with eventual discontinuation of asthmatic symptoms after surgery [4]. In our study, although three patients (14.3%) had been treated for asthma, their symptoms stopped after surgery. We used two-lung ventilation, and the procedure

Table 2. Efficacy of pain relief

Pain score	No. of patients (%)
0	12 (57.1)
1	4 (19.0)
2	5 (23.8)

0, no analgesics; 1, single dose of analgesics; 2, two or more doses of analgesics

was performed with artificial pneumothorax in all cases without encountering any unwanted events such as hypoxemia or hypercapnea during the operation. Moreover, the view was sufficient for the surgeons to operate. Therefore, it is not necessary to use one-lung ventilation. Although high-risk intraoperative complications such as cardiac or pericardial injury have been reported before the adoption of thoracoscopy in this approach [2], we did not encounter such complications. The thoracoscope is inserted preferentially from the right side, because the heart in severe pectus deformities is often displaced to the left side of the thorax. Preoperative CT scans and thoracoscopy at the time of bar placement is important to avoid cardiac or pericardial injury. Arrhythmia occurred frequently during insertion of the bar. Epidural anesthesia reduces the incidence of arrhythmia by sympathetic nerve block.

Early postoperative complications that occur within 24 h have been well described in the literature [1–4]. Residual pneumothorax is rather common on postoperative X-ray (59.6%) because of disturbance of the pleural space, but in 95% of patients, it resolves spontaneously [4]. In our study, pneumothorax was noted in 33.3% of patients, and all patients recovered spontaneously. Pleural effusion has been reported to occur in patients with a similar trend, but only rarely is tube thoracostomy needed to promote drainage [2]. Although they did not occur in our study, pleural hemothorax, pericarditis, and infectious complications have been reported previously [2,3]. The most common late postoperative complication reported is displacement of the stainless steel support bar, requiring operative correction. We did not encounter this complication. We should pay attention to the possibility of many complications in the perioperative period. Although this technique is minimally invasive, postoperative pain is still severe. The patient should emerge from anesthesia slowly with adequate analgesia and sedation to prevent postanesthesia agitation. The patient should maintain bed rest with sedation and pain control to prevent displacement of the bar, because agitation may cause early bar displacement. Also, postoperative pain leads to splinting of the chest, which can cause pulmonary complications.

Severe postoperative pulmonary complications were reduced by epidural anesthesia. Adoption of supplemental epidural analgesia contributed favorably to efficacious attenuation of postoperative pain. Continuous epidural opioid administration, such as of morphine or fentanyl, followed by a transition to treatment with nonsteroidal anti-inflammatory drugs affords early mobilization and improved pulmonary toilet postoperatively. Bed rest and continuous epidural infusion of ropivacaine and morphine have been reported effective for postoperative pain control [6]. Lumbar epidural infusion of morphine $30\,\mu g \cdot kg^{-1}$ at the beginning of the operation provides effective analgesia on immediately after the Nuss procedure, but continuous infusion of morphine at the rate of $3\,\mu g \cdot kg^{-1} \cdot h^{-1}$ is not effective after the first postoperative day [7]. In children, both intravenous and epidural parent-assisted patient-controlled analgesia are also useful [8]. Our infusion rate of fentanyl with local anesthetics provided effective postoperative pain relief in 76.2% patents, but the analgesic effect in 23.8% patients was not substantial. Further study is required to determine the effective dose for postoperative pain after the Nuss procedure.

In conclusion, although the Nuss procedure is minimally invasive, we should pay attention to the possibility of many complications in the perioperative period. Continuous epidural infusion of fentanyl with local anesthetics provides effective postoperative pain relief and prevents complications such as bar displacement after the Nuss procedure.

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