

Cite this article as: Bilgi Z, Ermerak NO, Çetinkaya Ç, Laçın T, Yüksel M. Risk of serious perioperative complications with removal of double bars following the Nuss procedure. *Interact CardioVasc Thorac Surg* 2017;24:257–9.

Risk of serious perioperative complications with removal of double bars following the Nuss procedure[†]

Zeynep Bilgi*, Nezih Onur Ermerak, Çağatay Çetinkaya, Tunç Laçın and Mustafa Yüksel

Department of Thoracic Surgery, Marmara University Faculty of Medicine, Istanbul, Turkey

* Corresponding author. Department of Thoracic Surgery, Marmara University Faculty of Medicine, The Ministry of Health of Turkey, Marmara University Hospital, Thoracic Surgery Clinic, 7th Floor, F wing, Fevzi Cakmak Mah., Mimar Sinan Cad., No: 41, Ust Kaynarca, Pendik, Istanbul 34899, Turkey. Tel: +90-216-625-3025; fax: +90-216-449-1828; e-mail: zeynep.bilgi@gmail.com (Z. Bilgi).

Received 18 June 2016; received in revised form 16 August 2016; accepted 25 August 2016

Abstract

OBJECTIVES: The aim of this study is to present our experience with Nuss bar removal and evaluate potential risk factors. The Nuss procedure requires an operation to remove the bar 2–3 years after the initial correction. Although removal of the bar is generally believed to be safe, perioperative complications including major bleeding can occur.

METHODS: All cases involving removal of the Nuss bar done since April 2007 were recorded in a prospective database. Data were collected on the amount of blood loss, the number of diagnostic interventions, operative management and postoperative course.

RESULTS: Of a total of 246 (162 with single bars, 80 with double bars, 4 with triple bars) cases, 43 patients (17.5%) experienced perioperative complications. Five patients underwent secondary postoperative interventions; one patient required same-session emergency video-assisted thoracic surgery (VATS) due to major bleeding. Patients who had complications were significantly older than patients with no complications (20.5 ± 6.5 years vs 17.2 ± 5.9 years, $P = 0.002$). People having double bars removed were significantly more likely to have perioperative complications (12% vs 27%, $P = 0.03$) and complications requiring secondary interventions ($n = 1$ for a single bar, $n = 5$ for double bars, $P = 0.01$).

CONCLUSIONS: Major complications after removal of the Nuss bar occur with some frequency. Although the double-bar removals in our cohort were associated with major complications, the reasons are poorly understood. Immediate management of the complications may require multidisciplinary care. Multicentric pooling of cases is needed for better risk stratification.

Keywords: Pectus excavatum • Nuss operation • Bar removal

INTRODUCTION

The Nuss procedure involves the placement of one or more custom-curved steel bars retrosternally and is widely accepted as the treatment of choice for carefully selected patients with pectus excavatum. The operation requires a second intervention ~2 years after the first one to remove the bar(s). Although removal of the bar is thought to be a safe and well-tolerated operation [1], complications do occur.

There have been many reports in the literature describing life-threatening complications that require a subsequent sternotomy [2] or bilateral thoracotomy [3], but there are no aggregate data focusing on risk factors and the management of such complications. The objective of this study is to analyse our surgical experience with removal of the Nuss bar and to present potential risk factors to be considered for safer management of those patients.

[†]Presented at the 24th European Conference on General Thoracic Surgery, Naples, Italy, 29 May–1 June 2016.

MATERIALS AND METHODS

All patients undergoing surgery for chest wall deformities in Marmara University Hospital Thoracic Surgery Clinic are recorded in a prospectively held database. All patients consented to the use of their medical data for research purposes. Patients who had the bar removed after having had the Nuss procedure were identified from the database. Demographic data and data on the initial Nuss procedure (number of bars, bar duration), perioperative complications of the bar removal procedure, and the postoperative length of hospital stay were collected. SPSS 20.0 was used for statistical analysis. Continuous data are presented as mean \pm standard deviation; the chi-square and the Mann–Whitney *U* tests were used for group comparisons.

Surgical technique

All patients initially underwent a modified Nuss procedure with right-sided video-assisted thoracic surgery (VATS) and shortened

Table 1: Patient characteristics and types of complications

	Number of patients	P-value
Male/female	207/39	NA
Single bar/double bars	162/80	NA
Complications/no complications	Single bar 20/142	Double bars 22/58 ^a 0.03
Type of complication	Single bar Subcutaneous drain: 16 Pneumothorax: 2 Pleural effusion: 1 Chest tube insertion: 1	Double bars Subcutaneous drain: 13 Pneumothorax: 1 Pleural effusion: 1 Chest tube insertion: 5 VATS: 1 ^b Transoesophageal echocardiograms: 1 ^b Major intraoperative bleeding: 3 ^b 0.01 ^c

VATS: video-assisted thoracic surgery.

^aOne patient with triple bars had a subcutaneous drain.

^bOne patient with major intraoperative bleeding underwent a chest tube insertion on the ward. One patient had both transoesophageal echocardiograms and VATS due to major bleeding but did not get a chest tube.

^cFor undergoing secondary interventions (transoesophageal echocardiograms, VATS, chest tube).

bars. The bar removal technique, described previously [1, 4, 5], involved the patient lying supine; only the skin and subcutaneous tissue were dissected; the calluses at both ends of the bar were resected. Subcutaneous drains were left in place at the surgeon's discretion, to prevent seroma formation, in cases of extensive dissection and resection of callus tissue. Chest tubes were inserted while the patient was still in the operating room if there was an obvious pneumothorax or intrathoracic intervention.

Postoperative care

The subcutaneous drains were removed as soon as <50 ml of serous fluid was produced in a 24-h period. Chest tubes were inserted while the patient remained on the ward if the patient was symptomatic or had progressing pleural effusion. The tubes were removed when there was no air leak and the serous drainage was <150 ml for a 24-h period.

RESULTS

Of 548 patients who underwent the Nuss procedure in our institution since April 2007, 246 had their Nuss bars removed. The mean age was 17.7 ± 6.2 years. The majority of the patients (84%) were male. The average time from implantation to bar removal was 34.6 ± 17.1 months; 162 patients had a single bar removed; 80 had double and 4 had triple bars removed.

The overall complication rate was 17.5% (*n* = 43). The rest of the patients were discharged on the morning of the day following the operation. The types of complications are summarized in Table 1.

Patients who had a double bar removed were more likely to have complications than patients who had a single bar removed (*P* = 0.03) and were more likely to have more severe complications involving major bleeding (*n* = 3) or requiring secondary interventions like VATS or a chest tube (*P* = 0.01).

Patients who had complications were on average older than patients who did not have complications (20.5 ± 6.5 years vs 17.2 ± 5.9 years, *P* = 0.002). The average time from implantation to

bar removal did not differ between patients with and those without complications (34.9 ± 12.8 vs 34.6 ± 17.9 months)

DISCUSSION

The Nuss operation is a well-established procedure of choice for correction of pectus excavatum. The initial procedure is associated with a 3–5% morbidity rate and requires a secondary surgical intervention in about 1–2% of cases [6, 7]. The operation itself has been modified (shorter bars, stabilizers) to minimize the complications [8, 9].

The procedure for removing the Nuss bar has been modified several times to standardize it and to make it safer; these modifications include the use of special equipment, the use of two operating tables, and suggested changes for positioning the patient [1]. We feel that it is easier to standardize the technique and decrease the operating time by placing the patient in a supine position and avoiding the use of specialized equipment [1].

Various case reports describe major arterial injury [2, 3] and emergency invasive surgery for repair. We had three instances of major intraoperative bleeding through the bar tract during the double bar removals [4]. The first case had a left VATS; transoesophageal echocardiograms and transthoracic ultrasound scans showed no bleeding into the large cavities (thorax, pericardium). The bar tract was packed bilaterally; the bleeding stopped after consistent pressure was applied, with a total blood loss of 1300 ml. In the second and third cases, the bar tract was packed immediately and intraoperative evaluation using transoesophageal echocardiograms, ultrasound scans and radiographs was started, limiting intraoperative blood loss to 300 ml in each case. The last case required insertion of a standard chest tube in the 5th intercostal space with the patient still on the ward; we evacuated 400 ml of blood and blood products from the pleural space, but the bleeding proved to be self-limiting. When major bleeding occurs during removal of the bar, if the patient's vital signs are stable, immediate packing and non-invasive intraoperative evaluation might eliminate the need for a more invasive procedure. Blood going directly into the rigid bar tract has little potential

space, which is hard to breach during manipulation. In two cases, the 'bleeder bars' were placed similarly to most of the single bars in the intercostal spaces. One case had a high (second to third intercostal space) and turned bar, also fitting the description of the case reported by Notrica *et al.* [3]. For safety, in cases of double bar removal, it is prudent first to prepare both bars for removal, take out the stabilizers next and, lastly, take out the bars after straightening both ends, starting from the lower bar. This approach provides better access if a secondary intervention (VATS, thoracotomy, sternotomy) is needed. Caution should be exercised when removing high bars, turned bars, and bars with sternal erosion, regardless of whether there is a single bar or double bars.

A Nuss bar induces many anatomical and functional changes while it is implanted [10, 11]. The facts that double bars are usually needed to correct deep deformities and that the chest wall loses its elasticity as the patient ages can explain the increase in complications when dealing with double bars and older patients [12]. Because the bar exerts more pressure on the bony structures to achieve the desired shape, erosion and callus formation may be more prominent, adding to the difficulty of bar removal and increasing the need for secondary interventions (chest tube insertion) in our cohort.

Although the average time the bar was in place did not differ across groups with complications and those without, 15 of 43 patients with complications had had their bar longer than the advised 3 years. Most of those patients were temporarily lost to follow-up due to address and telephone number changes. When choosing patients for whom the procedure is appropriate, it is important to consider social support systems and cultural factors as well as the technical aspects of the operation to obtain the best results.

Removal of the Nuss bar is a safe, well-tolerated operation that is even suitable as an outpatient procedure [1] in a majority of patients. When a large volume of cases are done in a single centre [1, 2], major complications do occur occasionally and require advanced, emergency care. Because these complications are rare but serious events, multi-institutional pooling of data is necessary to better define possible risk factors.

Funding

No funding was used in the production of this article.

Conflict of interest: none declared.

REFERENCES

- [1] Nyboe C, Knudsen MR, Pilegaard HK. Elective pectus bar removal following Nuss procedure for pectus excavatum: a single-institution experience. *Eur J Cardiothorac Surg* 2011;39:1040-2.
- [2] Jemielity M, Pawlak K, Piwkowski C, Dyszkiewicz W. Life-threatening aortic hemorrhage during pectus bar removal. *Ann Thorac Surg* 2011;91:593-5.
- [3] Notrica DM, McMahon LE, Johnson KN, Velez DA, McGill LC, Jaroszewski DE. Life-threatening hemorrhage during removal of a Nuss bar associated with sternal erosion. *Ann Thorac Surg* 2014;98:1104-6.
- [4] Bilgi Z, Ermerak NO, Laçın T, Bostancı K, Yüksel M. Previously complicated Nuss procedure does not preclude blind removal of the bar. *Thorac Cardiovasc Surg* 2016;64:83-6.
- [5] Pilegaard HK. Nuss technique in pectus excavatum: a mono-institutional experience. *J Thorac Dis* 2015;7(Suppl 2):172-6.
- [6] Sacco-Casamassima MG, Goldstein SD, Gause CD, Karim O, Michailidou MStewart D *et al.* Minimally invasive repair of pectus excavatum: analyzing contemporary practice in 50 ACS NSQIP-pediatric institutions. *Pediatr Surg Int* 2015;31:493-9.
- [7] Hebra A, Swoveland B, Egbert M, Tagge EP, Georgeson K, Othersen HB Jr *et al.* Outcome analysis of minimally invasive repair of pectus excavatum: review of 251 cases. *J Pediatr Surg* 2000;35:252-7.

- [8] Nuss D. Minimally invasive surgical repair of pectus excavatum. *Semin Pediatr Surg* 2008;17:209-17.
- [9] Ghionzoli M, Ciuti G, Ricotti L, Tocchioni F, Lo Piccolo R, Menciasci A *et al.* Is a shorter bar an effective solution to avoid bar dislocation in a Nuss procedure? *Ann Thorac Surg* 2014;97:1022-7.
- [10] Lawson ML, Mellins RB, Tabangin M, Kelly RE Jr, Croitoru DP, Goretsky MJ *et al.* Impact of pectus excavatum on pulmonary function before and after repair with the Nuss procedure. *J Pediatr Surg* 2005;40:174-80.
- [11] Chao CJ, Jaroszewski DE, Kumar PN, Ewais MM, Appleton CP, Mookadam F *et al.* Surgical repair of pectus excavatum relieves right heart chamber compression and improves cardiac output in adult patients-an intraoperative transesophageal echocardiographic study. *Am J Surg* 2015;210:1118-25.
- [12] Pilegaard HK, Licht PB. Routine use of minimally invasive surgery for pectus excavatum in adults. *Ann Thorac Surg* 2008;86:952-6.

eComment. The Nuss technique: A track full of hazards

Authors: Alain J. Wurtz and Emmanuel Brian

Thoracic Department, Institut Mutualiste Montsouris, Paris, France

doi:10.1093/icvts/ivw364

© The Author 2017. Published by Oxford University Press on behalf of the European Association for Cardio-Thoracic Surgery. All rights reserved.

Following a well-conducted prospective study, Bilgi and coworkers report the assessment of complication occurrence at the time of bar removal in patients having undergone a Nuss operation ([1]). We would like to congratulate the authors for this nice contribution to the highly debated field of pectus surgical repair. In fact, this work deserves some additional comments. First, the overall complication rate was 17.5%, but the authors, surprisingly, state that the initial procedure is associated with a 3-5% morbidity rate, according to their mentioned references [1]. The discrepancy between percentages could mean that the step of bar removal is found to be the riskiest procedure in the surgical course of patients undergoing the Nuss technique, which is obviously unrealistic [2]. Otherwise, we take the opportunity to mention that the authors failed to refer to additional cases of patients sustaining lethal or near-fatal haemorrhagic complications at the time of bar removal as a consequence of ventricle laceration [3-5]. All these patients were wearers of a single bar. The cause of these catastrophic outcomes is thought to be a postoperative pericardial effusion leading to a symphysis, i.e., a complete obliteration of the space between the pericardium and heart, and dense fusion of all adjacent tissues and bar, as shown by Bouchard and coworkers [3]. Another uncommon mechanism of heart lesion is the progressive intracardiac migration of the bar, which was retrospectively noticed by Sakakibara and coworkers on chest computed tomography performed before bar removal [5]. Similar findings were shown in a 18-year-old boy, whose history were reported in The DailyMail in 2014 (<http://www.dailymail.co.uk/health/article-2739727/Bullied-teenager-nearly-died-steel-bar-inserted-disguise-sunken-chest-came-1cm-heart.html>). Bar removal and cardiac repair required a 14-hour procedure under CPB. Fortunately, the patient made a satisfactory recovery. Apart from that, difficulties occasionally encountered during bar removal due to neo-ossification are other causes for concern. Finally, the safety of the so-called minimally invasive Nuss procedure appears for us strongly questionable [2]. Consequently, in our Institution we have opted to routinely perform pectus excavatum repair by means of a simplified Ravitch-type procedure including the placement of a straight titanium plate secured to the base of sternum. This device is easily removed under local anaesthesia through a 1-cm long lateral incision during an outpatient procedure 6 months after the initial operation, as shown on the video available on the CTSnet website (<http://www.ctsnet.org/article/simplified-open-repair-pectus-deformities>).

Conflict of interest: none declared.

References

- [1] Bilgi Z, Ermerak NO, Cetinkaya C, Lacin T, Yüksel M. Risk of serious perioperative complications with removal of double bars following the Nuss procedure. *Interact CardioVasc Thorac Surg* 2017;24:257-9.
- [2] Wurtz A. The Nuss Procedure: Above all, do no harm. *Ann Thorac Surg* 2015;99:1865-70.
- [3] Bouchard S, Hong AR, Gilchrist BF, Kuenzler KA. Catastrophic cardiac injuries encountered during the minimally invasive repair of pectus excavatum. *Semin Pediatr Surg* 2009;18:66-72.
- [4] Haecker FM, Berberich T, Mayr J, Gambazzi F. Near-fatal bleeding after transmyocardial ventricle lesion during removal of the pectus bar after the Nuss procedure. *J Thorac Cardiovasc Surg* 2009;138:1240-1.
- [5] Sakakibara K, Kinoshita H, Ando K, Yasuda Y, Mori Y, Fujiwara Y. Right ventricular perforation due to a stabilizing bar installed for the 'Nuss' procedure. *Minerva Anesthesiol* 2013;79:820-1.