Case Report

Cardiopulmonary arrest during the Nuss procedure: case report and review

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Case: The Nuss procedure is an established and widely approved minimally invasive technique for the correction of pectus excavatum. However, patients undergoing the procedure are at increased risk of cardiac arrest. It has not been established whether cardiopulmonary resuscitation is possible in patients who have received the Nuss procedure. We present here the case of a 14-year-old boy with pectus excavatum who underwent minimally invasive pectus repair but later had a fatal cardiac event before pectus bar removal.

Outcome: Bystander cardiopulmonary resuscitation was carried out immediately but resuscitation failed.

Conclusion: In patients who have undergone the Nuss procedure for pectus excavatum, it is important to manage perioperative events such as arrhythmia, develop measures for managing emergency situations in patients' areas of residence, and carry out continuing research and development of medical supply materials that can be used to manufacture Nuss bars.

Key words: Cardiopulmonary arrest, CPR, late onset complication, Nuss procedure, pectus excavatum

INTRODUCTION

PECTUS EXCAVATUM (PE) is a congenital deformity/depression of the anterior chest with a prevalence of approximately 1 in 800–1,000 children. Pectus excavatum has adverse effects on both the children and their families due to its abnormal external appearance and visceral disorders. The Nuss procedure was first reported in 1998 as a minimally invasive surgical procedure for treating PE.¹ Since then, the procedure has been carried out in increasing numbers of children. The procedure involves placing a metal bar—a pectus bar—in the thoracic cavity. The bar is inserted thoroscopically and left in place for at least 2 years to correct the deformity. The procedure is most commonly performed on children aged 5–6 years, in consideration of reported surgical outcomes and the psychological burden children often face from the reactions of their peers to their noticeably abnormal appearance. However, the mean age at surgery is gradually increasing because some eligible patients who initially refused surgery are later choosing to

undergo the procedure, even at age 16 or older in some cases. More than 10 years have passed since the procedure was introduced in Japan and many reports are now available on the procedure's techniques and safety. Few reports have described fatal complications of the procedure. Given that more patients are undergoing the Nuss procedure, it is important to standardize the procedure while minimizing the associated risks. Here we present the case of a boy who developed cardiopulmonary arrest following the procedure, but cardiopulmonary resuscitation (CPR) was unsuccessful. We discuss the lessons learned from this case.

CASE

IN MARCH 2012, a 13-year-old boy underwent sternal lifting surgery by the Nuss procedure at a high-volume center in Japan. With no significant postoperative complications, he was discharged 1 week after surgery. He had an eventless postoperative course and was scheduled to undergo surgery for Nuss bar removal in July 2013. One month before the surgery, he collapsed suddenly while playing basketball at school. Seeing he was unconscious, cyanotic in the lips, and apneic, bystanders started CPR, followed by automated external defibrillation and one application of a direct-current defibrillator. Seamless CPR was continued until paramedics arrived 6 min later. They confirmed cardiopulmonary arrest

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Fig. 1. Anteroposterior chest roentgenogram on admission of a 14-year-old boy who developed cardiopulmonary arrest shows two Nuss bars inserted in the chest wall.

(asystole) on an electrocardiography monitor and continued CPR while he was transported to our hospital 19 min after going into cardiopulmonary arrest. On arrival, advanced life support procedures were carried out, including airway management by endotracheal intubation (Fig. 1), establishment of vascular access, and use of circulatory agonists. Monitoring with electrocardiography was continued even though he was in a state of pulseless electrical activity. Despite the impeccable emergency medical procedures carried out by lay people, paramedics, and hospital staff, death was confirmed 1 h after onset.

Autopsy imaging revealed no cerebral abnormalities that could explain cardiopulmonary arrest (e.g., subarachnoid hemorrhage, intracerebral hemorrhage, subdural hematoma, or large infarction suggestive of cardiogenic cerebral embolism). No abnormalities were found in the thoracic or abdominal cavities (e.g., aortic dissection, cardiac tamponade, pleural hemorrhage, asphyxia, or damage to abdominal organs). Postmortem autopsy revealed cardiac hypertrophy (384 g), mild thickening of the right ventricular wall, abnormal origin of the right coronary artery (originating from the left sinus of the Valsalva and coursing between the pulmonary artery and aorta), and hepatosplenomegaly suggestive of right heart failure.

DISCUSSION

TO DATE, LATE life-threatening complications after Nuss bar placement have been reported in six cases, including the present case.^{2–6} The mean age of patients is 17 years, with a male : female ratio of 5:1 and a median time to onset of complications of 36 months. In the four surviving patients, complications were caused by cardiac tamponade, aortomediastinal fistula, bilateral hemothorax, and a fibrous band causing severe obstruction of right ventricle outflow in one case each. The two fatal cases were both due to sudden cardiac arrest (Table 1), one of which appeared to have involved arrhythmia due to preexisting heart disease (mitral valve prolapse). Because pectus excavatum is often associated with a Brugada-type electrocardiographic pattern⁷ and because patients with a pectus bar may develop arrhythmia such as incomplete left bundle branch block,⁸ the patient in this case might have had primary arrhythmia or arrhythmia secondary to the Nuss procedure. It is important, therefore, to pay attention to arrhythmic episodes before and after the Nuss procedure.

As is widely recognized, the presence of the pectus bar prevented effective cardiac massage in the present case. Although emergency room thoracotomy might have been effective, according to previous studies, the success rate of emergency room thoracotomy is close to 0% in patients who developed out-of-hospital cardiac arrest. The number of life-saving cases may be increased if physicians are dispatched promptly to the scene using doctor-heli or doctor-car services to perform medical procedures such as open-chest cardiac massage before arriving at a hospital equipped with a percutaneous cardiopulmonary support device.

Although patients who have undergone pectus bar placement carry an implant card, the card may well not be of practical use in emergency situations, as in the present case. Thus, it is important in areas where such patients live to share information and simulate emergency handling strategies in hospitals where the treatment is provided and other regional hospitals, workplace, schools, and fire stations.

To help make the Nuss procedure a safer treatment device, research and development is desirable into manufacturing bars made from material that not only deforms but also readily restores its shape. Compared with metals, carbon fiber is superior in compressive strength and modulus. In particular, carbon fiber-reinforced plastic (CFRP) is widely used as a lightweight alternative to metal materials in aerospace, automotive, sports, and other fields. Moreover, taking advantage of its mechanical characteristics, surgeons already apply CFRP in the form of braces and prosthetics in clinical settings.⁹ We hope that the technological development and application of CFRP will continue to advance.

Table 1. Reported cases of delayed onset, life-threatening complications following the Nuss procedure

Year of publication	Journal	Author	Patient age, years	Sex	Source of complication	Outcome	Time after procedure
2005	J. Pediatr. Surg.	Garret K <i>et al.</i>	21	M	Sudden cardiac arrest	Death	36 months
2006	Ann. Thorac. Surg.	Hoel TN <i>et al.</i>	17	M	Cardiac tamponade	Survived	2 months
2011	Ann. Thorac. Surg.	Marek Jemielity <i>et al.</i>	18	F	Aortomediastinal fistula	Survived	36 months
2012	Pediatr. Surg. Int.	Chieh-Wen Lin <i>et al.</i>	13	M	Bilateral hemothorax	Survived	5 months
2012	J. Pediatr. Surg.	Lisa Obert <i>et al.</i>	23	M	Fibrous band causing severe right ventricle outflow obstruction	Survived	11 years
	This case	Nakahara <i>et al.</i>	14	M	Sudden cardiac arrest	Death	15 months

F, female; M, male.

CONCLUSION

IN PATIENTS WHO have undergone the Nuss procedure for pectus excavatum, it is important to manage perioperative events such as arrhythmia, develop measures for managing emergency situations in patients' areas of residence, and carry out continuing research and development of medical supply materials that can be used to manufacture Nuss bars.

CONFLICT OF INTEREST

NONE.

REFERENCES

- Nuss D, Kelly RE Jr, Croitoru DP, Katz ME. A 10-year review of a minimally invasive technique for the correction of pectus excavatum. *J. Pediatr. Surg.* 1998; 33: 545–52.
- Zoeller GK, Zallen GS, Glick PL. Cardiopulmonary resuscitation in patients with a Nuss bar—a case report and review of the literature. *J. Pediatr. Surg.* 2005; 40: 1788–91.
- Hoel TN, Rein KA, Svennevig JL. A life-threatening complication of the Nuss procedure for pectus excavatum. *Ann. Thorac. Surg.* 2006; 81: 370–2.
- Jemielity M, Pawlak K, Piwkowski C, Dyszkiewicz W. Life-threatening aortic hemorrhage during pectus bar removal. *Ann. Thorac. Surg.* 2011; 91: 593–5.
- Lin CW, Chen KC, Diao GY, Chu CC. Late-onset vital complication after the Nuss procedure for pectus excavatum. *Pediatr. Surg. Int.* 2012; 28: 71–3.
- Obert L, Munyon R, Choe A, Rubenstein J, Azizkhan R. Rare late complication of the Nuss procedure: A case report. *J. Pediatr. Surg.* 2012; 47: 593–7.
- Awad SF, Barbosa-Barros R, Belem Lde S *et al.* Brugada phenocopy in a patient with pectus excavatum: Systematic review of the ECG manifestations associated with pectus excavatum. *Ann. Noninvasive Electrocardiol.* 2013; 18: 415–20.
- Grafe D, Fitze G, Heilmann A. Incomplete left bundle branch block as an artefact caused by the Nuss procedure for pectus excavatum. *Europace* 2011; 13: 258–61.
- Hachisuka K, Makino K, Wada F, Saeki S, Yoshimoto N, Arai M. Clinical application of carbon fibre reinforced plastic leg orthosis for polio survivors and its advantages and disadvantages. *Prosthet. Orthot. Int.* 2006; 30: 129–35.