pressure, we decided to perform a double-switch procedure at the same setting [4].

In view of heart failure, the risk of pulmonary hypertension, and progression of pulmonary vascular disease, a single-stage double-switch procedure with unifocalization is a satisfactory surgical treatment option in a patient with CCTGA, VSD, PA, and MAPCAs. It can result in a balanced circulation without heart failure or cyanosis, which could potentially occur if staged repairs were to be undertaken, resulting in inoperability toward complete repair [5].

References


Life-Threatening Hemorrhage During Removal of a Nuss Bar Associated With Sternal Erosion

David M. Notrica, MD, Lisa E. McMahon, MD, Kevin N. Johnson, MD, Daniel A. Velez, MD, Leigh C. McGill, MD, and Dawn E. Jaroszewski, MD

Department of Surgery, Phoenix Children’s Hospital, University of Arizona College of Medicine Phoenix, and Department of Surgery, Mayo Clinic Arizona, Phoenix, Arizona

We present a case of life-threatening hemorrhage occurring during Nuss bar removal without obvious cardiac or major vascular injury. A 19-year-old woman with marfanoid features had undergone a Nuss procedure 3 years earlier for a pectus index of 7.2. A lateral chest radiograph revealed erosion of the upper bar into the sternum. During surgery, a 3.5-L blood loss occurred after removal of the eroded bar. This case provided many opportunities to improve preparedness for bar removal. (Ann Thorac Surg 2014;98:1104–6) © 2014 by The Society of Thoracic Surgeons

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Address correspondence to Dr Notrica, 1920 E Cambridge Ave, #201, Phoenix, AZ 85006; e-mail: dnotrica@phoenixchildrens.com.

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inimally invasive repair of pectus excavatum requires placement of one or more subternal bars to elevate the sternum to the normal anterior position. Removal of the bars is recommended 2 to 3 years after implantation. Bleeding during bar removal secondary to aortic, pulmonary, or cardiac injury has been previously reported [1–3]. We present a case of life-threatening hemorrhage during removal of a bar associated with sternal erosion.

A 19-year-old woman presented for elective removal of her Nuss pectus bars. She had undergone repair of pectus excavatum (Haller index, 7.5; Fig 1) 3 years earlier. Preoperatively she had symptoms of lightheadedness and exercise intolerance documented on treadmill testing. There was no family history of Marfan syndrome. Although not meeting the diagnostic criteria for Marfan syndrome, the patient exhibited some marfanoid features, including minor skin stria on the back, arachnodactyly, and positive wrist and thumb signs as well as mild scoliosis. Her arm span was less than her height. She had no hypermobile joints. The remainder of her examination was unremarkable.

Minimally invasive repair with complete thoracoscopic transmediastinal dissection and placement of two 11-inch pectus bars (Biomet, Jacksonville, FL) was performed. The bars were secured with FiberWire (Arthrex, Inc, Naples, FL). She had an uneventful recovery. At her 3-year follow-up, she had excellent correction with resolution of all preoperative symptoms. A preoperative chest radiograph confirmed good bar position; however, the superior bar was noted to have migrated anteriorly through the posterior sternal table on the lateral view (Fig 2).

Bar removal was scheduled in the main operating suite. She was positioned supine with arms out. The prior incisions were opened bilaterally. Both bars had moderate heterotopic ossification as well as fibrin sheath encasement. Both bars were freed of all bony fragments and completely straightened. The lower bar was removed first without difficulty. The upper bar initially showed significant resistance to removal. With an additional effort, the straightened bar was removed. Immediately after the bar’s exit, a rapid flow of nonpulsatile bright red
blood flowed from both incisions. The patient rapidly became tachycardiac and hypotensive. Transfusion protocols and conversion to anterior thoracotomy were initiated. The right inframammary incision was extended to open the right chest. There was no blood in the right chest or pericardium. The anterior thoracotomy incision was extended to the left side. Bone cutters were required to cut across the heterotopic ossification where the bars crossed the ribs. The hemorrhage stopped spontaneously during exploration after extension of the left thoracotomy. Bleeding cessation correlated temporally with hypotension and the administration of epinephrine. At the site of bar erosion into the sternum, the internal mammary arteries (IMAs) were not visible and were assumed to be incorporated into the sternum. As this was the suspected site of bleeding, proximal ligation was performed bilaterally of the IMAs to decrease the risk of rebleeding. Chest drains were placed. The patient did not experience cardiac arrest or require chest compressions. Estimated blood loss was approximately 3.5 L. She received 4 units of packed red blood cells, 1 unit of fresh-frozen plasma, and 1 pheresis of platelets. At discharge, her hemoglobin was 8.4 mg/dL. Her repair has remained stable, and she recovered fully.

Comment

Minimally invasive repair of pectus excavatum as described by Nuss and modified by others has become the most common technique for repair [4–6]. Complications are not uncommon during the Nuss procedure, and many modifications of the original technique have occurred to prevent bleeding complications [5, 6]. Injury to major vascular and cardiac structures has been reported with bar placement and removal [1–3, 7]. Significant sternal or IMA bleeding after bar removal has not been previously published. In many cases, the IMA may be compressed or occluded during the initial bar placement [8]. We believe one or both IMAs incorporated into the sternum as a result of bar erosion contributed to the sternal bleeding.

This case brings to the forefront several important issues. It is the first published case describing life-threatening bleeding without evidence of a major intrathoracic vascular injury. The unexpected bleeding resulted in conversion to an open thoracotomy. This maneuver did not identify a source of bleeding and may have been avoided with readily available thoracoscopy and greater awareness of sternal bleeding as a potential source.

This case was associated with bar erosion into the sternum. Erosion has been rarely noted and would not typically be identified without lateral radiographs before bar removal. We had not previously encountered this situation and little has been written about the implications of these radiographic findings. The 3-year time frame from bar placement to removal cannot be excluded as a contributing factor to the complications experienced in this case. In retrospect, given the force necessary to remove this bar, sternal elevation [6] may have facilitated removal by minimizing pressure of the sternum on the bar.

The Nuss procedure remains a young operation with unexpected challenges. Although the majority of support bars are easily removed as an outpatient procedure, life-threatening bleeding can occur with bar extraction [2, 3]. Strategies to address potential complications should be incorporated into case preparation. Based on this case, a preoperative two-view chest radiograph should be part of the preoperative workup, and patients with sternal erosion should be crossmatched. Surgeons performing this operation should have enough experience with thoracic trauma to be able to control or repair an aortic, pulmonary, or cardiac injury. Urgent thoracotomy, when necessary, may be more difficult and time-consuming at the time of bar removal owing to heterotopic ossification fusing the ribs laterally. Bone cutters may facilitate cutting through heterotopic ossification bridging the ribs at the site of the bars, and a second rib retractor facilitates exposure after bilateral thoracotomy. Bar removal should be done in a facility capable of transfusion, transesophageal echocardiography, and cardiopulmonary bypass. RulTract sternal elevation may potentially decrease trauma to the fibrous tract if the bar does not slide easily. Video thoracoscopy may allow expeditious intrathoracic evaluation for moderate bleeding or pericardial effusion if complications arise.
Bar erosion into the sternum on preoperative lateral radiograph should heighten the concern for significant sternal bleeding. We believe the IMAs contributed to significant bleeding in this case. External elevation of the sternum during bar removal in cases of known sternal erosion might potentially facilitate removal and decrease the chance for significant bleeding. Urgent thoracotomy during bar removal provides for several unexpected challenges.

Dr H. J. Park suggested sternal elevation if sternal bar erosion is identified through the Chest Wall Interest Group.

References
6. Jaroszewski DE, Johnson K, McMahon L, Notrica D. Sternal bleeding. We believe the IMAs contributed to significant bleeding in this case. External elevation of the sternum during bar removal provides for several unexpected challenges.

Cartilage rings are uniquely shaped in the upper respiratory tract and develop from the growing mesoderm. Many abnormalities of the growing cartilages are common, the commonest being a complete cartilaginous ring causing segmental tracheal stenosis. Absence of cartilages can happen, especially associated with tracheoesophageal fistula, but isolated absence of last tracheal cartilage, known to be a unique embryological entity, is rare. Neonatal presentation with respiratory distress is potentially common, with the flail segment acting like a ball valve. We report the presentation and its link to possible embryological significance along with surgical treatment in such isolated absence of the last tracheal ring.

Case Reports
Three patients were referred with features of respiratory distress of varying intensity between January 2011 and December 2012. All were boys, and the diagnosis of tracheal stenosis was made postnatally after episodes of severe respiratory distress. Their clinical presentations are discussed below.

Patient 1
A 4-month-old child was initially diagnosed to have tracheomalacia after an episode of respiratory illness. A computed tomography (CT) scan of chest showed an innocuous cystic lesion on the right upper zone and also a localized distal tracheal lesion just above the carina (Fig 1). Further investigations included bronchoscopy, which suggested absence of cartilage with localized stenosis at juxtacarinal location. This, in addition, showed a complete collapse during the cycle of respiration (Fig 2). In view of the severity of presentation, surgical repair was considered.

The surgical repair was performed under cardiopulmonary bypass through a median sternotomy. A localized absence of cartilage was noted at the level of the stenosis, with normal cartilage otherwise in the rest of trachea. The affected segment was resected, and direct reimplantation of trachea to carina was performed, with an excellent postoperative result.

Patient 2
A 7-month-old child was referred after a difficult ventilatory course for viral pneumonitis caused by respiratory...