International Journal of Pediatric Surgery

ISSN: 2766-5577

Research Article

Pectus Excavatum and Scoliosis: Does Order of Repair Matter? A Case Series and Literature Review

Raj Shah[1,2], Scott Eldridge[2,3], David Bennett[2,3,4,5] and Lisa E McMahon[1,2,3]*

[1]University of Arizona College of Medicine-Phoenix, Arizona, USA [2]Phoenix Children's Hospital, Arizona, USA

[3]Mayo Clinic School of Medicine, Arizona, USA

[4]Barrow Neurological Institute, Arizona, USA

[5]Creighton University School of Medicine-Phoenix, Arizona, USA

Abstract

Pectus Excavatum (PE) and Adolescent Idiopathic Scoliosis (AIS) often coexist and pose challenges in surgical planning. The optimal order of repair remains uncertain, with concerns that uncorrected PE may compromise cardiopulmonary function during scoliosis surgery. We conducted an IRB-approved retrospective review of six pediatric patients who underwent both PE and AIS correction between 2020 and 2025. Five patients had PE correction first, while one initially attempted scoliosis surgery but experienced intraoperative hemodynamic instability requiring abortion of the procedure. This patient subsequently underwent successful scoliosis correction after PE repair. Across the cohort, mean preoperative Haller Index was 6.80 ± 1.9 (range 3.9-9.2) and mean Cobb angle was 67.4° ± 16.1° (range 54° to 97.5°). Average length of stay was 2.5 days following PE repair and 3.0 days following scoliosis surgery. Patients who underwent PE-first repair, including those with severe spinal curves and syndromic conditions, tolerated scoliosis surgery without cardiopulmonary compromise and returned to full activity at follow-up. Our findings, supported by existing literature, suggest that correcting PE before scoliosis surgery may mitigate perioperative hemodynamic risk associated with prone positioning and thoracic compression. Larger, prospective, multi-institutional studies are warranted to validate these observations and establish evidence-based sequencing guidelines.

Objective: Pectus Excavatum (PE) and Adolescent Idiopathic Scoliosis (AIS) often coexist, yet the optimal sequencing of surgical correction remains uncertain. This study evaluates whether performing PE repair before scoliosis surgery reduces perioperative hemodynamic risk.

Methods: A retrospective, IRB-approved, single-center case series of six pediatric patients who underwent surgical correction of both PE and AIS between 2020 and 2025 was conducted. Demographic information, preoperative Haller Index (HI), preoperative Cobb angle, cardiopulmonary function, length of stay, complications, hospital course, and follow-up visits were reviewed.

Results: Six patients met inclusion criteria, five patients underwent PE correction before scoliosis surgery. One patient initially attempted scoliosis correction surgery first but developed intraoperative hemodynamic instability, necessitating postponement of the procedure until after PE correction. All patients had severe AIS (mean Cobb angle 67.4° ± 16.1°) and severe symptomatic PE (mean HI 6.8 ± 1.9). Average length of stay was 2.5 days after PE repair and 3.0 days after scoliosis surgery. Following PE-first repair, no further intraoperative hemodynamic events were observed. All patients reported return to full activity at follow-up.

Conclusion: Uncorrected PE may predispose patients to perioperative hemodynamic instability during scoliosis correction. Prioritizing PE repair before scoliosis surgery may mitigate this risk and improve cardiopulmonary stability, creating safer conditions for subsequent spinal correction. Our findings align with prior reports and support a PE-first sequencing strategy. Larger, multi-center studies are needed to validate these observations and establish evidence-based guidelines for surgical sequencing in patients with concurrent PE and AIS.

Keywords: Pectus Excavatum (PE); Adolescent Idiopathic Scoliosis (AIS); Surgical sequencing; Nuss procedure; Posterior spinal fusion

Introduction

The optimal surgical sequencing of Pectus Excavatum (PE) and Adolescent Idiopathic Scoliosis (AIS) remains controversial. While both deformities can significantly impact cardiopulmonary function, there is no consensus on whether correcting PE or AIS first offers better perioperative outcomes. The lack of evidence-based guidelines has resulted in variability in surgical decision-making and perioperative management.

Pectus Excavatum (PE), the most common chest wall deformity, accounts for 65% to 95% of pectus anomalies. Long considered a cosmetic issue, it is now recognized for its physiological and mechanical consequences, including impaired cardiopulmonary function and its association with other structural deformities like scoliosis. In the literature, it is having been shown that patients with PE have a higher prevalence of scoliosis compared to the general population, particularly among individuals with Marfan syndrome [1-6].

Scoliosis severity is commonly measured using the degrees of curvature of the spine, which is referred to as the Cobb angle. It is important to note that although many institutions around the world

Citation: Shah R, Eldridge S, Bennett D, McMahon L. Pectus Excavatum and Scoliosis: Does Order of Repair Matter? A Case Series and Literature Review. Int J Pediatr Surg. 2025;6(1):1052.

Publisher Name: Medtext Publications LLC

Manuscript compiled: Dec 17th, 2025

***Corresponding author:** Lisa E. McMahon, Phoenix Children's Hospital, 1919 E. Thomas Rd, Phoenix, Arizona, 85016,USA

perform PE repair and scoliosis repair operations on young children (<10 years of age) and on mild to moderate scoliosis (<45 degrees), our institution does not. This practice aligns with the widely accepted threshold for surgical intervention in AIS, as surgery is generally reserved for severe scoliosis with curves exceeding 45° to 50°, given the higher risk of progression and long-term complications, particularly in skeletally immature patients [7,8].

The mechanical relationship between PE and scoliosis is complex, with studies suggesting that correction of one deformity may exacerbate the other. With both PE and scoliosis present, the need for and timing of the order of the surgery has been controversial. The literature provides evidence that the severity of concomitant scoliosis may be influenced by PE correction, but this effect is variable [9]. Studies have shown an increase in Cobb angle [10-17], a decrease in Cobb angle [10,12,15,18], a complete disappearance of scoliosis [10], as well as the development of scoliosis [10,19,20] after PE correction. In patients where PE correction worsened scoliotic curvature, these effects were generally observed in patients with low-moderate baseline Cobb angles (<45 degrees), children <10 years of age, and long-term progression remains unclear. This exacerbation of scoliosis shown due to PE correction is a potential mechanical reason why surgeons could prefer to choose scoliosis surgery before PE correction. In Ghionzoli et al. [12] reported that in adolescents with coexisting PE and moderate scoliosis (10°-45°), PE repair *via* the Nuss procedure led to modest improvement in scoliotic curvature over a three-year follow-up. These findings suggest that PE correction may stabilize or even improve mild spinal curves in select patients however results across studies have been inconsistent and limited by non-standardized scoliosis definitions and management.

Beyond mechanical considerations, recent case reports and small series have described intraoperative hemodynamic compromise during scoliosis correction in the setting of uncorrected PE [21-23]. These events, often triggered by prone positioning and posterior spinal instrumentation, are thought to result from retrosternal cardiac compression against a depressed sternum. A 2022 systematic review by van Es et al. identified three cases in the literature of perioperative hemodynamic compromise Oka et al. [9]. Described right pulmonary vein compression following scoliosis surgery, successfully relieved with delayed PE repair [24]. Similarly observed worsening of Haller Index post-scoliosis correction and theorized that sagittal and rotational forces may deepen sternal depression, exacerbating cardiac compression [11]. These findings have led some to advocate for correcting PE first to restore thoracic compliance and reduce cardiopulmonary risk.

With this conflicting evidence regarding the effects of PE correction on scoliosis, this case series aims to contextualize these findings within the experience of five pediatric patients treated for both conditions. This manuscript was prepared following the CARE guidelines.

Materials and Methods

Study design and setting

This was an IRB-approved (IRB -22-236) retrospective single-center case series of 6 patients. The data collection period spanned from 2020 to 2025. Patients were included if they had a documented diagnosis of both PE and AIS, had undergone surgical correction for both conditions, and had complete surgical and follow-up records available for review. Patients were excluded if they had incomplete surgical data or lacked follow-up documentation. Patient data and images were de-identified and institutional consent policies were followed.

Data collection

For each patient, the following data were collected and reviewed: demographic information including age, sex, relevant past medical history, past surgical history; characteristics of PE including preoperative Haller Index (HI), preoperative Correction Index, VO_2 max, stroke volume response during cardiopulmonary exercise testing; and characteristics of AIS including preoperative Cobb angle, indication for correction, length of surgery. The sequence of surgical interventions (PE-first versus AIS-first) was also recorded. The clinical course was assessed through review of intraoperative findings, postoperative complications, and hospital length of stay for each procedure. Follow-up data included postoperative clinical outcomes and narrative patient-reported satisfaction were documented.

Data analysis

Given the small sample size, data analysis is qualitative. Trends in surgical outcomes and complications are described narratively, without statistical comparison.

Results

Patient 1

Patient 1 is a 14-year-old male with no significant past medical history or past surgical history who presented to the orthopedic clinic with scoliosis. X-ray imaging (XR) revealed a double thoracic curve with a Cobb angle of 70 degrees (Figure 1a). The indications for scoliosis surgery were based on the severity of the curve and the associated risk of progression. Noting the PE on physical exam, the paediatric orthopedic surgeon discussed the order of surgery with a paediatric surgeon and together they decided that scoliosis surgery would be attempted first. On the day of scoliosis surgery, the patient had an unsafe drop in vital signs after induction of anaesthesia and prone positioning. When the patient was elevated from the bed in the prone position vital signs returned to normal, but with weight down in prone position, despite changing pad placement, acceptable vital signs while prone were not achieved to proceed with spinal surgery.

This patient then consulted with a different paediatric surgeon and underwent work up for PE. The patient had lack of endurance with exercise and was self-conscious about the cosmetic appearance. Patient was found to have a HI of 5.2 and a correction index of 19% on MRI (Magnetic Resonance Imaging). Cardiopulmonary exercise testing revealed low exercise capacity with a VO_2 max at 67% of predicted and a blunted stroke volume response at 61% of predicted. Thoracoscopic Nuss procedure with the placement of two titanium bars was performed one month later. The postoperative hospital stay was one day. Patient's recovery was uneventful, with no reported complications.

Approximately 4 months later, patient underwent posterior spinal fusion from T3 to L3 with posterior segmental instrumentation. The postoperative hospital stay was three days. His recovery was uneventful, with no reported complications. Post-operative XR with Nuss bars and spinal instrumentation seen in Figure 1b.

The Nuss bars were removed after nearly three years. At most recent follow-up, the patient had returned to full activity with no shortness of breath or lack of endurance (Figure 1c and 1d).

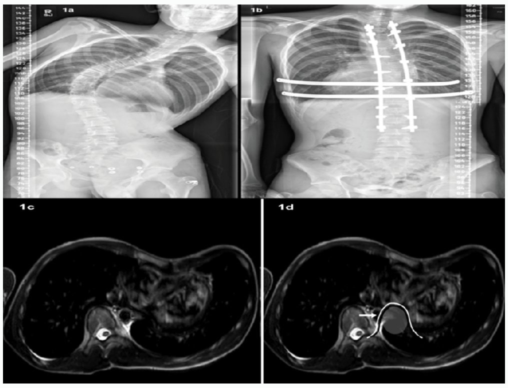

Figure 1: Preoperative and postoperative imaging of patient 1. Preoperative XR showing uncorrected PE and scoliosis (1a, left) and postoperative XR demonstrating PE correction with Nuss bar placement and scoliosis correction using spinal instrumentation (1b, right). Preoperative Chest CT (1c, left) shows cardiac compression from uncorrected PE and uncorrected scoliosis. Preoperative CT with overlayed drawing (1d, right) showing relationship of where spine would be in relation to the heart if scoliosis was corrected before PE.

Patient 2

Patient 2 is a 19-year-old male with a past medical history of Williams Syndrome and past surgical history of two coarctation of aorta repair surgeries and balloon dilation of the pulmonary artery for pulmonary artery stenosis. Even with arterial dilation, there was still significant compression of the aortic root and the left coronary artery due to the limited space in the chest due to the PE, and repeated cardiac surgery to repair congenital defects was deferred until PE and scoliosis surgery were completed. The Nuss procedure was chosen to be first due to the thoracic curve originally being only 38 degrees, and the orthopedic surgeon felt the patient would benefit from observation alone. The patient had symptomatic chest pain and discomfort. Preoperative cardiac MRI showed PE with a Haller index of 7.6 and a correction index of 61.7% as well as displacement and external compression of the heart. Preoperative XR showing uncorrected pectus and scoliosis seen in Figure 2a. Cardiopulmonary exercise testing revealed low exercise capacity with a VO_2 max at 58% of predicted and a blunted stroke volume response at 53% of predicted. Patient underwent a redo sternotomy to safely access his chest cavity followed by thoracoscopic Nuss procedure, which involved the placement of two bars. No intraoperative complications were reported. Patient's hospital stay was six days following the pectus procedure, during which chest tubes were placed to manage pleural effusions. The patient was readmitted ten days later with respiratory distress and was found to have pneumonia which was treated with antibiotics.

The patient was then re-evaluated by orthopaedic surgery for their scoliosis, and imaging demonstrated a left upper thoracic curve with a Cobb angle of 54 degrees, which had increased from 38 degrees prior to the Nuss procedure. The indications for surgical correction of scoliosis were due to magnitude of curve and risk of progression. Scoliosis correction surgery was performed 8 months after Nuss procedure and included posterior spinal fusion from T2 to T11 with segmental instrumentation. No intraoperative complications were reported. Patient's hospital stay was three days. Post-operative XR with Nuss bars and spinal instrumentation seen in Figure 2b. The patient was readmitted three weeks following scoliosis correction for acute hardware infection related to spinal surgery requiring drainage and antibiotics.

At most recent follow-up, the patient had returned to full activity with no shortness of breath or lack of endurance. The Nuss bars were removed after three and a half years.

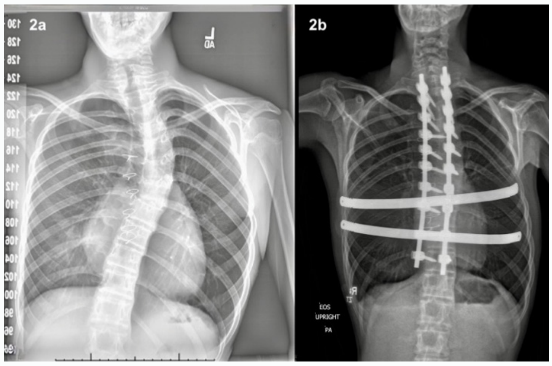

Figure 2: Preoperative and postoperative imaging of patient 2. Preoperative XR (2a, left) and postoperative XR after PE correction with Nuss bar placement and scoliosis correction using spinal instrumentation (2b, right).

Patient 3

Patient 3 is a 13-year-old male with no significant past medical history and past surgical history of myringotomy shortly after birth with a pectus excavatum and symptomatic chest pain and discomfort. PE was originally discovered at the age of 6 and was monitored until the age of 13. Preoperative Computed Tomography (CT) imaging demonstrated a HI of 76.7 and a correction index of 95% with evidence of external cardiac compression (Figure 3a). Cardiopulmonary exercise testing revealed low exercise capacity with a VO_2 max at 70% of predicted and a blunted stroke volume response at 56% of predicted. He underwent a minimally invasive Nuss procedure for PE correction with 2 bars. No intraoperative or postoperative complications occurred, and hospital stay was two days.

The patient was referred for their scoliosis and XR imaging revealed a thoracic curvature with a Cobb angle of 54 degrees (Figure 3b). The indication for surgical correction was based on curve magnitude and risk of progression. He underwent posterior spinal fusion with arthrodesis from T2 to T11, one year after PE repair. The procedure was uncomplicated, and postoperative hospital stay was three days. Post-operative XR with Nuss bars and spinal instrumentation seen in Figure 3c.

At most recent follow-up, the patient had returned to full activity with no shortness of breath or lack of endurance. Nuss bars remained in place at the time of most recent evaluation.

Patient 4

Patient 4 is a 14-year-old male with a past medical history of Ehlers-Danlos Type VI and no past surgical history who planned for surgical correction for PE prior to repair of his scoliosis. Preoperative CT revealed a HI of 9.2 and a correction index of 64% with external cardiac compression. The patient experienced symptomatic exercise intolerance compared to peers. Cardiopulmonary exercise testing revealed low exercise capacity with a VO_2 max at 61% of predicted and a blunted stroke volume response at 65% of predicted. He underwent

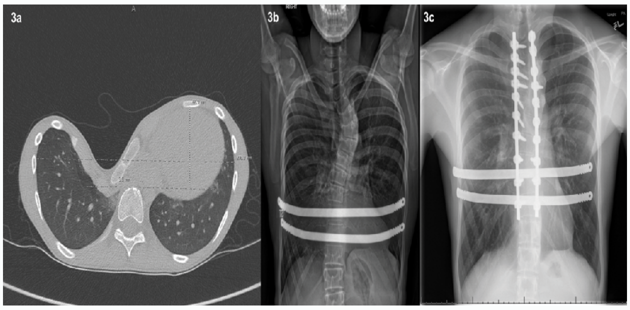

Figure 3: Preoperative and postoperative imaging of patient 3.
Preoperative CT with HI of 76.7 (3a, left). Anterior XR (3b, middle) demonstrates PE correction with Nuss bars prior to scoliosis surgery. Anterior XR (3c, right) demonstrates both subsequent scoliosis correction.

a thoracoscopic Nuss procedure with the placement of three titanium bars. There were no intraoperative or immediate postoperative complications, and hospital stay was one day.

Regarding this patient's scoliosis, XR demonstrated a thoracic curvature with a Cobb angle of 64 degrees (Figure 4a). Surgical correction was indicated based on the severity of the curve and anticipated progression. He underwent posterior spinal fusion with segmental instrumentation from T2 to L4, 6 months after Nuss procedure. During intraoperative positioning in the prone position, the patient experienced a brief episode of hypotension, which stabilized promptly, allowing the procedure to proceed without further complication. The postoperative hospital stay was three days, and there were no reported surgical complications. Post-operative XR with Nuss bars and spinal instrumentation seen in Figure 4b.

At most recent follow-up, the patient had returned to full activity with no shortness of breath or lack of endurance. Nuss bars remained in place at the time of his most recent evaluation.

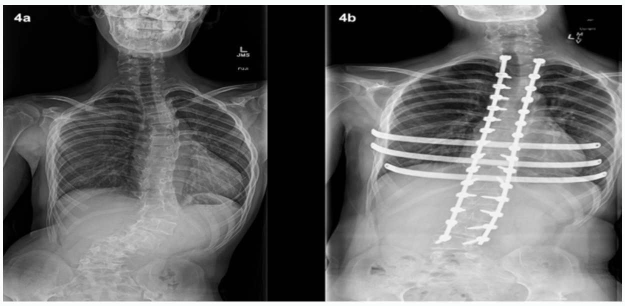

Figure 4: Preoperative and postoperative imaging of patient 4.
Preoperative XR showing uncorrected PE and scoliosis (4a, left) and postoperative XR demonstrating PE correction with Nuss bar placement and scoliosis correction using spinal instrumentation (4b, right).

Patient 5

Patient 5 is a 15-year-old male with a past medical history of sacral agenesis and a past surgical history of lumbar laminectomy and spinal cord detethering at the age of 10. Patient was initially evaluated for PE and was sent to the spine surgeon following the initial exam and imaging for his severe scoliosis (Figure 5a). The patient's symptoms included symptomatic chest pain, discomfort, but was wheelchair bound and did not experience shortness of breath. He underwent a pectus workup and was found to have a Haller index of 7.2 and a correction index of 37% on MRI. Cardiopulmonary exercise testing revealed low exercise capacity with a VO_2 max at 55% of predicted and a blunted stroke volume response at 79.8% of predicted. He underwent a thoracoscopic Nuss procedure with the placement of two titanium bars. No intraoperative or postoperative complications occurred, and the hospital stay was one day.

Regarding the patient's scoliosis, XR demonstrated a thoracic curvature with a Cobb angle of 97.5 degrees. Surgical correction was indicated based on the extreme curve magnitude and associated risk of progression. He underwent posterior spinal fusion with instrumentation from T4 to L1, five months after Nuss procedure. The procedure was uncomplicated, and the hospital stay was three days. Post-operative XR with Nuss bars and spinal instrumentation seen in Figure 5b.

At most recent follow-up, the patient had returned to full activity with no shortness of breath or lack of endurance. Nuss bars remained in place at the time of most recent evaluation.

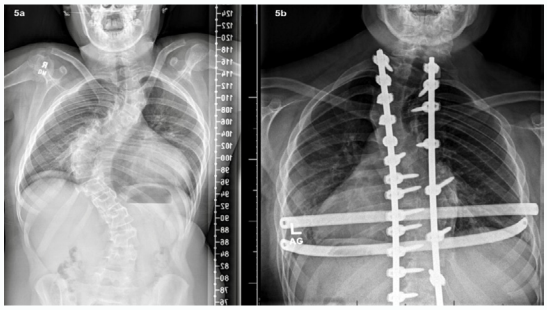

Figure 5: Preoperative and postoperative imaging of patient 5.
Preoperative XR (5a, left) and postoperative XR demonstrating PE correction and scoliosis correction (5b, right)

Patient 6

Patient 6 is a 15-year-old male with a past medical history of Neurofibromatosis Type I and no past surgical history who planned for surgical correction for PE prior to repair of scoliosis. The patient was being followed by orthopaedic surgery for scoliosis progression and was evaluated for PE correction at age of 15. Order of repair was discussed and both surgeons agreed that PE correction should occur before scoliosis correction. Preoperative XR showing uncorrected pectus and scoliosis is seen in Figure 6a. The patient experienced symptomatic exercise intolerance compared to peers. Preoperative CT scan showed Haller index of 3.9 and a correction index of 19.2%. Cardiopulmonary exercise testing revealed low exercise capacity with a VO_2 max at 60.0% of predicted and a blunted stroke volume response at 74.6% of predicted. The patient underwent a thoracoscopic Nuss procedure with the placement of two titanium bars. No intraoperative or postoperative complications occurred, and the hospital stay was four days.

Regarding this patient's scoliosis, XR demonstrated a thoracic curvature with a Cobb angle of 65.0 degrees. Surgical correction was indicated based on the growing curve magnitude and associated risk of progression. Patient underwent posterior spinal fusion with instrumentation from T3 to L3, sixteen months after Nuss procedure. The procedure was uncomplicated, and the hospital stay was three days. Post-operative XR with Nuss bars and spinal instrumentation seen in Figure 6b.

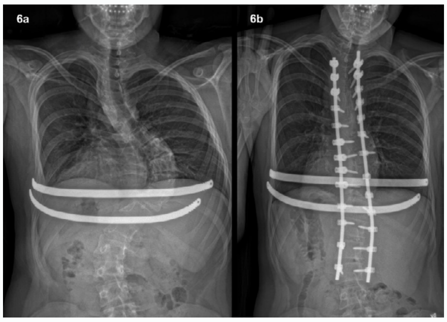

Figure 6: Preoperative and postoperative imaging of patient 6. XR showing corrected pectus excavatum and uncorrected scoliosis (6a, left) and postoperative XR demonstrating PE correction and scoliosis correction (6b, right).

At most recent follow-up, the patient had returned to full activity with no shortness of breath or lack of endurance and Nuss bars had been removed.

Results summary

Overview of results can be seen in Table 1. Across the cohort, the mean age at PE surgery was 14.3 years (range 12-18). The mean Cobb angle was 67.4° (SD 16.1, range 54-97.5°). The mean Haller index was 6.8 (SD 1.9, range 3.9-9.2). The mean VO_2 max was 60.8% predicted (range 55% to 70%). Length of stay following scoliosis surgery was uniform at 3 days for all patients. Length of stay after PE repair averaged 2.5 days (SD 2.1, range 1-6 days).

Overall, 5 of 6 patients (83%) underwent PE correction prior to scoliosis surgery and experienced stable intraoperative courses. The single patient who underwent attempted scoliosis correction first developed significant hemodynamic compromise, reinforcing concerns about uncorrected PE compromising cardiopulmonary function during scoliosis repair.

Discussion

All six patients underwent pectus excavatum repair prior to scoliosis correction. For patient 1, we saw that when scoliosis surgery was attempted first, he had an unsafe drop in vital signs when put in prone positioning and PE correction was subsequently performed. The prone position can significantly increase intra-abdominal pressure, which can compress major blood vessels, reduce venous return to the heart potentially causing a decrease in cardiac output and hemodynamic instability. Also, a higher Haller index has been associated with increased cardiopulmonary dysfunction. With patient 1 having a HI greater than 5 and a thoracic curvature in excess of 70 degrees, we hypothesize that the presence of a significantly large thoracic curvature and/or large HI can play a dominant role in the hemodynamic instability caused when scoliosis surgery is performed before PE correction.

This hypothesis is supported by the retrospective study by Tauchi, et al. [11]. They evaluated the impact of scoliosis correction on thoracic morphology in 20 patients with concurrent PE and scoliosis with an average preoperative Cobb angle was 72.1°, and mean age of 13.2. The authors found that the mean Haller index increased from 4.8 preoperatively to 5.3 postoperatively, with one illustrative case demonstrating an extreme rise in Haller index from 8.0 to 15.4 postoperatively, with notable cardiac compression on imaging. The authors hypothesize that sagittal alignment changes and rotational corrective forces during posterior instrumentation may reduce the anterior-posterior diameter of the chest, thereby worsening sternal depression. The authors also hypothesized that scoliosis surgery alone in individuals with concomitant PE, particularly in patients with flexible or anteriorly displaced sternums, may exacerbate PE and contribute to cardiopulmonary risk postoperatively. As a result, Tauchi, et al. suggested that high-risk patients with a severely steep, left-deviated and deeply depressed (high HI) sternum should first receive surgical treatment of PE and then corrective scoliosis surgery to minimize the negative impact on the cardiac function from the PE deformity [11].

A case report by Oka et al. [24] further highlights the potential cardiopulmonary risks of correcting scoliosis prior to PE repair. The authors describe a 49-year-old woman who developed worsening dyspnea after undergoing posterior spinal fusion for scoliosis. Imaging revealed that the spinal correction maneuver had narrowed the mediastinal space, resulting in compression of the right Inferior Pulmonary Vein (IPV) between the thoracic vertebrae and a severely depressed sternum. To alleviate the resulting ventilation-perfusion mismatch and venous stenosis, the patient underwent a combined Ravitch and Nuss procedure (CRN), which led to successful sternal elevation and symptomatic improvement. This case provides direct anatomical evidence that scoliosis correction in the presence of uncorrected PE may exacerbate cardiovascular compression, particularly in patients with rigid thoracic anatomy. The authors suggest that repairing PE prior to scoliosis surgery may preserve the retrosternal space and mitigate the risk of cardiopulmonary compromise. Their findings further support the growing consensus that prioritizing PE correction, especially in patients with severe sternal depression, may be essential to avoid postoperative complications.

This is also further illustrated in a case report by Keefe et al. [25], in which they describe a patient with a HI of 19.2 who attempted to have scoliosis surgery and as they were correcting the scoliosis intraoperatively the patient had an acute hypotensive episode after placement of a single rod. Multiple attempts were made and every time the correction manoeuvre was attempted, the patient would become acutely hypotensive. They aborted scoliosis correction until after PE correction (in which HI improved from 19.3 to 4.7), and patient had no perioperative complications with the scoliosis procedure. They

Table 1: Patient demographics, thoracic, and cardiopulmonary characteristics of patients with concurrent pectus excavatum and scoliosis.

Patient	Age at First Operation	Haller Index	Correction Index (%)	Scoliosis Curvature (°)	VO_2 Max (% predicted)	Stroke Volume Response (% predicted)
1	14	5.2	19	70	67	61
2	19	7.6	61.7	54	58	53
3	14	76.7	95	54	70	56
4	14	9.2	64	64	61	65
5	15	7.2	37	97.5	55	79.8
6	13	3.9	64	65	60	74.6

Footnote: VO_2 max and stroke volume response reflect preoperative Cardiopulmonary Exercise Testing (CPET) values.

hypothesized that the temporal relationship between corrective manoeuvre and hypotension supported an anatomic cause of the hypotension, most likely related to an elevated HI. Although Patient 1 in our cohort had a relatively modest Haller index compared to the patient described by Keefe et al. [25], the intraoperative instability observed in both cases supports the hypothesis that anatomical configuration.

Our findings support the prioritization of PE repair before scoliosis correction in patients with both deformities. Uncorrected PE can contribute to significant intraoperative cardiopulmonary compromise during scoliosis correction surgery. Patient 1's intraoperative instability despite a relatively modest HI (5.2) and normal preoperative vitals highlights this risk. Conversely, all patients in our cohort who underwent PE correction proceeded through scoliosis surgery without complication, including patients with severe scoliosis curvature (up to 97.5°), syndromic conditions (Ehlers-Danlos syndrome), and extremely elevated Haller indices (up to 76.7) [26].

We believe that it is not merely the absolute value of the HI or Cobb angle that determines surgical risk, but the anatomic relationship between a posteriorly displaced sternum and the anterior spinal column. Intraoperative positioning, especially prone positioning for scoliosis correction, can exacerbate retrosternal compression, compromising venous return and right heart filling, even in patients with only moderately elevated Haller indices. Thus, the correction of PE may act as a necessary decompressive intervention to restore thoracic compliance and retrosternal space before safely undertaking spine correction. This mirrors the mechanistic findings of Oka et al. and Tauchi, et al. Who demonstrated that scoliosis correction can worsen chest wall depression or cause vascular compression in the absence of prior PE repair [11,24]. In evaluating a patient with scoliosis, the orthopaedic surgeon should take steps to evaluate the pectus excavatum to determine surgical risk.

Limitations

This study has several limitations. First, the sample size is small (n=6), limiting broad generalizability and precluding statistical modelling. However, the uniformity of outcomes, specifically, the resolution of perioperative instability after PE-first repair, strengthens the validity of our clinical observations. Second, as a retrospective single-center study, it is vulnerable to selection and information bias. Surgical sequencing was not randomized but determined through interdisciplinary consensus between thoracic surgery, orthopedic surgery, and anaesthesia teams, introducing potential institutional and selection bias. Third, our cohort lacked representation from milder cases of PE or AIS, which may behave differently with respect to sequencing. Finally, standardized thoracic indices such as sternal tilt, cross-sectional thoracic volume, or post-operative Haller indices were not routinely collected, which could further quantify the physiologic benefit of PE correction. Future multi-institutional prospect.

Future Directions

Future research should focus on defining clear thresholds for surgical intervention in patients with concurrent pectus excavatum and scoliosis by incorporating combined severity indices such as Haller index, Cobb angle, sternal tilt angle, thoracic volume, and cardiopulmonary function metrics. Large, multi-institutional retrospective studies could help identify which patients are at highest risk for perioperative complications depending on the order of repair. Prospective studies are needed to establish evidence-based guidelines on the optimal timing and sequencing of interventions, particularly in patients with severe deformities. Simultaneous correction remains an area of interest and future translational studies should evaluate the safety, feasibility, and biomechanical effects of simultaneous correction strategies, particularly in cases where thoracic flexibility and patient anatomy may permit such an approach.

Conclusion

Given our patient cohort, we recommend performing PE correction prior to scoliosis surgery to reduce the risk of perioperative hemodynamic instability during scoliosis correction. Future studies should aim to define surgical thresholds using combined severity indices and establish evidence-based guidelines for sequencing interventions in patients with concurrent deformities.

References

1. Hong JY, Suh SW, Park HJ, Kim YH, Park JH, Park SY. Correlations of adolescent idiopathic scoliosis and pectus excavatum. J Pediatr Orthop. 2011;31(8):870-4.
2. Jaroszewski D, Notrica D, McMahon L, Steidley DE, Deschamps C. Current management of pectus excavatum: a review and update of therapy and treatment recommendations. J Am Board Fam Med. 2010;23(2):230-9.
3. Zhong W, Ye J, Feng J, Geng L, Lu G, Liu J, et al. Effects of pectus excavatum on the spine of pectus excavatum patients with scoliosis. J Healthc Eng. 2017;2017:5048625.
4. Beltsios ET, Mitsos SL, Panagiotopoulos NT. Pectus excavatum and scoliosis: a review about the patient's surgical management. Gen Thorac Cardiovasc Surg. 2020;68(11):1225-33.
5. Frick SL. Scoliosis in children with anterior chest wall deformities. Chest Surg Clin N Am. 2000;10(2):427-36.
6. Kelly RE, Mellins RB, Shamberger RC, Mitchell KK, Lawson ML. Pectus excavatum in a 112-year autopsy series: anatomic findings and the effect on survival. J Pediatr Surg. 2005;40:1275-8.
7. Jada A, Mackel CE, Hwang SW, Samdani AF, Stephen JH, Bennett JT, et al. Evaluation and management of adolescent idiopathic scoliosis: a review. Neurosurg Focus. 2017;43(4):E2.
8. Maruyama T, Takeshita K. Surgery for idiopathic scoliosis: currently applied techniques. Clin Med Pediatr. 2009:3:39-44.
9. van Es LJM, van Royen BJ, Oomen MWN. Clinical significance of concomitant pectus deformity and adolescent idiopathic scoliosis: systematic review with best evidence synthesis. N Am Spine Soc J. 2022:11:100140.
10. Park HJ, Kim JJ, Park JK, Moon SW. Effects of Nuss procedure on thoracic scoliosis in patients with pectus excavatum. J Thorac Dis. 2017;9(10):3810-6.
11. Tauchi R, Kawakami N, Tsuji T, Ohara T, Suzuki Y, Saito T, et al. Evaluation of thoracic factors after scoliosis surgery in patients with both scoliosis and pectus excavatum. Eur Spine J. 2018;27(2):381-7.
12. Ghionzoli M, Martin A, Bongini M, Bongini U, Ciuti G, Grisotto L, et al. Scoliosis and pectus excavatum in adolescents: does the Nuss procedure affect the scoliotic curvature? J Laparoendosc Adv Surg Tech A. 2016;26(9):734-9.
13. Floccari LV, Sucato DJ, Ramo BA. Scoliosis progression after the Nuss procedure for pectus excavatum: a case report. Spine Deform. 2019;7(6):1003-9.
14. İşcan M, Turna A, Kaynak MK. The effect of minimally invasive pectus excavatum repair on thoracic scoliosis. Eur J Cardiothorac Surg. 2020:ezaa328.
15. Nagasao T, Noguchi M, Miyamoto J, Jiang H, Ding W, Shimizu Y, et al. Dynamic effects of the Nuss procedure on the spine in asymmetric pectus excavatum. J Thorac Cardiovasc Surg. 2010;140(6):1294-9.
16. Chu CC, Chang JW, Yang HH, Kuo FC, Tsai HL. Experience in minimally invasive Nuss operation for 406 children with pectus excavatum. J Chin Med Assoc. 2024;87(3):314-9.
17. Kuru P, Bostanci K, Ermerak NO, Bahadir AT, Afacan C, Yuksel M. Quality of life

improves after minimally invasive repair of pectus excavatum. Asian Cardiovasc Thorac Ann. 2015;23(3):302-7.

18. Chung JH, Park HJ, Kim KT. Scoliosis after pectus excavatum correction: does it improve or worsen? Eur J Cardiothorac Surg. 2017;52(1):76-82.
19. Meng Y, Lin T, Shao W, Gao R, Zhou X. Acquired scoliosis following Nuss procedure for pectus excavatum: a case report. Medicine (Baltimore). 2019;98(1):e13855.
20. Niedbala A, Adams M, Boswell WC, Considine JM. Acquired thoracic scoliosis following minimally invasive repair of pectus excavatum. Am Surg. 2003;69(6):530-3.
21. Alexianu D, Skolnick ET, Pinto AC, Ohkawa S, Roye DP, Solowiejczyk DE, et al. Severe hypotension in the prone position in a child with neurofibromatosis, scoliosis and pectus excavatum presenting for posterior spinal fusion. Anesth Analg. 2004;98(2):334-5.
22. Bafus BT, Chiravuri D, van der Velde ME, Chu BI, Hirshl R, Farley FA. Severe hypotension associated with the prone position in a child with scoliosis and pectus excavatum undergoing posterior spinal fusion. J Spinal Disord Tech. 2008;21(6):451-4.
23. Galas JM, van der Velde ME, Chiravuri SD, Farley F, Parra D, Ensing GJ. Echocardiographic diagnosis of right ventricular inflow compression associated with pectus excavatum during spinal fusion in prone position. Congenit Heart Dis. 2009;4(3):193-5.
24. Oka N, Masai K, Okubo Y, Kaseda K, Hishida T, Asakura K. Combined Ravitch and Nuss procedure for pectus excavatum with dyspnea following scoliosis repair. J Surg Case Rep. 2023;2023(11):rjad618.
25. Keefe G, Beauchamp EC, Lilly JD, Duron VP, Anderson RCE, Vitale MG, et al. Intraoperative hemodynamic instability in concomitant pectus excavatum and scoliosis. Ann Thorac Surg Short Rep. 2023;1(3):454-57.
26. Swanson JW, Avansino JR, Phillips GS, Yung D, Whitlock KB, Redding GJ, et al. Correlating Haller Index and cardiopulmonary disease in pectus excavatum. Am J Surg. 2012;203(5):660-4.