24th ANNUAL CONGRESS OF THE CHEST WALL INTERNATIONAL GROUP
PHOENIX ADVANCED PECTUS COURSE 2024

ABSTRACTS

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ORAL ABSTRACT PROGRAM

★ *5-minute presentation & 3 min Q&A*
★ *3-minute presentation & 2 min Q&A*
The presenting author is in blue bold

Wednesday, October 23, 2024

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★ **Utilizing artificial intelligence for the prediction of cardiopulmonary improvement after Pectus Excavatum repair**
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★ **Predicted Peak Oxygen Uptake as a cardiopulmonary function marker: Assessing disease impact in Pectus Excavatum**
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★ **The electrocardiographic manifestations of Pectus Excavatum before and after surgical correction**
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★ **The effect of atrioventricular groove compression on cardiopulmonary function in patients with Pectus Excavatum**
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★ **Multidisciplinary assessment of standard low dose versus ultra-low dose chest CT scans for Pectus Excavatum imaging**
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★ **Impaired right ventricular remodeling and function as assessed by cardiac MRI in adolescents with Pectus Excavatum**
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Improving Quality of Life with Dynamic Compression Bracing in Patients with Pectus Carinatum
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Safety protocol for bar removal after the Nuss procedure Analysis of results after 5 years of implementation
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- **Proposal of a new semi-automated volumetric thoracic index for the evaluation of severity in Pectus Excavatum**
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- **Does a high Haller Index impact outcomes in Pectus Excavatum repairs**
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- **Beyond the Chest: A novel approach to assess cardiovascular strain in Pectus Excavatum patients**
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- **Efficacy of the Nuss procedure in patients with asymmetric Pectus Excavatum**
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- **Alternative treatment of Pectus Excavatum - the method of choice?**
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  Cecilia Gigena, **Luzia Toselli**, Maxroxia Vallee, Daniela Sanjurjo, Gaston Bellia-Munzon

- **Life threatening spontaneous pneumothorax after Pectus Excavatum repair due to buffalo chest: Are congenital blebs an underestimated risk factor?**
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- **Thoracoscopic intercostal nerve thermal radiofrequency ablation (INTRA) for postoperative pain relief after the Nuss procedure. Is it safe and effective?**
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- **Vacuum bell therapy for Pectus Excavatum: Long-term experience at a single center**
  Shelby Aughtman, Robert Obermeyer, Michael Goretsky, Jamie Golden, Charles T Hehman

- **Importance of immediate postoperative pneumothorax after MIRPE**
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Moderators: Dr. John DiFiore & Dr. Mark Molitor

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- **PurePectus Bars: Learning Curve**
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- **Results of vacuum therapy in Pectus Excavatum patients**
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- **Effect of vacuum bell therapy on subcutaneous fat of chest wall in patients with Pectus Excavatum**
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Innovative surgical repair of severe Pectus Carinatum using 3d surgical planning and advanced rib fixation techniques
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My Nightmares - 1522

Moderators: Dr. Hyung Joo Park & Dr. Dawn Jaroszewski

8-minute presentation & 4 min Q&A

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Disaster preparedness: Getting ready for potential cardiac injury during MIRPE in a patient with previous sternotomy
Matias Nicolas, Alejandro Carmona, Juan Carlos Climente, Luzia Toselli, Daniela Sunjurjo, Gaston Bellia-Munzon

My Biobridge nightmare
Dawn Jaroszewski

The Sternum Strikes Back! – Hammock stitching to the rescue for a rigid sternum
Megan Zaiyi Chiu, Donna Koo, Tom Jaksic, Farokh Demehri

A year of pain: Painfulness after initial Nuss
Jeffrey Zitsman

ORAL PRESENTATION ABSTRACTS

Utilizing Artificial Intelligence for the Prediction of Cardiopulmonary Improvement After Pectus Excavatum Repair

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Authors: Juan M Farina[1] MD, Kenan A Shawwaf[1] MD, Rawan M Zeineddine[1] MD, Andrew Saleeb[1] MD, Dawn E Jaroszewski[1] MD
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Disclosure: Dawn Jaroszewski discloses consulting and IP/royalties through Mayo Clinic Ventures with Zimmer Biomet, Inc Other authors report no conflict of interest

Background and Aim: The cardiopulmonary implications of Pectus Excavatum (PEx) are not completely understood The degree of cardiopulmonary limitations and the possibilities of improvement following surgery are heterogeneous and could be influenced by several factors Machine learning predictive models, a subset of artificial intelligence, are algorithms that utilize patient-specific variables to predict outcomes and have not been largely applied to PEx populations This study aims to developan artificial intelligence-based model to predict the cardiopulmonary improvement of PEx patients following a minimally invasive repair

Method: A machine learning model using neural networks was developed to predict the probability of a patient to improve the cardiopulmonary function following a minimally invasive repair of PEx Patients from a single institution with pre- and post-operative Cardiopulmonary Exercise Testing (CPET) were included Postoperative improvement was defined as the normalization of CPET following surgery A training and a validation cohort were created, and accuracy of the model was tested using confusion matrix and ROC curves

Results: In total 121 patients were included, 70 in the training cohort and 51 in the validation cohort Ten variables were chosen as potential predictors from preoperative demographics, Computed Tomography and Echocardiography results **(Table)** In the training cohort, the model was able to achieve an accuracy of 786%, sensitivity of 788%, and specificity of 784% (ROC curve 078) **(Figure)** The adequate accuracy of the model was confirmed in the validation cohort, with an accuracy of 720% (AUC 073)

Conclusions: This novel and easy to apply artificial intelligence predictive model could have great clinical utility With the use of only ten predictors that are widely available in PEx patients, it can predict with adequate accuracy the chances of a patient to improve the cardiovascular function following a surgical intervention, thus facilitating decision making at the preoperative stage

Figure:

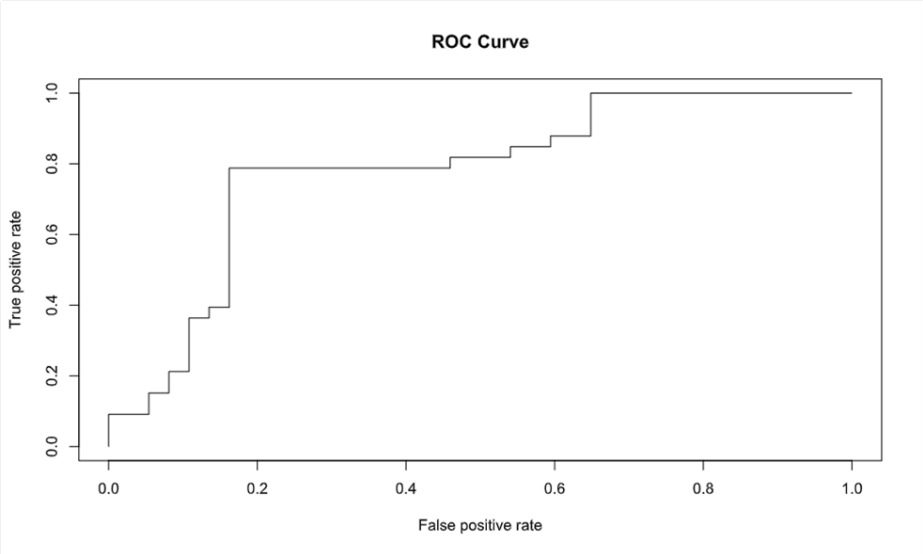

Table:

Demographics	**CT scan**	**Echocardiography**
Sex	Haller Index	Ejection Fraction
Age	Correction Index	Right Ventricular Compression
Body Mass Index	Sternal Tilt	
	Asymmetry Index	
	Presence of Asymmet	

Table:

Demographics	**CT scan**	**Echocardiography**
Sex	Haller Index	Ejection Fraction
Age	Correction Index	Right Ventricular Compression
Body Mass Index	Sternal Tilt	
	Asymmetry Index	
	Presence of Asymmetry	

Predicted Peak Oxygen Uptake as a Cardiopulmonary Function Marker: Assessing Disease Impact in Pectus Excavatum

Presenting Author: Rebeccah L Brown, MD, FACS, FAAP, Professor of Clinical Surgery and Pediatrics Cincinnati Children's Hospital Medical Center

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Background: The impact of pectus excavatum on cardiopulmonary function remains controversial Cardiopulmonary exercise testing (CPET) is often performed to assess functional impact in this patient population One well-established measure of functional capacity is the percent predicted peak oxygen uptake (VO2) We sought to evaluate the association of predicted peak VO2 extremes (<80% and >95%) with patient and pectus characteristics to better delineate its applicability as a marker of disease or indication for treatment

Methods: Single center retrospective study including patients diagnosed with pectus excavatum between 2017 and 2022 Patient demographics, symptoms, imaging (cardiac MRI), and cardiopulmonary function were evaluated

Results: Of 678 patients who underwent CPET, 444 were categorized into low <80% predicted (n=257) and high >95% predicted (n=187) VO2 groupings Patients were mean age 153 years, predominantly male (77%), white race (98%), and 594 (75%) were symptomatic with shortness of breath, chest pain, and/or exercise intolerance In univariate analysis, lower peak VO2 was significantly associated with male gender, deeper pectus indices (Haller and correction index), and lower pulmonary function (FEV1, FVC, FEV1/FVC, and TLC) (p<005) There was however no correlation with extremes of peak VO2 and biventricular function or z-scores After adjustment, older patients (>18 years), males, and higher correction index were significantly associated with lower percent predicted peak VO2 (p<005) There was no correlation with symptoms on both univariate and multivariate analysis

Conclusion: In patients with pectus excavatum, peak VO2 differs according to age and gender with males and older patients >18 years more significantly impacted; however, it also decreases with increased severity of the defect Symptoms, however, are not predictive Peak VO2 may be a useful indicator of impaired cardiopulmonary function in patients with severe pectus deformities Further studies are warranted to assess the impact of repair

Table 1 Demographic and Clinical Characteristics by VO2 Group (Low, High) in patients with Pectus Excavatum

	Low VO2 (<80)	*High VO2 (>95)*	*p-value*
N	257	187	
Age (years), mean (SD)	158 (39)	147 (45)	0008
Age < 18 years, % (n)	821% (211)	909% (170)	0009
Male, % (n)	887% (228)	615% (115)	<0001
White race, % (n)	988% (254)	973% (182)	029
Haller, median (Q1, Q3)	49 (39, 67)	46 (40, 53)	0042
Depression, mean (SD)	066 (034)	068 (053)	081
Correction, mean (SD)	350 (165)	308 (139)	0004
CCI, mean (SD)	288 (133)	282 (121)	063
Sternal Torsion, mean (SD)	133 (104)	131 (98)	088
RVEF, mean (SD)	536 (49)	537 (47)	081
RVEF z-score, mean (SD)	-174 (169)	-181 (106)	061
LVEF, mean (SD)	587 (43)	584 (40)	038
LVEF z-score, mean (SD)	-111 (092)	-112 (082)	092
FEV1, mean (SD)	889 (123)	964 (123)	<0001
FVC, mean (SD)	893 (127)	984 (124)	<0001
FEV1/FVC, mean (SD)	903 (110)	880 (96)	0030
TLC, mean (SD)	988 (131)	1017 (137)	0033

CCI (Cardiac Compression Index), RVEF (Right Ventricular Ejection Fraction), LVEF (Left Ventricular Ejection Fraction), FEV1 (Forced Expiratory Volume in 1 second), FVC (Functional Vital Capacity), TLC (Total Lung Capacity)

The electrocardiographic manifestations of pectus excavatum before and after surgical correction

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Disclosures:
Presenting author has no conflicts of interest.
Dawn Jaroszewski discloses consulting and IP/royalties through Mayo Clinic Ventures with Zimmer Biomet, Inc and ArtiCure, Inc. Other authors report no conflict of interest.

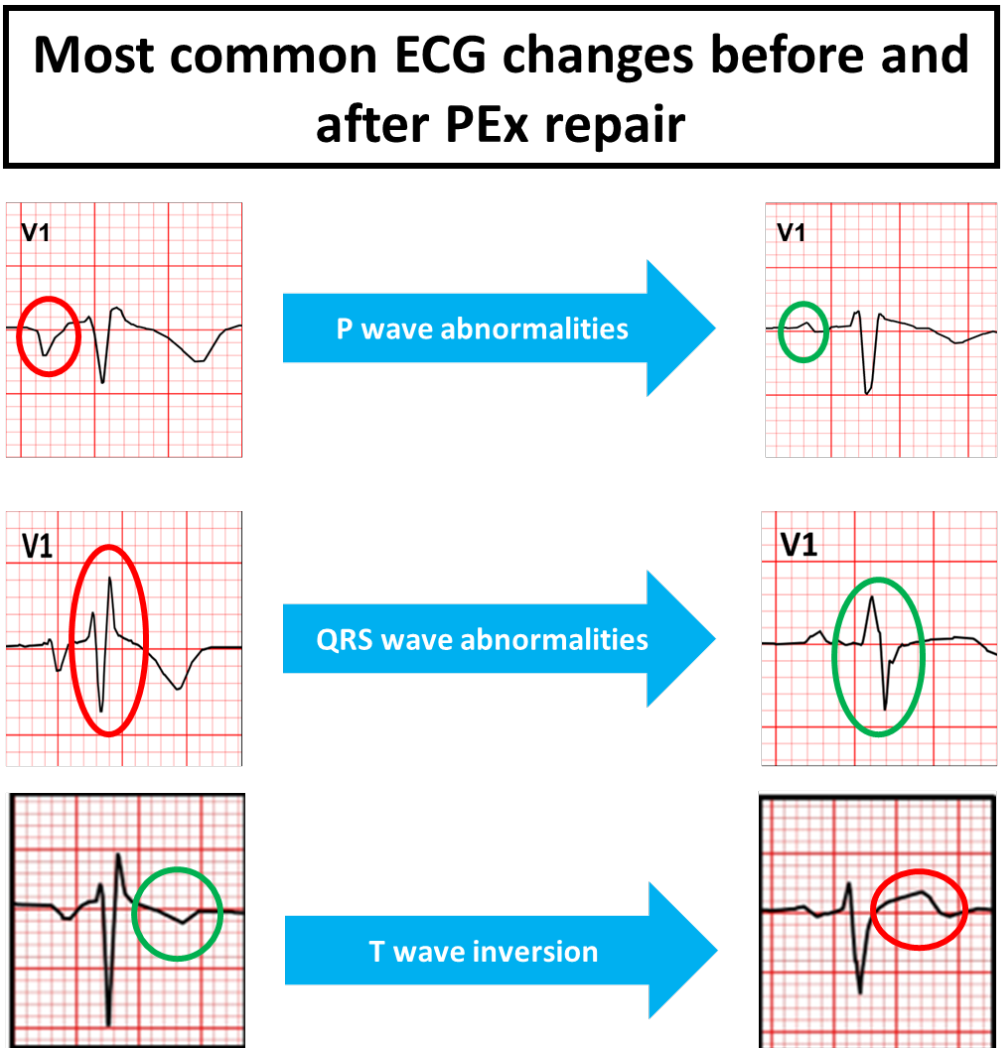
Background: Pectus excavatum (PEx) may compress and displace the heart causing limited cardiopulmonary function. The literature has limited information on electrocardiogram (ECG) changes before and after PEx repair. This study aims to explore PEx ECG changes before and after surgery and their relationship with exercise capacity.

Methods: A retrospective chart review was conducted for primary PEx repairs at our institution. ECGs before and after surgical correction were compared. Associations between pre-op ECG anomalies and cardiopulmonary function were investigated.

Results: In total, 315 patients were included (mean age 35.0 ± 11.4 years). Most common ECG findings that decreased in prevalence postoperatively were (**Figure**): predominant negative P wave morphology in V1 (86.0% to 57.1%, $p < 0.001$), abnormal P wave amplitude in lead II (7.4% to 1.5%, $p < 0.001$), right bundle branch block (RBBB) (9.3% to 3.8%, $p < 0.001$), rsr' patterns (40.1% to 13.1%, $p < 0.001$), and T wave inversion in leads V1-V3 (62.0% to 37.9%, $p < 0.001$). Preoperative presence of RBBB (OR = 4.8; 95%CI 1.1-21.6) and T wave inversion in leads V1-3 (OR = 2.3; 95%CI 1.3-4.2) were associated with abnormal results in cardiopulmonary exercise testings.

Conclusion: Preoperative PEx ECG abnormalities often reverses after surgical repair. RBBB and T wave inversion in V1-3 predicts reduced exercise capacity, warranting cardiovascular evaluation in this population.

Figure 1


Most common ECG changes before and after PEx repair
V1
P wave abnormalities
V1
V1
QRS wave abnormalities
V1
T wave inversion

The Effect of Atrioventricular Groove Compression on Cardiopulmonary Function in Patients with Pectus Excavatum

Presenting Author: Rebeccah L Brown, MD, FACS, FAAP, Professor of Clinical Surgery and Pediatrics Cincinnati Children's Hospital Medical Center

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Background: Beyond the obvious psychosocial and cosmetic concerns, the impact of pectus excavatum (PE) on cardiopulmonary function remains highly debated. The aim of this study was to investigate the cardiopulmonary consequences of right atrioventricular groove (AVG) compression in PE using cardiac magnetic resonance imaging (cMRI).

Methods: A retrospective single center analysis of 661 patients with PE referred for evaluation, including cMRI, CPET, and PFT, between 2017 and 2022. Patients were categorized into three groups based on the degree of right AVG compression [no compression (NC), partial compression (PC), and complete compression (CC)]. Pectus indices were measured: Haller index (HI), depression index (DI), correction index (CI), cardiac compression index (CCI), and sternal torsion.

Results (See Table 1): CC of the right AVG was seen in 30% (195/661) of patients. Mean age was 15.5 years, and older age was associated with increased right AVG compression (P<0.01). There were significant increases in all pectus indices with increasing right AVG compression (P<0.01). There were no significant differences in left ventricle ejection fraction (LVEF): NC = 58.72% ± 3.94; PC = 58.49% ± 4.02; CC = 57.95% ± 3.92 (P=0.0984), however there were significant differences in right ventricular ejection fraction (RVEF): NC = 55.2% ± 5.3; PC = 53.8% ± 4.4; CC = 53.1% ± 4.8 (P<0.0001). Notably, the tricuspid valve (TV) measurement on the 4-chamber view decreased in patients with greater compression: NC = 29.52 ± 4.6; PC = 28.26 ± 4.8; CC = 24.74 ± 5.73 (P<0.0001). PFTs (FVC and FEV1) decreased with increasing right AVG compression (P<0.01), while there were no significant differences in exercise capacity (% predicted VO2, O2 pulse, AT, breathing reserve) in those with right AVG compression compared to those without.

Conclusion: This study provides valuable insights into the cardiopulmonary consequences of right atrioventricular groove compression seen in PE.

Table 1

	No (NC) N=327	Partial (PC) N=139	Complete (CC) N=195	P-value
Demographics				
Age	14.95 ± 3.05	15.26 ± 3.07	16.39 ± 4.57	<0.01
Cardiopulmonary Exercise Test				
FVC %	101.41 ± 12.98	96.13 ± 11.69	91.44 ± 12.89	<0.01
FEV1 %	99.59 ± 12.19	93.31 ± 10.3	88.62 ± 12.03	<0.01
VO2 (ml/kg)	43.39 ± 7.98	43.71 ± 8.26	41.04 ± 8.08	<0.01
VO2 %	87.64 ± 17.23	87.29 ± 17.37	85.73 ± 16.15	0.45
AT %	64.63 ± 61.14	58.48 ± 19.14	56.39 ± 17.14	0.10
O2 pulse %	89.44 ± 17.82	88.26 ± 17.33	88.45 ± 17.68	0.73
BR %	32.72 ± 13.37	30.5 ± 11.9	30.41 ± 13.49	0.09
Pectus Indices				
Haller Index (HI)	4.15 ± 0.94	4.93 ± 1.24	7.2 ± 4.01	<0.01
Depression Index (DI)	0.47 ± 0.22	0.56 ± 0.25	0.82 ± 0.3	<0.01
Correction Index (CI) (%	23.77 ± 11.08	30.7 ± 12.14	44.76 ± 15.53	<0.01
Cardiac Compression Index (CCI)	2.28 ± 0.53	2.83 ± 0.73	3.64 ± 1.47	<0.01
Sternal Torsion (degrees)	10.73 ± 8.39	11.73 ± 7.89	18.5 ± 10.68	<0.01
Cardiac Function Measurements				
RV EF (47-67)	55.17 ± 5.33	53.76 ± 4.36	53.07 ± 4.81	<0.01
RV ESV/BSA (ml/m2) (26-62)	42.68 ± 9.58	45.14 ± 9.78	46.47 ± 11.28	<0.01
RV stroke volume/BSA (ml/m2)	52.18 ± 7.4	51.83 ± 9.5	51.59 ± 8.3	0.72
LV EF (57-77)	58.72 ± 3.94	58.49 ± 4.02	57.95 ± 3.92	0.09
LV ESV/BSA (ml/m2) (16-44)	37.03 ± 7.35	37.35 ± 7.45	38.49 ± 8.15	0.10

LV Stroke Volume/BSA (ml/m2)	52.12 ± 7.86	52.52 ± 8.21	52.41 ± 7.65	0.85

Multidisciplinary assessment of standard low dose versus ultra-low dose chest CT scans for pectus excavatum imaging

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Background and Aim: Evaluate adequacy of ultra-low dose chest computer tomography (CT) imaging for the assessment of pectus excavatum severity as determined by pediatric radiologist and pediatric surgeons using Haller (HI) and Correction indices (CI).

Methods: A single institution, retrospective evaluation of patients being evaluated for pectus excavatum were scanned with a standard low-dose chest CT protocol (CARE) followed by a consecutive ultra-low dose CT scan (ULDCT). 3 surgeons and 4 radiologists were instructed to determine HI and CI in each series. The Intraclass Correlation Coefficient (ICC) was used to calculate the agreement level between CARE and ULDCT.

Results: 32 patients had CARE and ULDCT consecutively. The ICC for HI demonstrated good reliability with a value of 0.888 and excellent reliability for CI with a value of 0.915. The reliability for HI was greater in the surgeon group (0.895) compared to the radiologist group (0.882). The reliability for CI was greater in the radiologist group (0.92) compared to the surgeon group (0.902). The Bland Altman plots for the HI and CI demonstrate no consistent bias for CARE or Ultra approach when evaluating HI and CI.

Conclusion: Ultra-low dose CT scan imaging compared to standard low-dose CT appears to be a reliable alternative for evaluating PE severity as assessed by HI and CI. This work supports the evaluation and potential development of a standardized CT imaging protocol capable of reducing radiation exposure without sacrificing imaging for PE patients.

Table 1 Individual ICC for Haller and Correction Index

ICC	Surgeon 1	Surgeon 2	Surgeon 3	Radiologist 1	Radiologist 2	Radiologist 3	Radiologist 4
HI	0.921	0.949	0.781	0.786	0.945	0.949	0.899
Lower Bound	0.848	0.901	0.604	0.613	0.892	0.898	0.s
Upper Bound	0.96	0.975	0.885	0.888	0.972	0.974	0.949
CI	0.91	0.917	0.827	0.938	0.957	0.947	0.843
Lower Bound	0.826	0.84	0.679	0.88	0.915	0.896	0.705
Upper Bound	0.954	0.958	0.91	0.969	0.978	0.974	0.92

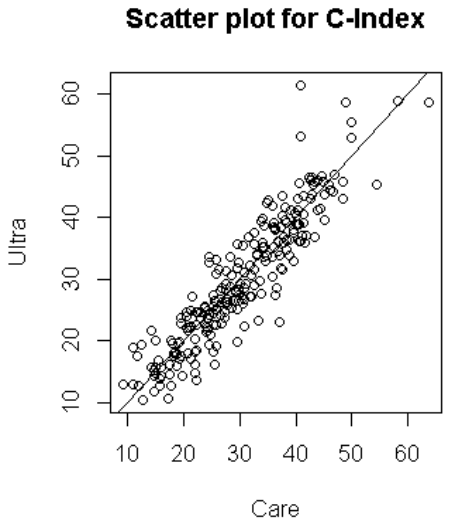

Figure 1. Demonstrates that corrective index values are nearly the same when calculated using ULTRA or CARE.

Impaired right ventricular remodeling and function as assessed by cardiac MRI in adolescents with pectus excavatum

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Presentation type request: oral and poster
Conflicts of Interest: none

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Background: Pectus excavatum (PE) is a common chest wall abnormality characterized by posterior depression of the sternum. Clinical features include chest pain, shortness of breath, dizziness, exercise intolerance, and body image disturbance. The use of cardiac magnetic resonance imaging (CMR) in PE has increased due to its unique ability to identify structural and functional abnormalities of the right ventricle, which lies directly behind the sternum. The purpose of this study was to evaluate the association of PE severity (Haller index) with CMR parameters of right ventricular (RV) size and function, as well as cardiovascular performance by cardiopulmonary exercise testing (CPET).

Methods: A single-center, IRB-approved, retrospective review of 62 consecutive children and adolescents with PE (ages 8- 20 years; mean 15.6 years) was performed between 2021 and 2023. The indexed left ventricular (LV) and right ventricular (RV) end-diastolic (EDVi) and end-systolic volumes (ESVi), and ejection fractions (EF), were calculated. Maximal oxygen consumption (VO2max) and oxygen pulse (a surrogate for LV stroke volume), were calculated from the CPET and adjusted for weight.

Results: The majority of our cohort was non-white [26 Hispanic (42%), 22 White (35%), 6 Asian (10%), and 8 Other (13%)]. As expected, most of the subjects were male (86%). Median HI was 4.4 [3.8,5.1] at inspiration and 6.2 [4.7,7.5] at expiration. Both the VO2 max and O2 pulse were lower than normal in terms of percent predicted (68% and 70%, respectively). RVESVi was elevated above normal 27% of subjects and the RVEF was diminished in 71%. The LV was relatively less affected. A larger RVESVi was associated with a higher inspiratory HI (Figure).

Conclusions: Limitations to cardiovascular function and abnormalities in RV remodeling are evident in adolescents with PE. Data from CMR and CPET may help identify patients in whom surgical repair of PE may be most beneficial.

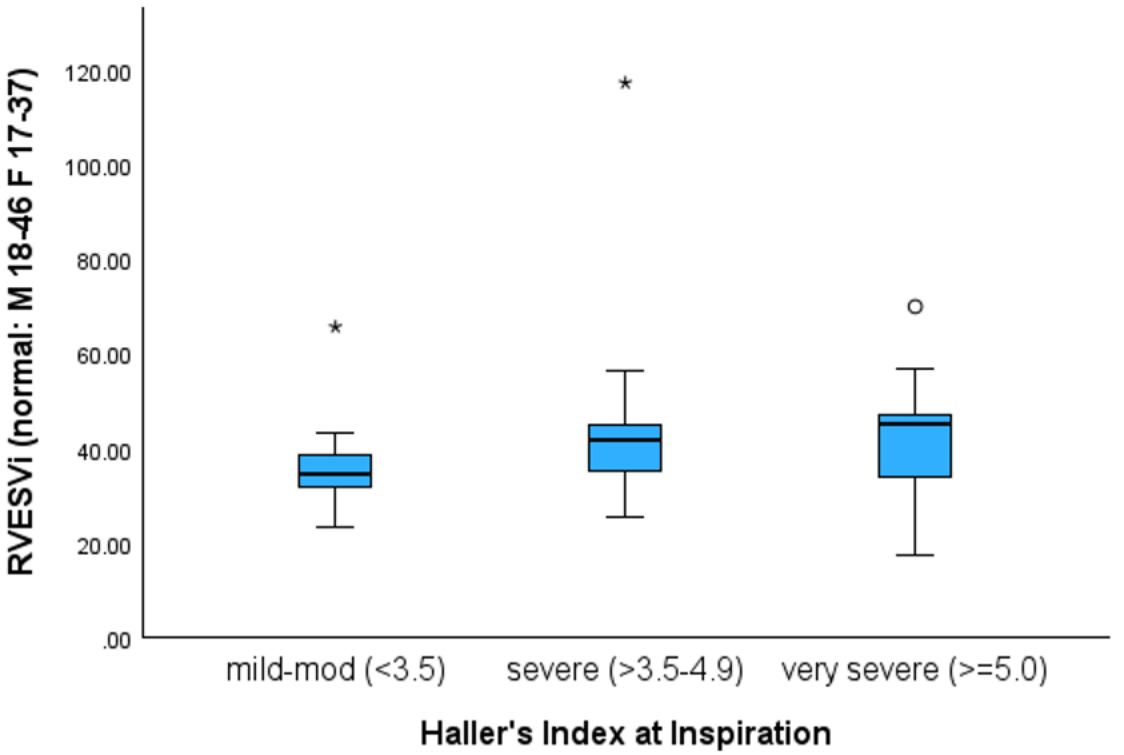

Figure. RVESVi tended towards lower values with milder Haller's index values at inspiration, median [IQR]: mild-mod, 34.8 [31.9, 38.5]; severe, 41.8 [35.5, 45.2]; very severe, 45.3 [34.1, 47.0]; p=.052, Kruskal-Wallis test. RV end-systolic volume and systolic function were both adversely affected in our cohort, especially in patients with more severe PE.

Revision after prior failed pectus excavatum repair: higher risks and greater complications than primary surgery

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Disclosures:
Presenting author has no conflicts of interest.
Dawn Jaroszewski discloses consulting and IP/royalties through Mayo Clinic Ventures with Zimmer Biomet, Inc and ArtiCure, Inc. Other authors report no conflict of interest.

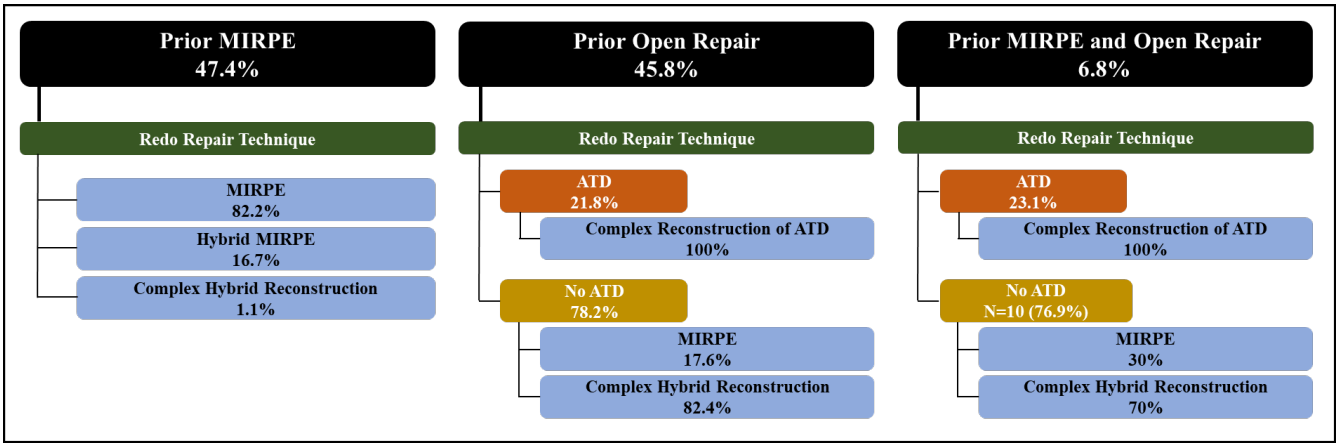
Background: Reoperation for a prior failed pectus excavatum (PE) repair is sometimes necessary. These surgeries and procedures may be technically more complex and carry higher risks of complications. This study assesses the outcomes of adult patients undergoing revision procedures.

Methods: A retrospective review of adult patients who underwent revision of a prior PE repair from 2010 to 2023 at our institution was performed. Patients were classified by prior procedure (minimally invasive repair of PE [MIRPE], Open/Ravitch, and both) and the type of revision procedure performed (MIRPE, hybrid MIRPE, complex hybrid reconstruction, or complex reconstruction of acquired thoracic dystrophy [ATD]).

Results: In total, 193 revision cases were included, (mean age was 33 ±10 years; 72.6% males, mean Haller Index: 4.4 ±1.8). Most of the patients with a prior MIRPE (82.2%) were repaired successfully with a revision MIRPE, while most of those with a prior open repair (85%) required complex reconstructions (Figure). None of the ATD patients attempted revision MIRPE (Table). Operative times varied, with the shortest being in the MIRPE redo approach (3.5 ±1.3 hours) and longest in the complex reconstruction of ATD patients (6.9 ± 1.8 hours; $p < 0.001$). The median hospital stay was 5 days (IQR 3.0), being shortest in the MIRPE approach (4 days, IQR 3.0) and longest in the complex reconstruction of ATD patients (7 days, IQR 4.0; $p < 0.001$). Major and minor complications were more frequent in the ATD complex reconstruction than any other group. Long-term chronic pain was most prevalent in the post open/Ravitch patient group (13.6% versus MIRPE 3.6%, $p = 0.022$).

Conclusions: Revision of a previous failed pectus excavatum repair can be technically challenging and carries an increased risk of complications, extended operative time and longer hospital stays. However, they can be successfully repaired with acceptable outcomes.

Table



Figure

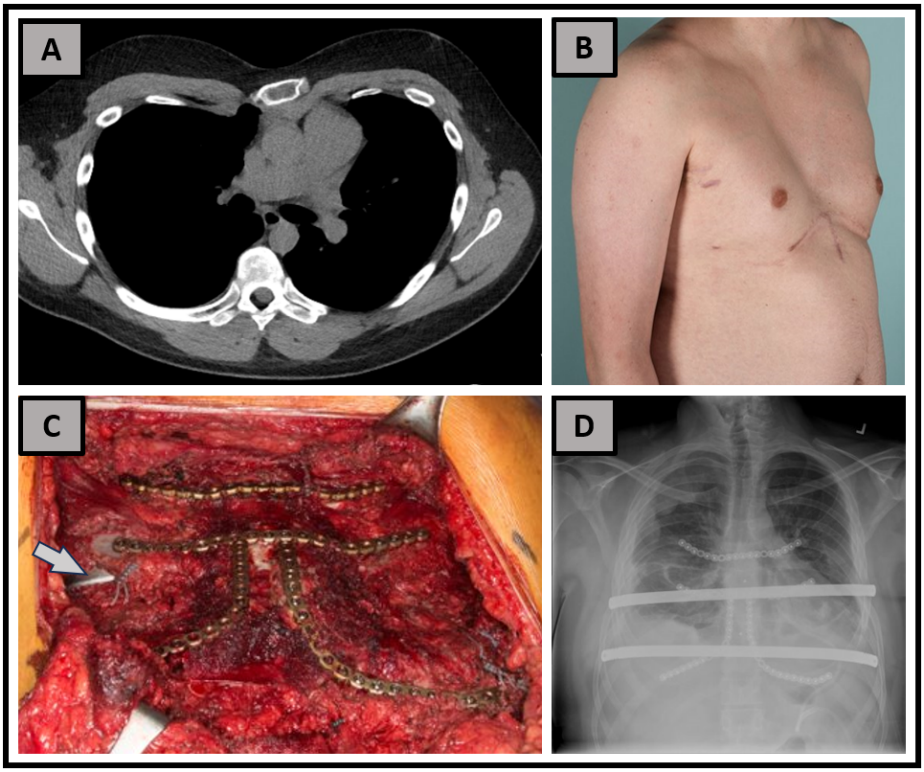


Figure 1. (**A**) Pre-revision chest Computerized Tomography of a patient with a history of 2 prior Ravich procedures. (**B**) Anterior gross view of the patient's chest deformity. (**C**) Intraoperative photograph of the patient after undergoing a Complex Hybrid Reconstruction (Arrow points to the upper Nuss bar). (**D**) Anterior-Posterior Chest Xray of the patient after the reconstruction with 2 Nuss support bars and multiple titanium plates.

Does Pectus Carinatum cause dysfunction of exercise physiology?

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Background: Whilst Pectus Carinatum has been reported to cause symptoms of exercise dysfunction, there is poor correlation of physiological measurements and symptoms. We undertook cardiopulmonary exercise tests to determine the nature of the physiological dysfunction when patients with pectus carinatum exercise.

Methods: 9 patients with pectus carinatum underwent investigation with CT scan, pulmonary function and cardiopulmonary exercise testing. Subgroups defined by VO_2 max $\geq$ 80% predicted (HVO, n=5) and <80% (LVO, n=4), were utilised to delineate abnormalities of exercise pathophysiology.

Results: Haller's index was 1.68 (range 1.35 – 2.2) and standard pulmonary function test values were normal for the group. They achieved a higher RER 1.3 (1.16 – 1.4, $p<0.01$) and Lactate 10.3 (6.1 -15.1, $p<0.01$), but reduced value of $VO_{2\,Max}$ of 82% (range 55 – 110) than reference data. Subgroup analysis indicated LVO lower values of work 73% (68 – 96%, $p = 0.036$) and of VO_2 max of 73% (55 – 74, $p = 0.014$), with elevated breathing reserve at 65% (54 – 71%, $p = 0.05$) than the HVO subgroup. Compromised VO_2 max and stroke volume was causally related to abnormalities in ventilation, $R2 = 0.64$, $p = 0.005$.

Conclusion: This is the first study to report that 100% patients with clinical severe Pectus Carinatum exhibit a elements of disturbed exercise physiology. The findings suggest exercise dysfunction is attributable to compromised ventilation during exercise, that are not apparent at rest. Clinical assessment of pectus carinatum requires evaluation of exercise physiology.

Improving Quality of Life with Dynamic Compression Bracing in Patients with Pectus Carinatum

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Declaration of interest: Presenting/corresponding author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Background: Patients with pectus carinatum have lower quality of life and self-esteem than their peers. We assessed the impact of dynamic compression system bracing on quality of life in patients with pectus carinatum.

Methods: We conducted a prospective cohort study on patients aged 10-21 years. We assessed quality of life using the Child Health Questionnaire-87, the State-Trait Anxiety Inventory-6, the World Health Organization Quality of Life-BREF, the 36-Item Short Form Survey, and the Single-Step Questionnaire adapted for pectus carinatum.

Results: Between March 2013 and March 2016, 225 patients treated with dynamic compression system bracing were included. Patients showed improvements across the overall scores of the 36-Item Short Form Survey (Δ7.7 (2.9-12.4)), Single-Step Questionnaire (Δ4.1 (2.0-6.3)) and three out of four World Health Organization Quality of Life-BREF domains (physical health (Δ8.7 (3.7-13.7)), psychological health (Δ11.8 (6.1-17.5)), environment (Δ5.7 (0.2-11.3))). No changes across the Child Health Questionnaire-87 overall score were observed (Δ5.5 (-0.5-11.5)). Most improvement occurred within six to twelve months after treatment initiation, stabilizing thereafter. Anxiety scores on the State-Trait Anxiety Inventory-6 did not improve (Δ0.5 (-0.1-1.2)). Scores on physical complaints, pain, psychological health and self-esteem/self-image improved across all questionnaires. In contrast to the successfully treated group, the unsuccessfully treated group showed no improvement on any of the questionnaires. Most patients (87.2%) would choose bracing again, 94.9% of patients were satisfied with the treatment.

Conclusions: Dynamic compression system bracing improves quality of life, reduces physical complaints and pain and boosts psychological health and self-esteem in patients with pectus carinatum.

Defining the optimal annual institutional case volume for minimally invasive repair of pectus excavatum: an evidence-based approach

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Background and Aim: The Nuss procedure is the accepted standard approach to correct pectus excavatum. Still, is associated with potential major complications that are in part believed to be preventable as they might be the consequence of institutional case-volume differences. The objective is to evaluate the presence of a volume-outcome relation for the Nuss procedure and determine the optimal annual institutional case-volume threshold, defining high-volume centers.

Methods: A systematic literature search was performed, considering studies from unique centers reporting on pectus excavatum patients who underwent the Nuss procedure. Primary and secondary outcome were, respectively: the incidence of significant perioperative complications (Clavien-Dindo≥grade-III and significant intraoperative complications) and bar displacement. The presence of a non-linear volume-outcome relation was evaluated through restricted-cubic-spline-analyses. If present, the optimal annual institutional case-volume was determined by the elbow-method.

Results: Forty-nine studies from 49 unique centers were included, enrolling 13,352 patients in total. The significant perioperative complication rate was low (7.7%, 95%-confidence interval [CI]:6.4-9.0) and demonstrated a significant non-linear volume-outcome relation ($p<0.001$), even after covariate adjustment. The optimal annual institutional case-volume was determined at 73 cases/year (95%-CI:67-89). In this scenario, the number needed to treat to prevent a single perioperative complication compared to a low volume center was 11 (95%-CI:8-19). A similar volume-outcome relation ($p<0.001$) and optimal case volume of 73 cases/year was observed for bar displacement.

Conclusions: A significant volume-outcome relation for repair of pectus excavatum by the Nuss procedure exists with an optimal annual institutional case-volume of 73 cases/year. These findings provide rationale for centralization.

Parks Bridging Bar Pectus System: Techniques to Optimize Functional and Aesthetic Results in 52 cases

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Background/Aim: The use of bridging bars is new to many pectus surgeons. Our aim is to discuss advantages and technical considerations when beginning their use.

Method: This is a prospective study of our first group of patients using Parks pectus system.

Results: An average of 2.4 bars/case were used. 12/52 (23%) had parallel bars; 14/52 (27%) had cross bars and 26/52 (50%) had three bar, X-I configuration. On average, 2.3 “flarebuster” and “magic” compression strings were used for contouring (range 0-7). Mean operative time was 289 minutes. Advantages of Parks bridging bar techniques include remodeling of a larger area of the chest wall, increased rotational and lateral stability of the bars, effective aesthetic treatment of costal flaring and other areas of protrusion anywhere on the chest and a sternal elevation system that allows for multiple points of fixation/elevation. Asymmetric bar bending is common. Crossbar techniques are used liberally, are favored overall and are especially useful for points of maximal depression below the xyphoid and when interspaces are not favorably aligned with the deepest point of indentation. A more inferior dissection is required for proper placement of crossbars and for reliable relief of cardiac compression; this can be safely achieved. Several technical modifications are available to decrease hardware prominence with crossbars and facilitate placement of compression strings, which is sometimes challenging. Additional, more inferior cryo-nerve blocks to T9 help control pain from costal margin compression strings. Potential disadvantages include longer operative times, more prominent palpation of hardware on the lateral chest wall and untested durability with contact sports.

Conclusion: Parks pectus system with lateral bridging bars provides functional and aesthetic advantages over traditional hardware systems. There is a technical learning curve when initiating its use, but proficiency is readily achievable. Longer operative times may be required for optimal aesthetic results.

Sternal elevation in pectus excavatum repair: unilateral vs. bilateral frame crane system

Presenting Author: Elise J van Polen, MD

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Background and Aim: Instability in the conventional, unilateral frame crane system has been observed when greater sternal elevation forces are required which potentially limits optimal sternal elevation during Nuss repair of pectus excavatum. A bilateral frame crane system was therefore developed. We hypothesized that by increasing the retractor's stability, the bilateral frame crane system yields a superior sternal elevation as reflected by a greater lift of the anterior chest wall.

Methods: Patients who underwent the Nuss bar procedure utilizing sternal elevation were included in this crossover study. Three-dimensional surface imaging was used to evaluate differences in established maximum and average combined chest wall elevation, comparing unilateral to bilateral frame crane system. The results were also compared to the effect of bar implantation on the deepest point of the deformity.

Results: The 30 patients included in final analysis were predominantly male (83%) with a median age of 16.0 years (IQR 14.3-17.0) and median Haller index of 3.3 (IQR 2.9-3.8). The bilateral frame crane system was superior in maximum combined chest wall elevation (figure 1) (33 mm vs. 24 mm, $p < 0.001$) and equaled the effect of definitive bar placement (33 mm vs. 38 mm, $p = 0.06$), while the unilateral frame system failed to do so. Both systems, however, showed similar results for average combined chest wall elevation (4 mm vs. 5 mm, $p = 0.48$).

Conclusions: The bilateral frame crane system demonstrates superiority in achieving sternal elevation at the deepest point of the deformity which may theoretically facilitate safer and more optimal bar placement.

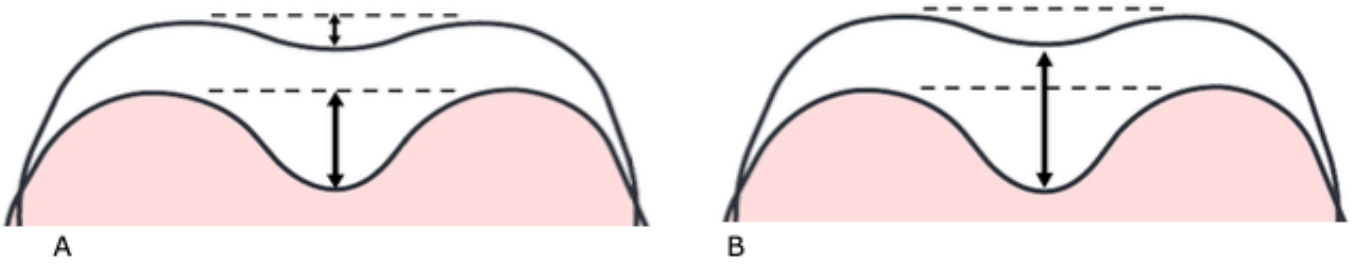

Figure 1: Schematic transversal overview of the anterior chest wall before and after sternal elevation. A. The reduction in pectus depth is visualized as the difference between the two arrows. B. The combined chest wall elevation (i.e., simultaneous reduction in pectus depth and elevation of the anterior chest wall) is indicated by the arrow. Of note: subfigure A only serves for visualization purposes as pectus depth was not assessed.

Surgical Treatment and Outcomes of Pectus Arcuatum

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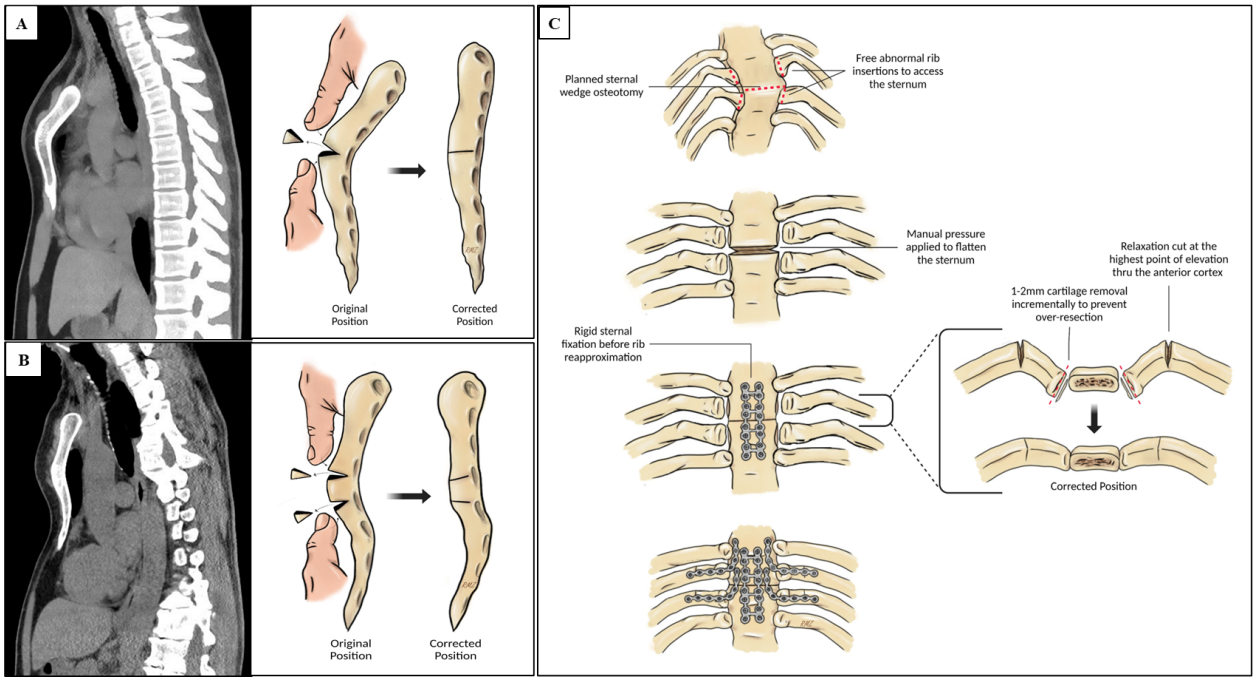
Disclosure: Dawn Jaroszewski discloses consulting and IP/royalties through Mayo Clinic Ventures with Zimmer Biomet, Inc. Other authors report no conflict of interest.

Background and Aim: Pectus arcuatum is a rare variant of pectus deformities that can cause varying degrees of cardiac compression. With the majority of literature consisting of only case reports or series, there is considerable variability in diagnosis and surgical management, highlighting the absence of a standardized approach. This study aims to provide a comprehensive evaluation, surgical repair (Figure), and outcomes of one of the largest cohorts of pectus arcuatum cases at a single institution.



Method: A retrospective review of all patients undergoing surgical treatment of pectus arcuatum at a single institution was conducted between January 1st, 2010, and December 31st, 2023. Descriptive statistics and surgical techniques are presented.

Results: Eighteen patients underwent pectus arcuatum repair (median age 23.5 years, 55.6% males, median Haller index 2.8 (IQR 1.4)) during the study period. Preoperatively, all patients were bothered by their chest appearance and symptomatic, with the most common symptoms being exercise

intolerance (94.4%), shortness of breath (88.9%), and chest pain (88.9%). Preoperatively, cardiopulmonary exercise testing was performed in half the patients with abnormal findings (median maximum oxygen consumption: 67.0% of predicted).
A hybrid approach with sternal osteotomy and minimally invasive pectus excavatum repair was utilized in 17/18 cases, with one case requiring sternal osteotomy only. Single wedge osteotomy was sufficient in most cases (66.7%). Median intraoperative time was 3.4 (1.2) hours. The adoption of cryoablation in 2018 significantly reduced hospital stays, from 5.5 (1.2) days to 3.0 (1.7) days ($p<0.001$). At follow-up, all reported cosmetic satisfaction and most symptom improvement.

Conclusions: Pectus arcuatum can be successfully repaired with a hybrid surgical approach involving sternal osteotomy and Nuss bar placement. Symptomatic patients should be considered for surgery, with postoperative improvement expected.

Safety protocol for bar removal after the Nuss procedure Analysis of results after 5 years of implementation

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Type of study:
Original Research Article. Observational retrospective cohort.

Article level of evidence:
Level of evidence 4. (Expert opinion based on scientific evidence, clinical practice guidelines, consensus panel)

Keywords:
Pectus excavatum; bar removal, complications; safety protocol.

Abbreviations:
C-D: Clavien-Dindo.
PICU: Pediatric intensive care unit.
LOS: Length of stay.
BESP: Bar extraction safety protocol.

Funding: The study had no funding. The authors have nothing to disclose.

Background and Aim: Nuss bar removal carries risks, ranging from mild to severe. We introduce the Bar Extraction Safety Protocol (BESP) to enhance safety. This study compares outcomes before and after implementing BESP to highlight its effectiveness in reducing complications.

Materials and Methods: This observational cohort study conducted a retrospective chart review of patients undergoing Nuss bar removal at a University hospital from November 2013 to March 2024. Examined variables included patient demographics, time from bar placement to removal, type and number of bars extracted, and occurrence of complications before and after implementing the Bar Extraction Safety Protocol (BESP). The BESP encompasses preoperative measures such as using smooth-ended bars, pre-workup lab tests, and chest X-rays; operative procedures like bilateral incisions and the "safety-string" maneuver; and postoperative measures including PICU admission and

post-procedural chest X-rays. Statistical analysis using chi-square compared pre and post-BESP groups using Stata v16 software.

Results: Sixty-seven (67) patients were included; 62 were male. Mean age at surgery: 17 years (range:14-24). Thirty patients were operated pre-BESP, 37 post-BESP. Fourty-three bars were removed pre-BESP, 81 post-BESP. Bars pre-BESP were all dentated (30), only smooth bars were used for the protocol. Time from placement-to-removal: 27 months (IQR 23-33) pre-BESP, and 24 months (IQR 23-25) post-BESP. Median LOS 1 day in both groups, (max LOS: 16 days pre-BESP, 4 days post-BESP). Complications pre-BESP: 30% (9/30); 3 Clavien-Dindo class I; 3 class II; 2 class IIIb, 1 class IV. Complications post-BESP: 10.8% (4/37) all C-D class I, p 0.048. Pre-BESP patients presented a higher rate of complications than those operated post-BESP (30% vs 10.8%; $p < 0.05$).

Conclusion: Implementing the BESP post-Nuss surgery proved beneficial in reducing complications and improving patient outcomes. Following established guidelines, thorough planning, and attentive postoperative care helped minimize complications and enhance patient safety. The protocol plays a significant role in maintaining high-quality care standards in Nuss surgery.

Surgical Repair of Pectus Arcuatum: Long-Term Results

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The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

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Background: Pectus arcuatum is a rare congenital chest wall deformity characterized by prominent protrusion of the manubriosternal angle and bilateral deformity of the sternocostal cartilages. Concomitant depression of the lower third of the sternum may be present. In this study, we aim to report our clinical experience in the surgical management of pectus arcuatum.

Methods: The records of our prospectively collected data from the *Chest Wall Deformities Clinical Database*, from September 2018 to March 2024 revealed 445 patients who underwent correction for chest wall deformities. Of 445 patients, 24 were identified with pectus arcuatum. The surgical procedure involved transverse wedge osteotomy of the protruded part of the sternum, along with excision of the deformed cartilages. Two vertical titanium plates were placed to secure the sternum, and an excavatum bar was inserted if there was significant depression at the sternal body. Follow-up involved postoperative PA and lateral chest X-rays.

Results: The patients who underwent arcuatum repair (n=24, 8F,16M) had a mean age of 24,9 years. The average amount of blood loss was 150 mL. The mean operative time was 118 minutes. A pectus bar was inserted in seven patients. No operative complications were encountered. Mean hospital length of stay was 5,6 days.All patients were satisfied with the cosmetic appearance. One patient had pericardial and right pleural effusion two weeks after the surgery which resolved with antiinflammatory treatment. Two patients had their pectus bars removed three years after insertion and no recurrence was detected after removal. The mean follow-up was 42 months.
Conclusion. The success of the sternal correction depends on the site of the osteotomy, the decision to preserve the posterior lamina of the sternum and the site of the placement of the correct length of the pectus bar for the sternal depression. Using algorithmic step-by-step surgical procedures helps ensure the stability of the sternum.

Minimally invasive repair of pectus excavatum in adult patients: lessons learned in 63 cases

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Disclosure: The authors have nothing to disclosure

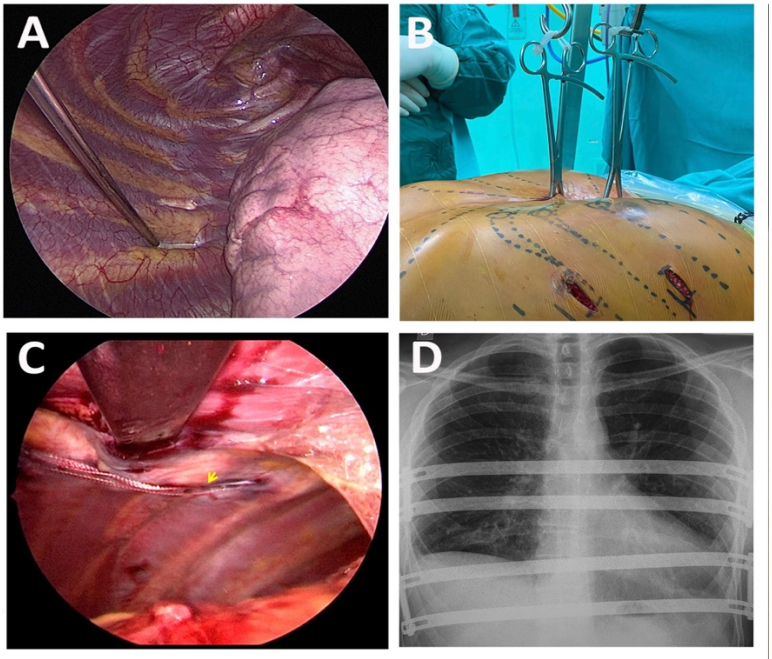
Introduction: Although widely performed in adolescents, minimally invasive repair of pectus excavatum (MIRPE) in adult patients is less popular. Their reduced chest compliance and higher thoracic rigidity demand technical adaptations in search of safety and effectiveness. We report lessons learned and specific strategies to overcome these challenges in a cohort of 63 adults undergoing MIRPE.

Methods: Retrospective study comprising patients aged ≥18 years undergoing MIRPE between September 2018 and March 2024 by the same surgical team.
Specific technical strategies employed in this cohort included:

- Cryoanalgesia for effective postoperative pain management.
- Compulsory sternal elevation (with two-point traction -cephalic and caudal- for retrosternal visibility enhancement).
- Use of multiple implants for better distribution of sternochondral force.
- Interspace reinforcement with the “Hammock technique” to prevent intercostal muscle tear.
- Lateral fixation of implants with bilateral self-locking bridges to prevent implant rotation.

Results: During the study period, 295 patients underwent MIRPE, of which 63 (21.4%) were adults (87.3% males) with a mean age of 24.4±6.2 years. Cryoanalgesia was performed in 81% of the patients. A crane was employed in all cases for sternal elevation and a two-point traction was used in xx cases. We introduced a mean of 2.84±0.41 implants per patient with self-blocking bridges in all cases. The hammock technique was employed in 12 (19%) cases. The average operative time was 108.2±38.8 minutes, the mean hospital stay was 1.96±1.4 days, and there were no readmissions due to uncontrolled pain. None of the patients required reoperation due to implant displacement by the end of the study.

Conclusion: In brief, our study showcases tailored technical strategies for MIRPE in adults, resulting in successful outcomes for 63 patients. These adaptations allowed for effective postoperative pain control, no implant issues, and ensured swift recovery without readmissions.
Keywords: Pectus excavatum, Nuss, cryoanalgesia, adults, MIRPE.


A
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C
D

3D scanning as a comprehensive assessment tool in management of Pectus Carinatum: Report of 267 patients

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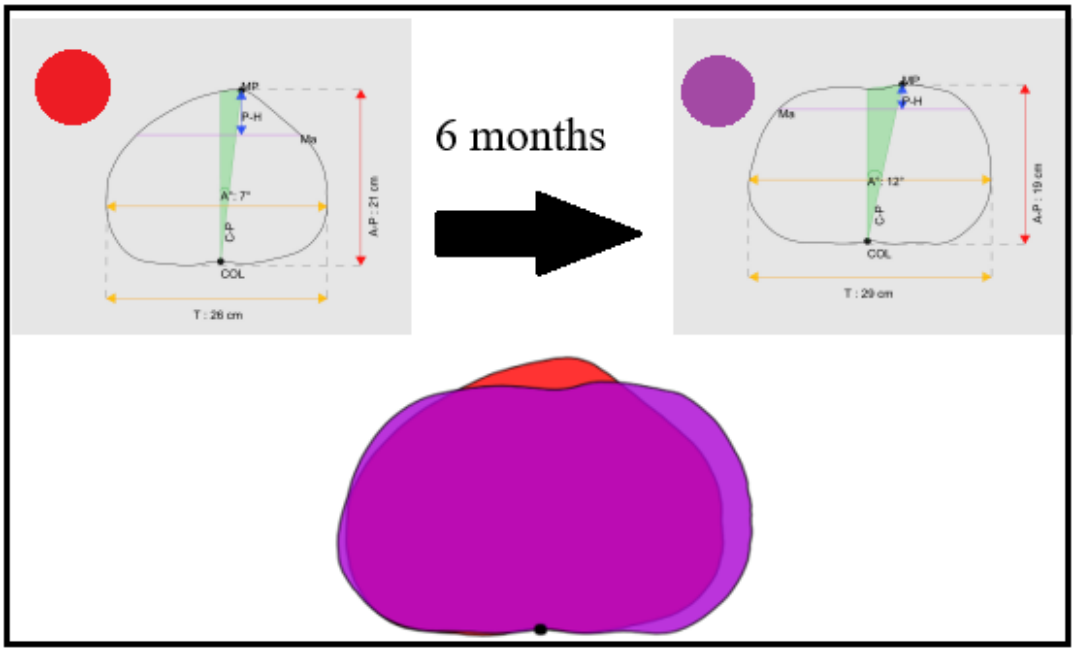
Introduction: 3D scanning (3DS) is an objective, radiation-free imaging study with underexploited potential. We have had the opportunity to evaluate a large cohort of patients with Pectus Carinatum undergoing treatment with a Dynamic Compressor System (DCS) and followed them with a novel software that calculated several anthropometric measurements and a specific External Pectus Carinatum Index (EPCI). We aim to present our findings with this technology.

Methods: Records of all patients with PC treated with DCS and assessed using 3DS (Scanmed SRL, Buenos Aires, Argentina) between 2017 and 2024 at a single center were reviewed. Different serial external thoracic measurements including the External Pectus Carinatum Index [(AP/T)x1000] were analyzed. (Fig. 1).

Results: Of the 267 patients undergoing DCS with a follow-up 3DS, 26 were excluded due to failure or withdrawal. Accordingly, we analyzed 243 patients (87% male) who achieved a flat chest during a mean 16.9±6.9 months. Their mean age was 13.7±3.4 years and their mean baseline pressure of correction was 6.9±2.3 PSI.
Compared to baseline, their 3DS analysis showed the thoracic perimeter increased significantly (79.4±8.2 cm vs. 81.8±8.3 cm, $p<0.0001$), as expected due to overall growth in this age group. We also identified a significant decrease in both the anteroposterior diameter (21.4±2.4 vs. 20.7±2.5, $p<0.0001$) and the EPCI (782.4±66.3 vs. 722.3 ±59.5, $p<0.0001$).
In terms of relative differences, the relative change in EPCI was significantly higher than the change in AP (-7.4±6.9% vs. -3.0±7.0, $p<0.0001$), suggesting it to be a more sensitive indicator of PC correction in adolescents where the transverse diameter also increases with growth.

Conclusions: 3DS is a valuable study for the assessment of PC patients undergoing DCS treatment. The External Pectus Carinatum Index arises as a promising tool for the follow-up evaluation of PC, even in adolescents with rapid body growth.

Fig. 1


MP
P-H
Ms
A-P : 21 cm
A' : 7"
C-P
COL
T : 28 cm
6 months
MP
P-H
Ms
A' : 12"
C-P
COL
A-P : 19 cm
T : 29 cm

Eight Years of Expertise with the Sandwich Technique for Asymmetric Pectus Carinatum and Excavatum-Carinatum Complex

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Confict of interests: none

BACKGROUND AND AIM: Sandwich technique (ST) is a novel approach for managing asymmetric pectus carinatum (APC) and excavatum-carinatum complex (ECC). Although the ST was first described in 2016, global experience and literature on it are scarce. Thus, we report our experience using ST in the last 8 years.

METHODS: The data of patients undergoing ST for APC and ECC from 2017 to 2024 in two centres (G1 and G2) was reviewed. Patient demographics and operative outcomes were analyzed with special emphasis on the surgical technique employed.
Surgical technique
Intercostal cryoanalgesia was performed before chest wall remodeling. Under thoracoscopic guidance and sternal elevation, the internal bars with lateral bridges were introduced in a parallel, oblique, or crossed disposition aiming to elevate the excavated areas of the chest. Next, the external bar was placed and the chest was flattened with a press. Depending on the stabilization modality of the prostheses, the external implant was fixed to the bridges directly or through specially designed polymer zip-ties (Figure 1A and B).

RESULTS: There were 24 patients (G1: 10; G2: 14). The median age was 16 years (range: 12-26) and 16 were male. Nineteen patients had ECC while 5 had APC. All but one patient had cryoanalgesia. Median operative time was 156 minutes (range: 95-360). Parallel/oblique internal bars and 1 external bar were introduced in 21 and internal crossed bars in 3. Additionally, flare-buster was performed in 5, magic string in 4, and thoracoscopic chondral section in 1. There were 3 complications: intercostal stripping leading to revision and Abramson procedure, unilateral pneumothorax secondary to undiagnosed ruptured bullae requiring pulmonary apicectomy, and superinfected granuloma requiring in-patient treatment. The median patient satisfaction score was 4.5 on a 5-point Likert Scale.

CONCLUSION: Despite technical variations, ST offers satisfactory outcomes for APC and ECC. The indication, number of bars and their disposition requires diligent planning.

Surgical management of Pectus Excavatum and Carinatum in Australia: a descriptive analysis of the Medicare Benefits Schedule database 2000 -2024

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Conflict of interest: No completing interests identified with any authors.

Background and Aim: There is no standard reporting of chest wall deformities, such as pectus excavatum and pectus carinatum in Australia and prevalence data are lacking. The only Australian-wide data available are the medical services provided for surgical repair of these deformities. The aim of this study was to assess and describe trends in surgical management of pectus excavatum and carinatum in Australia from 2000 to 2024.

Method: A review was conducted of the Australian Medicare Benefits Scheme (MBS), specifically querying the item numbers pertaining to management of pectus excavatum and carinatum from January 2000 to February 2024 (year to date). Relevant MBS items prior to March 2023 included 38457 and 38458, and MBS items from March 2023 onwards included 38846, 38847, and 38848. Data were recorded as the number of surgeries and overall incidence per 100,000 people (enrolled in Medicare). Where possible, data for males and females were extracted.

Results: During the 2000-2024 period, there were a total of 2,618 surgeries for repair of pectus excavatum and pectus carinatum in Australia (Table), majority occurring in males (85.5%). The overall number of surgeries per capita over 2000-2024 were 11 per 100,000 people. There were surgeries conducted over the full spectrum of ages (<4 years, to ≥85 years), however majority were aged 15-24 (65.5% in total, 45.5% of all females and 69% in males). There were overall increases in surgeries reported (Figure) from 2000 (n=50) to a peak in 2014 (n=166), with a 230% increase between the initial 5-year-average (2000-2004: 58.6) and the final 5-year-average of complete data (2019-2023: 134.2).

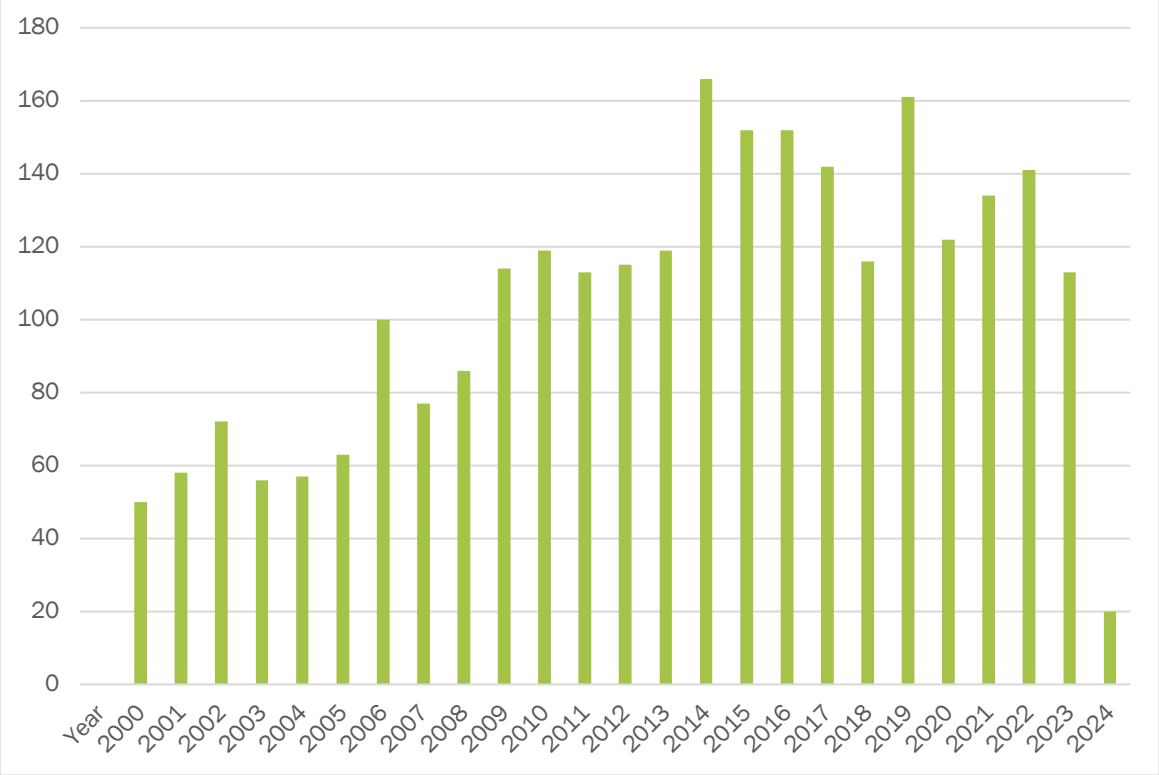
Conclusions: There is an increasing prevalence of chest wall repair surgeries performed in Australia, most performed in young males. These increases are in keeping with recent evidence suggesting several physiological (cardiopulmonary) and psychosocial advantages when chest wall deformities are corrected.

Table: Total numbers of surgeries performed for repair of pectus excavatum and pectus carinatum in Australia January 2000 until February 2024, data reported per age group for each gender and total.

Age (years)	Female (n)	Female per capita (n/100,000 population)*	Male (n)	Male per capita (n/100,000 population)*	Total (n)	Total per capita (number per 100,000 population)*
0-4	2	0	1	0	3	0
4-14	41	3	317	21	358	12
15-24	173	12	1544	101	1717	58
25-34	73	5	179	10	252	8
35-44	37	2	88	6	125	4
45-54	23	1	48	3	71	2
55-64	17	2	30	2	47	2
65-74	7	1	19	2	26	1
75-84	7	1	11	1	18	1
>=85	0	0	1	1	1	0
Total	380	0	2238	19	2618	11

* Please note that data for calculations per capita were only provided to the nearest number

Figure: Total number of surgical procedures performed between 2000 and 2024 (year to February) in Australia per year.



Chest wall reconstruction utilizing OviTex® Reinforced Tissue Matrix: Early single centre experience

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Conflict of interest: Authors have no conflicts of interest to declare.

Background: Reconstruction of extensive chest wall defects is often a challenging scenario. Satisfactory reconstruction mandates full-thickness coverage of intrathoracic contents utilizing a durable material which minimizes the disturbance of respiratory dynamics. Several synthetic, biological and hybrid materials have been utilised. Each has its respective strengths and weaknesses, and no single material proves to be ideal. OviTex® Reinforced Tissue Matrix is a hybrid biosynthetic ovine derived polymer reinforced mesh which has shown promising results in small series of chest wall and hernial repairs.

Methods: We reviewed all patients who underwent chest wall resection and reconstruction with OviTex® Reinforced Tissue Matrix at our institution from 06/2022 to 04/2024. En-block resection of the tumour was performed with partial or complete sternectomy, resection of pericardium/diaphragm or spinal transverse processes when indicated. Soft tissue coverage was then completed by the plastic team using pedicled latissimus dorsi flap. More patients will be added to our cohort by the time of the conference.

Results: Nine patients (4 male and 5 female, median age 66years) underwent chest wall reconstruction using OviTex mesh (table 1). One patient needed a redo surgery due to involvement of one margin and was completed with OviTex® mesh. None of the patients received postoperative chemo/radiotherapy treatment. One patient died as an inpatient following cardiac event. No reported deep wound infection.

Conclusion: OviTex® 2S Reinforced Tissue Matrix is a safe and feasible option to cover large defects obviating the need for traditional rigid reconstruction. It is s associated with satisfactory short-term outcome of restoration of chest wall dynamics and resistance to infection. OviTex® 2S Reinforced Tissue Matrix is optimal for coverage of costal and abdominal wall defects. The unique design allows for durable repair and early tissue regeneration and remodeling without compromising chest wall mechanics.

Case	Age	gender	Max.diameter of lesion(mm)	ribs/sternum/spinal involvement	Diaphragm/pericaridal involvement	Stage	Histology	LOS	Complications
1	60	F	100	Sternum	Pericardium, diaphragm detached	p T2 No M0 G1	Central chondrosarcoma, Grade 1	8	Re-admission to intensive care, desaturation, hydropneumothorax
2	79	M	80	4th-6th ribs	-	pT1 N0 M0 G2	Chondrosarcoma, grade 1	10	None
3	58	F	90	Partial lower sternectomy with costal cartilages of 5-7th ribs	-	N/A	Metastatic breast cancer	10	None
4	49	M	60	6th-8th ribs	Diaphragm detached	pT1 N0 M0 G3	Central chondrosarcoma, grade 3	6	None
5	69	M	75	Body of Sternum and lower left 3 ribs	Pericardium	pT1 No G2	Chondrosarcoma	11	Revision surgery for resection due to involvement of superior margin
6	70	M	80	8-11th ribs +transverse processes	-	pT1 Nx Mx	Dedifferentiated chondrosarcoma.	-	Inpatient death (cardiac complications)
7	70	F	45	Hemi-sternum, 3rd and 4th rib	-	pT1Nx Mx G2	Central chondrosarcoma Grade 2	8	None
8	60	F	90	Left upper Hemi-sternum &1st-3rd ribs, clavicular head	-	pending	Carcinosarcoma, final histology pending	pending	pending
9	79	F	96	5 ribs	-	pending	Angiosarcoma, final histology pending	pending	pending

Table 1:Description of study population; perioperative findings and early outcomes.

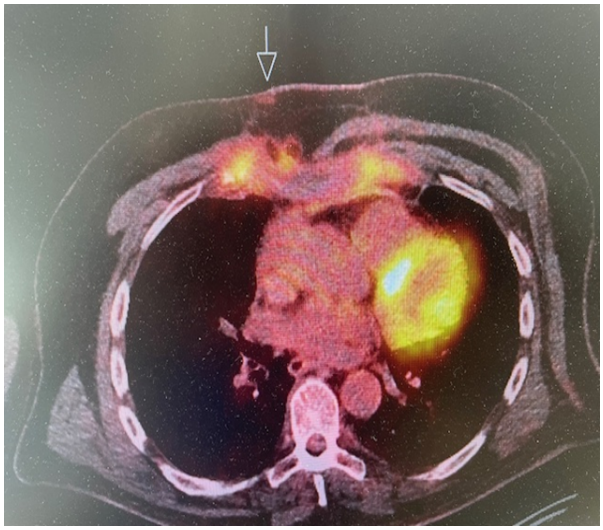

Figure 1:PET avidity observed around OviTex mesh at two months postoperatively

Nitinol clip and mesh repair of visceral herniation through intercostal muscle defects

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Word count: 291 (Abstract body excluding table and figure)

Conflict of interest: None.

Background and Aim: Disruption of intercostal muscles can lead to rib separation and herniation of thoracic or upper abdominal organs. Patients can experience pain and local bulging, symptoms may worsen over time and incarceration can occur. Different treatment strategies have been described but there is no standardized approach. This article presents the results of surgical management for visceral herniation through intercostal muscle defects using combined Nitinol clips and mesh repair.

Method: Between January 2019 and March 2024 13 patients underwent surgery for visceral herniation through intercostal muscle defects. Electronic patients files were screened for demographic information, symptoms, surgical management and outcomes. Surgical strategy was determined pre-operatively based on CT-imaging. The main strategy applied was a combination of Nitinol clips to reduce the intercostal space and for osteosynthesis of pseudo-arthrosis of the costal margin and mesh repair to cover the defect.

Results:

Demographic and injury characteristics are shown in table 1.

Table 1. Demographics and characteristics of injuries

N = 13	N (%)	Mean (SD)
Gender: Male	12 (92.3)	
Age		62.1 (14.1)
BMI		31.7 (4.5)
BMI >25	14 (82.4)	
BMI >30	9 (52.9)	
Respiratory disease	4 (30.8)	
Smoking	5 (38.5)	
Mechanism injury		
Trauma	6 (46.2)	

(Excessive) Coughing	3 (23.1)	
Iatrogenic	4 (30.8)	
Type of trauma		
Motor vehicle accident	3 (23.1)	
Sports	1 (7.7)	
Penetrating trauma	1 (7.7)	
Fall	1 (7.7)	
Other cause than trauma	7 (53.8)	
Diagnosis		
Intercostal muscle defect	5 (38.5)	
Intercostal muscle defect with costal margin injury	8 (61.5)	
Side: Left	10 (76.9)	
Affected ribs		
Fifth rib	2 (15.4)	
Sixth rib	2 (15.4)	
Seventh rib	5 (38.5)	
Eight rib	8 (61.5)	
Ninth rib	11 (84.6)	
Tenth Rib	2 (15.4)	
Surgical technique		
Open procedure	6 (46.2)	
VATS + Open procedure	7 (53.8)	
Mean follow-up duration (months)		14.8 (16.4)

Reasons for surgery were pain (n= 13, 100%), mechanical instability (n= 2, 15.4%), dyspnoea (n=3, 23.1%) and pain or herniation upon physical examination (n=12, 92.3%). Eleven patients (86.6%) were treated successfully with significant reduction of pain and without recurrence of herniation. Two patients (15.4%) had recurrence of herniation, underwent a second procedure and remained asymptomatic afterwards. One patient with poorly managed COPD pre-operatively experienced an exacerbation with pneumonia post-operatively.

Conclusion:
Surgical repair of visceral herniation through intercostal muscle defects using Nitinol clips combined with mesh repair is a safe and viable treatment option. Surgical strategy should be chosen based on pre-operative CT-imaging and assessment during the surgical procedure. The repair should aim to reduce and stabilize the widened intercostal space to anatomical proportions, stabilize any osseous pseudo-arthrosis around de defect and cover the intercostal muscle-defect from the inside with a mesh.

Precision Surgery: Navigating Thoracic Wall Tumor Removal with Advanced Planning and Intraoperative Guidance

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Type of study:
Original Research Article. Observational retrospective cohort.

Article level of evidence:
Level of evidence 4. (Expert opinion based on scientific evidence, clinical practice guidelines, consensus panel)

Keywords:
Chest wall tumors, Surgical planning, Surgical navigation, Computed-assisted surgery.

Abbreviations:
CWT: Chest wall tumors.
LOS: Length of stay.
CSF: Cerebrospinal fistula
Yr-OS: Years Overall Survival

Funding: The study had no funding. The authors have nothing to disclose.

Background and Aim: Chest wall tumors (CWT) may be benign or malignant, primary or metastatic. Attaining complete resection with clear margins is paramount. Preoperative virtual planning and intraoperative navigation may improve surgical thoroughness providing a comprehensive view of the patient's anatomy, enabling integration of imaging data to optimize surgical precision. This study aims to assess the efficacy of surgical planning and intraoperative navigation in managing CWT.

Methods: Retrospective analysis of patients who underwent CWT resection with virtual planning and intraoperative navigation. November 2013-March 2024. Variables included pre-operative findings and treatments. Virtual planning performed using 3D Mimics® and MCAS planner® software with patient´s 3D-chest-CT-scan and MRI. Skin landmarks were placed under CT guidance. During surgery, a

navigation tracker was used for virtual navigation. Using an optical pointer, the surgeon delineated the sectioning area ensuring complete tumor removal with clear margins. Visual feedback through a display showed the patient's thoracic image, tumor, and surgeon's pointer.

Results: Five patients were included. Median age: 16 years (IQR:11-17). Preoperative biopsies (7/8): Ewing's sarcoma (3), undifferentiated sarcoma (1), Neurofibromatosis (1). Virtual planning and Intraoperative navigation followed by en-bloc resection through a postero-lateral thoracotomy were performed in all patients. A mean of 3 complete costal arches (r:2-4) (3/5), 4 posterior costal archs (1/5), and 2 costal archs in their mid portion were resected. Thoracoplasty was performed using Vicryl (4/5) and Prolene (1/5) mesh. Rib osteosynthesis applied in 3/5. Rotating flaps from latissimus-dorsi and serratus-anterior muscles were utilized in all patients. Negative tumor margins were achieved in all cases. Mean operation length: 7.2 hs (r: 5.5-8 hs); mean LOS: 8 days (r: 5-16 days). Complications (2/5): wound infection (1), CSF (1). Tumor recurrence (1/5). 5 yr-OS: 80% 22 ms (r: 4-30 ms).

Conclusions: CWT demands precise en-bloc resection for optimal outcomes. Preoperative virtual planning and intraoperative navigation were useful tools for achieving good outcomes.

Vacuum Bell Therapy for Pectus Excavatum: Retrospective analysis of 1578 patients

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BACKGROUND AND AIM: Although minimally invasive repair of pectus excavatum (MIRPE) has become the standard treatment in many centers, vacuum bell therapy (VBT) has gained popularity as a non-surgical alternative treatment for patients rejecting surgical correction. We hereby present our results with vacuum bell in the treatment of pectus excavatum.

METHODS: Data were collected among patients who underwent vacuum bell therapy between 2017-2024 and all data were retrospectively reviewed from a prospectively conducted database.

RESULTS: Among 1578 patients; 1214 (76.9%) were male and 327 were female (20.7%). Mean age was 11.85 (2 months -52). 1136 (71.9%) of them had symmetric deformity and 442 (28.1 %) had asymmetric deformity. Mean Haller index was 4.2. The most common complications were petechial bleeding in 223 patients (14.1%), subcutaneous hematoma in 114 patients (7.2%), and pain in 71 patients (4.4%). Mean duration of the treatment was 10.2 months (6 -24). We experienced complete correction in 348 (22%) patients and fail to treat in 173 (10.9%) patients. QOL questionnaire revealed 32% (505 patients) satisfactory results. On the other hand, 37% (583 patients) and 489 (31%) patients reported fair and unsatisfactory results, respectively. Patients with satisfactory results had longer treatment duration, lower Haller Index, and younger age compared to patients with fair and unsatisfactory results ($p<0.005$)

CONCLUSION: Vacuum Bell Therapy is an alternative non-surgical treatment option in the treatment of pectus excavatum in a selected group of patients. Succession can be achieved in younger patients with longer application time and lower Haller Index values.

Determination of Nutritional Status and Evaluation of the Effect of Telenutrition on Body Image in Patients with Pectus Excavatum

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Background and Aim: The purpose of this study was to determine the nutritional status, body image, and anthropometric measurements of patients with pectus excavatum (PE) and to determine the effect on body image before and after telenutrition support.

Method: This study was conducted with 17 patients diagnosed with PE living in Istanbul and Izmir using an online survey method. At the beginning of the study, anthropometric measurements (body weight, height) of the patients were obtained. A 37-item Body Image Scale (BIS) was administered. A retrospective 24-hour food record was taken to assess nutritional status. Telenutrition support was provided by the researchers for two months according to healthy nutrition rules. At the end of this support, the BIS was administered again. The data obtained were evaluated with the program SPSS 22 package.

Results: The mean daily energy intake of 17 patients with PE (88.2% male, 11.8% female) was 1396.8±326.9 kcal, carbohydrate 18.2±4.3%, protein 35.9±7.3%, and fat 46.0±5.5%. While the total BIS score was 50.8±14.1 at baseline, it increased to 61.2±13.3 after telenutrition support.

Conclusions: Patients with PE have an inadequate carbohydrate intake and a high fat intake. This study suggested that nutritional intervention in patients diagnosed with PE could improve body image. Therefore, referring the patients to a dietician to apply longer-term and improved training models would be beneficial.

Keywords: pectus excavatum, telenutrition, nutrition therapy, body image

Can chronic pain after minimal invasive repair of pectus excavatum (MIRPE) be caused by low grade infection?

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Conflicts of interest declaration
The authors declare to have no conflicts of interest

Background and Aim: Pectus excavatum is the most common congenital thoracic wall deformity sometimes needing surgical correction if symptomatic. After initial postoperative pain a small portion of patients following MIRPE suffer from prolonged or intermittent pain with unknown cause. In this study we aim to investigate the presence of cutibacterium acnes in postoperative cultures at bar removal as indicator for chronic low grade infection (LGI) causing chronic pain.

Method: Patients were included after MIRPE, with a subsequent removal of the bars and of whom cultures were taken perioperative during bar removal. Patients were excluded if they used antibiotics in between the two operations. Culture results were compared between patients with or without suspicion of low grade infection. The patient characteristics as well as the follow up course after bar implantation and removal were compared between patients with or without a cutibacterium positive culture.

Results: A total of 106 patients were included for analysis and cutibacterium acnes was cultured a total of 53 (50%) times. Chronic pain was reported in 26 (49.1%) cases in c. acnes positive cultures group compared to 13 (24.5) cases in the c. acnes negative culture group (difference = 24.6%, p=0.009). A total of 28 (26.4%) patients were classified as LGI suspected and C. acnes was cultured in 23 (82.1%) of the patients compared to 30 (38.5%) of the patients in the LGI not suspected group (difference 43.6, p = < 0.001). No significant difference was seen in postoperative surgical site infection following bar removal.

Conclusion: Cutibacterium acnes is present in a larger proportion of patients than suspected. In patients with chronic pain, a significant higher incidence of c. acnes is present, indicating possible causality. Following this, antibiotic treatment might be indicated in patients suffering from chronic pain after MIRPE.

Table

Table 1. Group characteristics with or without a C. Acnes positive culture			
Variable	C. Acnes positive culture	C. Acnes negative culture	p-value
Total (N)	53	53	
Smoking (N, %)	6 (11.3)	9 (17.0)	0.70
Alcohol use (N,%)	24 (45.3)	21 (39.6)	0.57
BMI (SD)	19.5 (2.3)	19.9 (3.0)	0.42
Amount of bars (N,%) 1 2 3	 10 (18.9) 42 (79.2) 1 (1.9)	 13 (24.5) 39 (73.6) 1 (1.9)	0.50*
Average bar carriage time, in months (SD)	41.4 (14.6)	37.1 (8.3)	0.066
Short term postoperative complications after bar implantation (N,%) None Wound dehiscence Pneumonia/empyema Pericarditis Implant failure	 45 (84.9) 0 7 (13.2%) 0 1 (1.9)	 49 (92.5) 1 (1.9) 0 2 (3.8) 1 (1.9	**0.038**
(Chronic) pain (N,%)	26 (49.1%)	13 (24.5)	**0.009**
Long term postoperative complications after bar implantation (N,%) None Skin color changes Edema/swelling in surgical area	 46 (86.8) 3 (5.7) 4 (7.5)	 50 (94.3) 3 (5.7) 0	0.13
LGI suspicion (N,%)	23 (43.4)	5(9.4)	**<0.001**
Postoperative infection after bar removal (N,%)	7 (13.2)	8 15.1)	0.59
Postoperative antibiotic use (N,%)	8 (15.1)	8 (15.1)	1.00
Reoperation due to infection after bar removal (N,%)	2 (3.8)	3 (5.7)	0.65

Postoperative Analgesia After Minimally Invasive Repair of Pectus Excavatum; a Systematic Review and Network Meta-Analysis

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BACKGROUND AND AIM: The Nuss procedure is the standard approach for surgical correction of pectus excavatum.
Postoperative pain is the dominant factor affecting the duration of hospitalization. Numerous analgesic modalities are available, however, the most efficient is yet to be corroborated. The objective is to systematically evaluate and compare the most recent literature on analgesic modalities for pain management after the Nuss procedure through a network meta-analysis.

METHODS: A systematic search was applied to the electronic scientific databases. Articles were eligible for inclusion if they were designed as a comparative study which evaluated any form of postoperative pain management for pectus excavatum repair with Nuss procedure, and where length of hospital stay was reported as an outcome measure. Data concerning length of hospital stay were extracted. If possible, data were submitted for network meta-analysis.

RESULTS: Thirty-five unique studies were included, enrolling a total of 3,160 patients. Through network
meta-analysis, combining direct and indirect evidence, intercostal nerve cryoablation was found to be superior to all other analgesic modalities. Cryoablation was associated with a statistically significant weighted reduction in the length of hospitalization of respectively 1.1 days (95% confidence interval [CI]: 0.6-1.6), 2.1 days (95% CI: 1.5-2.6) and 1.5 days (95% CI 1.1-1.9) in comparison to locoregional anesthesia, thoracic epidural analgesia and patient-controlled analgesia,

CONCLUSIONS: Regarding postoperative pain management after the Nuss procedure, intercostal nerve cryoablation is superior to other forms of analgesia with regard to the length of hospitalization as primary determinant of pain.

Cryoanalgesia in patients undergoing surgical stabilization of rib fractures: a comparative study

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Background and Aim: Effective pain management is crucial in patients with multiple rib fractures to reduce complications and enhance recovery. Although intercostal cryoanalgesia (Cryo) is emerging as a promising strategy to optimize conventional multimodal analgesia in patients with rib fractures, the literature is sparse. We report our experience of cryoanalgesia in patients undergoing surgical stabilization of rib fractures (SSRF) and compare the results with a similar historical cohort managed without Cryo.

Methods: This retrospective study was performed at a single center over 7 years. The patients with traumatic rib fractures undergoing SSRF with multimodal analgesia including Cryo (Group A) were compared with a cohort of similar patients managed without Cryo (Group B). Multimodal analgesia comprised epidural analgesia, opioids, and nonsteroidal anti-inflammatory drugs. Demographics, severity of pain using Visual Analog Scale (VAS), and median requirement of morphine equivalent dose (MED) were compared between the two groups.

Results: There were 29 patients; 20 in Group A and 9 in Group B. Both groups were similar in age, number of rib fracture fixations required, preoperative requirement of opioids, and length of stay (Table 1). With regards to postoperative opioid, Group A required less than half of MED than Group B (A: 16.3±12.9 daily MED vs B: 37.2±13.7 daily MED, $p<0.0001$). This difference increased and was twenty times higher in the outpatient setting (A: 1.2±3.3 daily MED vs B:21.7±9.5 daily MED, $p<0.0001$). Pain at discharge showed significant differences in both groups at 7, 14, and 30 days ($p<0.0001$).

Conclusions: Multimodal analgesia including Cryo is more effective and should be included as one of the important components in the analgesic armamentarium of patients undergoing SSRF.

Keywords: Rib fracture, cryoanalgesia, surgical stabilization of rib fractures (SSRF)

Table 1

	Cryo	No cryo	P value
N	20	9	
Age	53.5±17.1	56.2±11.6	0.6
N fractures			*0.03*
1-3	1 (5%)	0	
4-6	12 (60%)	1 (11%)	
7-9	4 (20%)	7 (78%)	

Preliminary Results of Intercostal Nerve Cryoablation Versus Thoracic Epidural Analgesia for Minimally Invasive Nuss Repair of Pectus Excavatum: A Randomized Clinical Trial (ICE-trial)

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BACKGROUND AND AIM: The Nuss procedure for pectus excavatum (PE) can be associated with severe postoperative
pain, which is the main limiting factor for early discharge. Thoracic epidural analgesia (TEA) is currently considered the gold standard, but can cause side effects such as severe nausea, urinary retention, and obstipation. Intercostal nerve cryoablation (INC) seems to be a promising postoperative pain management modality. Prior studies have compared INC to other postoperative pain management modalities showing promising results. These studies however posed significant limitations due to small sample sizes, retrospective design, and unmatched treatment groups. This randomized controlled trial aims to compare INC to TEA in a larger sample size.

METHODS: A single center, prospective, unblinded randomized controlled trial was performed including patients aged 12-24 with PE who underwent a corrective Nuss procedure. The primary endpoint was length of hospital stay (LOS). A power calculation revealed a required sample size of 50 participants.

RESULTS: Currently 15 patients have been included. Seven patients were randomized for TEA and eight were randomized for INC. Of these patients 93% was male and the mean age was 17 years with a mean Haller Index of 3.8. Preliminary analysis showed significant reduction of LOS by -2.9 days (95%CI -3.4 to-2.3, p = <0.001) when comparing INC to TEA.

CONCLUSIONS: Preliminary results of a single center, unblinded randomized controlled trial comparing INC to TEA as postoperative pain management modality for the minimally invasive Nuss procedure to correct PE, show a reduced LOS by 2.9 days, indicating INC to be an effective form of postoperative pain management.

An Easier Way to Determine Where to Put Multiple Bars in Pectus Excavatum Repair: The "No-brainer" XI Bar Approach at 6-5-4 Intercostal Spaces

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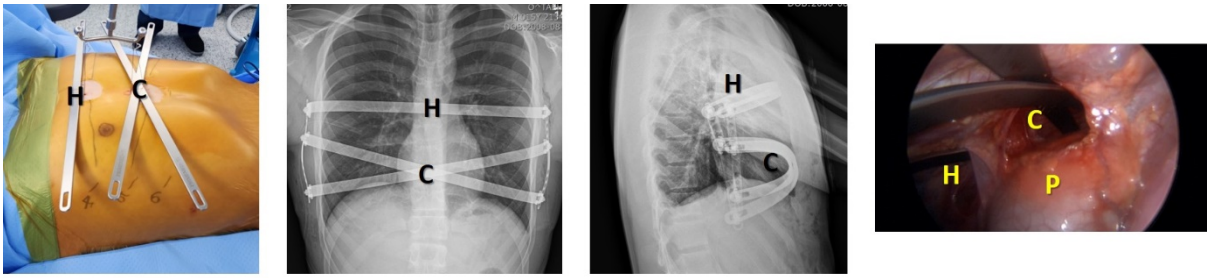
Conflicts of Interest: Hyung Joo Park: consultant of Primemed

Background and Aim: Our pectus excavatum repair technique uses crane sternal lifting and entire chest wall remodeling with multiple bars in an "XI" configuration (cross bars and a top horizontal bar) for the best anatomical and aesthetic outcomes. However, the complexity of multiple-bar positioning hinders an efficient repair procedure. We aim to create a simple formula for intercostal space (ICS) assignments for the "XI" bars to make the repair procedure uniformly successful across different deformity settings.

Methods: We evaluated 112 consecutive pectus excavatum (PE) repairs using the "XI" bar technique from May 2023 to April 2024. Three-dimensional skeletal reconstruction models were used to identify the ICS's where the pectus bars were inserted. To evaluate the efficacy and safety of this relatively complex multiple bar procedure, complication rates, operation time, and length of hospital stay were analyzed.

Results: The mean age was 17.9 years (range: 11–42 years). The most common bar placements were at the 6th, 5th, and 4th intercostal spaces (ICSs) on the right (R654, 60.8%) and the 5th, 4th, and 3rd ICSs on the left (L543, 37.1%), followed by L654, 17.5%. The most frequent lower ICS's were R6 (72.2%) and L5 (48.5%). The common upper ICS's were R4 (66.1%) and L3 (58.8%). Complications were all minor, with an overall rate of 9.8%, including pneumothoax 6, thoracic outlet syndrome 1, and minor hemothorax 1. There were no life-threatening complications or bar displacements. The mean operation time was 100.5 minutes (range: 65–160 minutes), and the hospital stay was 5 days.

Conclusions: Our "XI" bar technique for comprehensive chest wall coverage most commonly placed pectus bars in 654R-543L in over 70%, suggesting that these ICS's are the most reliable for successful repairs. Using this simplified formula, surgeons can quickly determine bar placement and make the procedure streamlined.



A B C D

Figure1. The XI bar repair of pectus excavatum

A. Surgical planning: XI bars at 6th, 5th, 4th intercostal spaces

B, C. Post-repair Chest X-rays of postero-anterior view and lateral view

D. Internal view of the XI bar repair

(C: cross bars, H: horizontal bar, P: pericardium)

Do Cardiac and Pulmonary Volumes Regain Their Capacity After Pectus Excavatum Repair? A Volumetric Measurement Study

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Conflicts of Interest: Hyung Joo Park: consultant of Primemed

Background and Aim: The primary aim of pectus excavatum (PE) repair is to restore the chest cavity's volume, including the heart and lungs, by relieving compression caused by the chest wall. Our PE repair technique uses a crane for full chest wall elevation, placing multiple pectus bars, typically in an "XI" configuration with cross bars and a top horizontal bar for chest wall remodeling. We measured changes in cardiac and pulmonary volumes, to assess the impact of PE repair.

Method: This analysis included 30 patients who underwent the "XI" bar technique for pectus excavatum (PE) repair from April 2023 to February 2024. The study measured volumetric changes using SYNAPSE 3D (Fujifilm, Tokyo, Japan) and assessed CT indexes (Haller index, Depression index), complication rates, reoperation rates, and length of hospital stay.

Results: The mean age of the patients was 17.6 years (range: 11-32), with 84.3% being male. The average operation time was 101.4 minutes, and the average hospital stay was 4.67 days. Complications included pleural effusions in 3.1% of patients and spontaneously resolved postoperative air leakage in 4.6%. There were no life-threatening complications or bar displacements. Cardiac volume increased from 415.4 ml to 464.6 ml after PE repair ($p<0.01$). However, total lung volumes decreased from 4,488.9 ml to 4,299.4 ml after surgery ($p=0.04$).

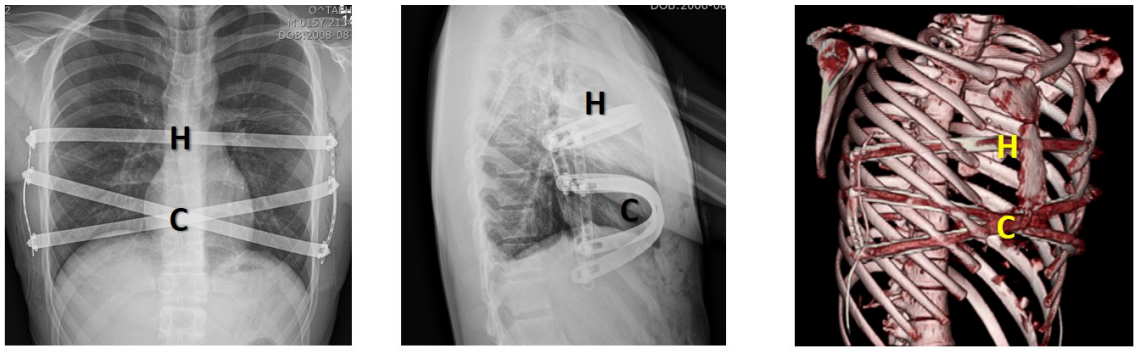
Conclusion: The crane-powered "XI" bar technique for chest wall remodeling is a safe and effective approach for pectus excavatum (PE) repair. It achieves anatomical restructuring and functional recovery with low morbidity. The technique significantly increases cardiac volume but not pulmonary volume, likely due to the compression mainly affecting the mediastinal structures in PE. We suggest that volumetric measurement can serve as a valuable tool to assess the effectiveness of chest wall restoration procedures, compared to traditional single or two-dimensional measurements of CT indexes.

Volumetric Change	Pre	Post	*p*-value
Lung (Total)	4488.9(2096~6090)	4299.4(2385~5578.7)	0.04*
Left Lung	2108.9(962~2838)	2061.5(1111~2697)	0.14
Right Lung	2379.8(1133~3086)	2389.6(1268~2977)	0.87
Heart	415.4(289~527)	464.6(332~655)	0.00**

Table 1. Volumetric Changes after the XI bar repair of pectus excavatum (PE)

* Total lung volume decreased likely due to restricted chest wall motion immediately after surgery

** Cardiac volume significantly increased after PE repair



A B

Figure1. The XI bar repair of pectus excavatum

A. Post-repair Chest X-rays of postero-anterior view and lateral view

B. 3-Dimensional reconstruction of the patient's CT scan using SYNAPSE 3D for volumetric measurement of the lung and heart

(C: cross bars, H: horizontal bar)

Use of Percutaneous Cryoanalgesia in Pain Management after Open Repair of Pectus Deformities: A Preliminary Report

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Background and Aim: Cryoanalgesia has demonstrated safety and efficacy in postoperative pain management following the Nuss procedure. However, its application for open pectus repair is less common. We present our initial experience with using percutaneous cryoanalgesia for this approach.

Method: We retrospectively reviewed medical records of patients who underwent percutaneous cryoanalgesia before open pectus surgery at our institution between March 2023 and March 2024. Postoperative pain scores, opioid consumption, and lenght of stay were recorded.

Result: Nine patients recieved percutaneous cryoanalgesia before open pectus repair. The procedure was performed between 1 and 9 days before surgery (mean 4.8 days). According to the Visual Analog Scale (VAS), the average pain scores on postoperative days 1, 2, 3 was 3, 2 and 1, respectively. Total opioid consumption ranged from 0.11 to 2.13 morphine miligrame equivalents per kilogram (MME/kg) with a mean of 0.77 MME/kg. The average lenght of postoperative hospital stay was 5 days. No complications related to cryoanalgesia were observed.

Conclusions: Percutaneous cryoanalgesia appears to be a safe and effective pain management strategy for patients undergoing open pectus repair. This preliminary data suggests further investigation is warranted.

First Report of Enduring Cardiac Decompression Assessed with MRI after Bar Removal in Pectus Excavatum Patients

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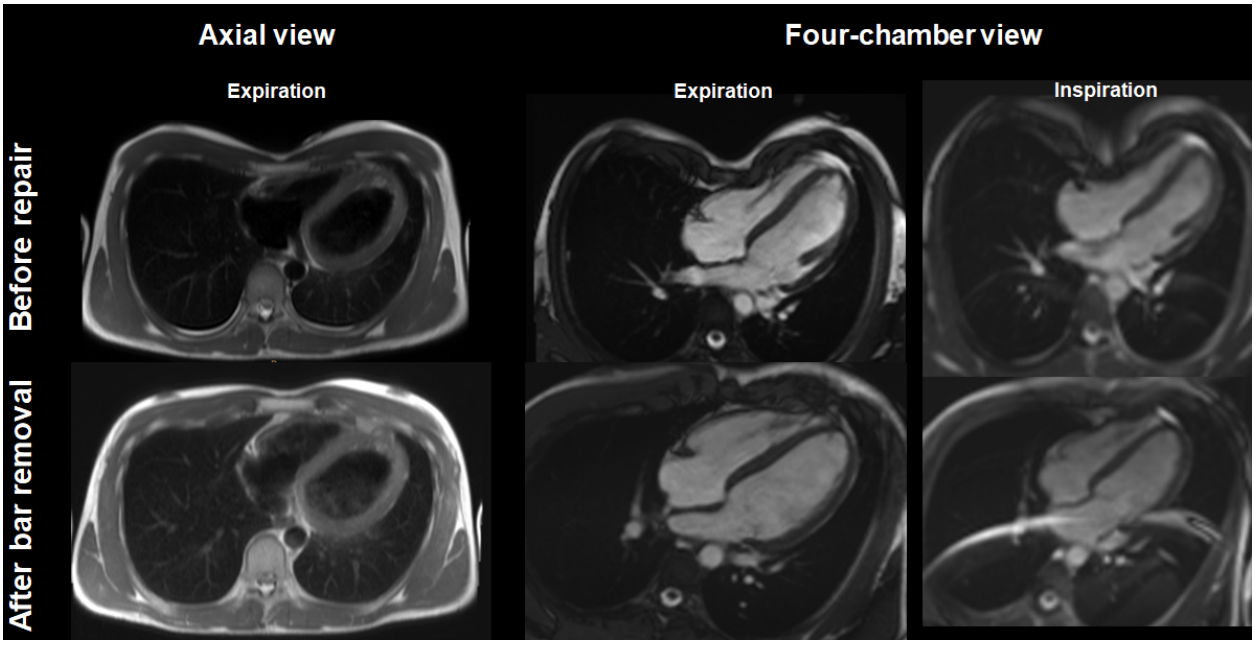
Introduction: Pectus excavatum can cause cardiac compression and exercise intolerance. Despite MIRPE has been related to diverse beneficial outcomes, most studies have evaluated this shortly after repair, whereas it remains unknown whether cardiac compression persists after bar removal. This is the first report exploring cardiac outcomes after bar removal using magnetic resonance (CMR).

Methods: Retrospective cohort of patients with pectus excavatum who underwent CMR before MIRPE, and after bar removal. We evaluated symptomatology and cardiac compression including a previously reported classification (type 0: no compression; type 1: RV compression; type 2: RV and AV Groove compression).

Results: We included 36 patients with a mean age of 16.7±3.7 years (89% male) who had the implants in place for a mean of 30.7±6.2 months. Symptoms related to chest malformation were referred by 22 (61%) patients, including exercise intolerance in 16 (44%) cases, and were resolved in 100% after bar removal. Before repair, CMR showed cardiac compression in 100% (type 1 in 29 and type 2 in 7) and, a mean 3.7±2.7 months after bar removal, CMR showed improvement in all but 1 case. There was a significant decrease in the number of patients with any cardiac compression [before repair: 36 cases vs. after bar removal: 11 cases, ($p<0.0001$)] (Fig.1A and B). Of those with persistent cardiac compression, 7 had “mild” or “discrete” compression, 1 had “compression only during inspiration”, and 2 decreased from type 2 to type 1. One patient remained as type 1. Mild pericardial effusion was evident in 13 (36%) cases decreasing significantly to 2 (6%) after bar removal ($p=0.0046$)].

Conclusions: We identified a significant decrease in the rates of cardiac compression using CMR after Nuss bar removal. Of note, all the patients who had symptoms related to their chest wall malformation before repair referred complete resolution after bar removal.

Figure 1


Axial view
Four-chamber view
Expiration
Expiration
Inspiration
Before repair
After bar removal

Early Bar Removal after MIRPE: Indications, Outcome and Recurrence in a Multicenter International Retrospective Study

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Background and Aim: Typically, implant removal after minimally invasive repair of pectus excavatum (MIRPE) is performed after 3 years. However, there are several reasons for early bar removal. This study reports our multicenter experience with early bar removal surgery after MIRPE.

Methods: This retrospective, multicenter study analyzed patients who underwent implant removal before or at 24 months after the initial MIRPE procedure from 2010 to 2023. Age, reasons for implant removal, and recurrence rates were collected from the databases. The modified one-step questionnaire was used to assess self-esteem and quality of life (QoL).

Results: A total of 1393 patients underwent MIRPE during the observation period. Among them, 45 (3.2%) patients with a mean age of 21.8 years had to undergo bar removal prior to 24 months. Implant removal was necessary due to overcorrection in 5 (11.1%), patients-demand in 4 (8.9%), intractable pain in 10 (22.2%), metal allergy in 6 (13.3%), wound infection in 9 (20.0%) and bar dislocation in 7 (15.6%) patients. The recurrence rate in patients over 19 years was 57.1% vs. 33.3% in younger patients. The chi-square test showed a significant correlation for recurrence when implants had to be removed earlier than 1.5 years ($n=35$ vs. $n=3$, $p<0.05$). 13 patients completed the QoL questionnaire.Among them, 6 were satisfied with the correction result with a mean QoL score of 56 (min 50, max 69).

Conclusion: Early bar removal rate after MIRPE is low, and the recurrence rate is also low when the implant is removed at 1.5 years or longer. Age over 19 years may be a risk factor for recurrence if early bar removal is required. However, further prospective studies should be performed to determine whether implant removal can be performed safely after 2 years without risk of recurrence.

Upper sternal cleft associated with congenital heart defect - single stage surgical correction

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Conflicts of Interest: The authors declare no conflicts of interest.

Background: A sternal cleft is a rare congenital malformation of the anterior chest wall resulting from the failure of mesoderm migration to the midline early in embryological development. It occurs as an isolated anomaly or in connection with other congenital defects, most often of the cardiovascular system.

Case presentation: In a video presentation, the authors document the case of a 6-month-old female patient with an upper sternal cleft, combined with atrial and ventricular septal defect, and their surgical correction in one session. The timing of the operation was planned as a compromise between the need for the earliest possible reconstruction of the sternal cleft and the correction of the cardiac defect postponed by a few months. The primary repair was performed without complications, with an uneventful postoperative course. The cosmetic and functional result of the reconstruction is very good with a stable anterior chest wall, the child is thriving well, without cardiac limitations.

Conclusion: The success of surgical correction of a combined sternal and heart defect depends on the patient's age and the hemodynamic response of the cardiovascular system to the new configuration of the anterior chest wall after surgery. In the event of an unfavorable hemodynamic response, the use of additive autologous or synthetic material should be kept in reserve to create sufficient space for a reconstructed thoracic cage.

Analysis of the clinical presentation pattern of scoliosis associated with funnel chest

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Background and Aim: To review the occurrence and development of Adolescent Idiopathic Scoliosis (AIS) in patients with Idiopathic Pectus Excavatum (IPE), to summarize the different scoliosis patterns of AIS related to IPE, and to analyze their relationships with patient characteristics of demography, clinical presentation, and surgical procedure.

Method: 219 patients with IPE who completed the Nuss procedure at Beijing Children's Hospital and underwent bar removal between April 2020 and June 2021 were included, their medical records and imaging data were obtained pre-Nuss procedure and within 1 month pre-bar removal surgery. Different scoliosis modes of AIS related to IPE were classified. Differences in characteristics between patients with AIS with different scoliosis patterns and uninvolved patients with pre-Nuss combined as well as post-Nuss complications were compared separately.

Results: The ribs and thoracic vertebrae corresponding to IPE recesses overlap with the distribution peaks of the apex vertebra corresponding to AIS upper thoracic curvature (UTC) and main thoracic curvature (MTC), respectively, according to which IPE-associated AIS can be categorized into the two main types of scoliosis patterns, UTC and MTC. Regarding IPE-comorbid AIS, there was an increased risk of combined UTC in those aged >10 years and with a Correction Index <28%, and an increased risk of combined double thoracic curvature in those aged >10 years. Regarding Nuss surgery combined with AIS, those aged <10 years tended to combine the MTC postoperatively; aged >10 years tended to combine the UTC postoperatively.

Conclusions: There are mainly two types of lateral curvature patterns in AIS related to IPE. Apex vertebra curvature involving T10/T11 is most common in patients younger than 10 years of age, while apex vertebra curvature involving T4 is most common in patients older than 10 years of age or in patients with flat chest.

Proposal of a new semi-automated volumetric thoracic index for the evaluation of severity in Pectus Excavatum

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i. Background and Aim

Pectus Excavatum (PE) diagnosis traditionally relies on manual measurement of clinical indexes derived from CT or MRI scans, leading to time-consuming, operator-dependent, and potentially inaccurate evaluations. Moreover, existing indexes are limited by their dependence on linear measurements from single slices rather than on thoracic volumetric data. Our aim was to develop an automated image processing pipeline to assist radiologists in PE diagnosis using MRI with a dual purpose: (i) automatizing the computation of clinical indexes to standardize pre-operative evaluation; (ii) introducing a novel marker, termed Volumetric Correction Index (VCI), of pathological severity via volumetric analysis to address the shortcomings of current axial slice-based indexes.

ii. Method

The software code was developed in MATLAB® 2020a on Windows 10. The image analysis framework comprised four interconnected elements: pre-processing, chest depression quantification, inner chest contour segmentation, and results presentation (Figure 1). The resulting framework was semi-automatic, requiring user intervention facilitated by a Graphical User Interface (GUI) at key stages.

iii. Results

Our pipeline was tested on MRI data from 50 pediatric patients [41 males 9 females, age 13.5 ± 2.78 (mean ± SD), 5–18 years, HI 6.18 ± 3.63 (mean ± SD)], with manual computation of indexes serving as the gold standard. Automatic index computation demonstrated strong agreement with manual measurements by two independent readers. Furthermore, the newly proposed VCI exhibited good correlation with standardized markers of pathological severity, showing promise as an innovative diagnostic tool.

iv. Conclusions

The study introduces an innovative approach to PE evaluation using MRI, offering a radiation-free and efficient method for radiologists. The framework enables quick and accurate assessment of classical PE severity indexes while introducing the VCI. These findings suggest potential enhancements in diagnosis, treatment, and follow-up of PE patients using the automated image processing tool.

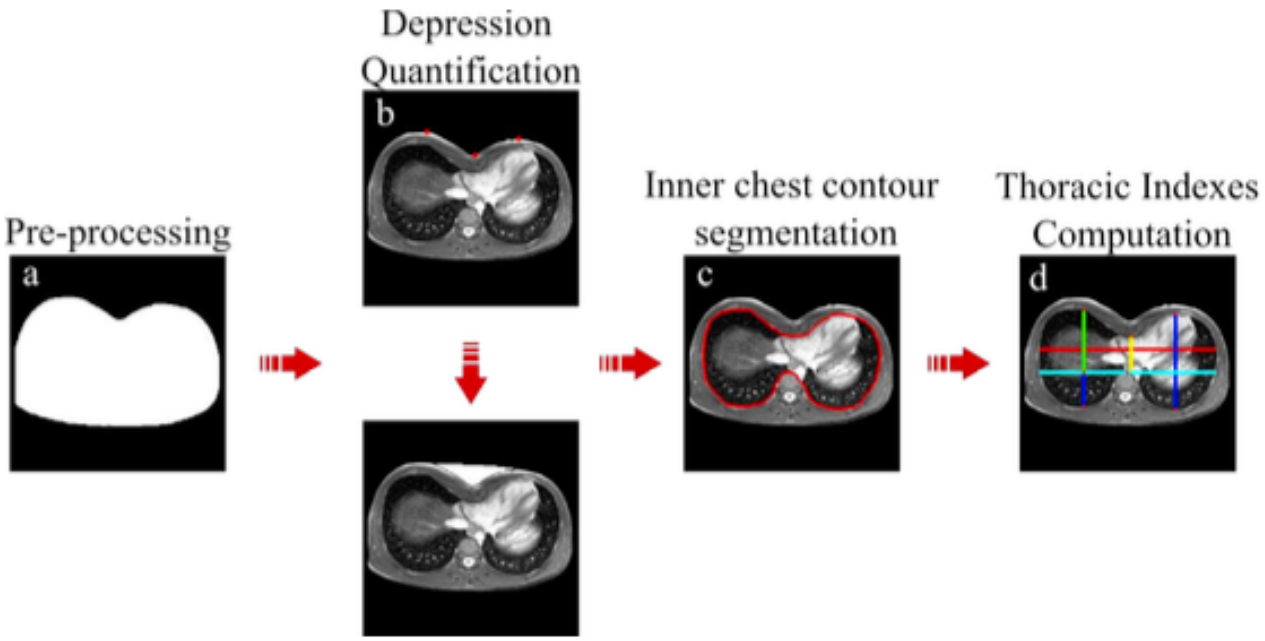

Figure 1. Image analysis framework is composed of four interconnected elements.

Does A High Haller Index Impact Outcomes in Pectus Excavatum Repaired

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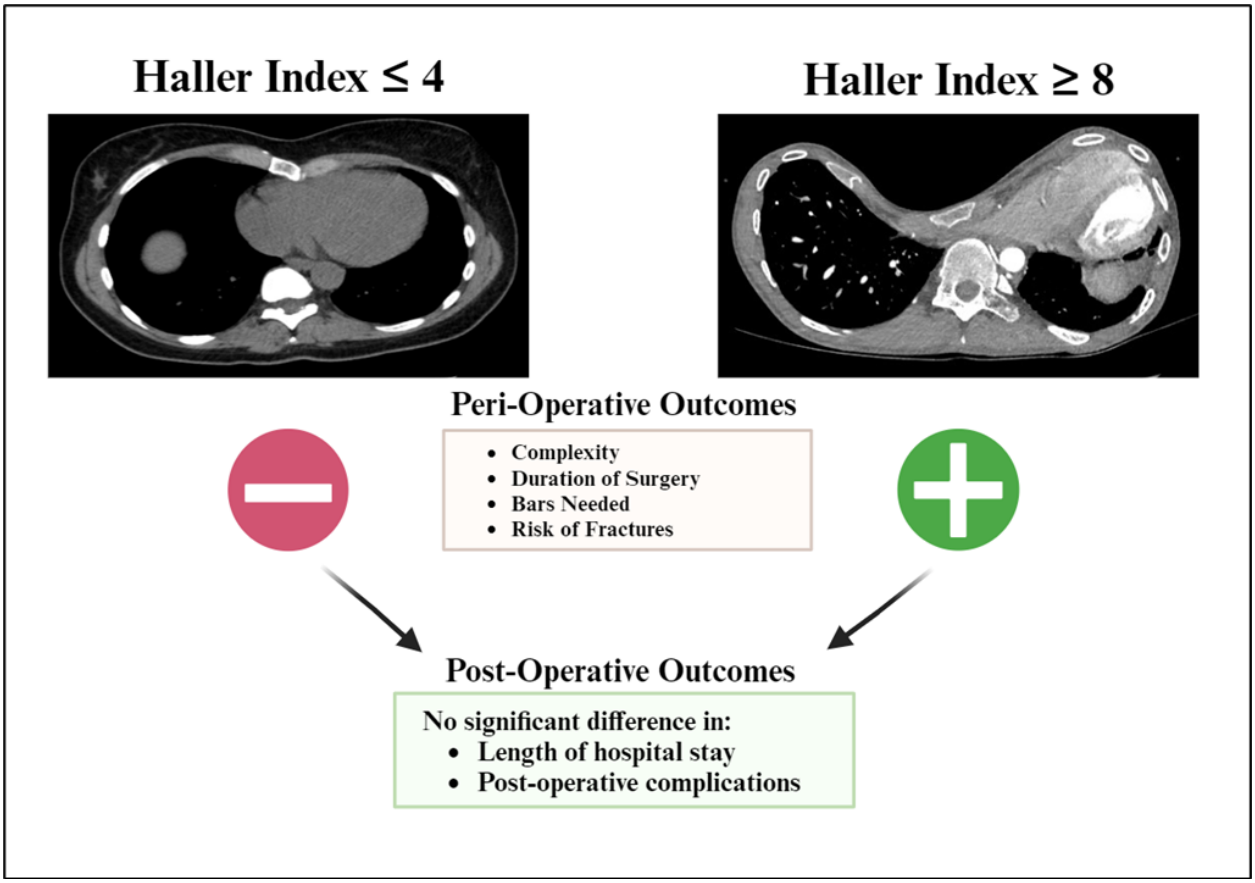
Disclosure: Dawn Jaroszewski discloses consulting and IP/royalties through Mayo Clinic Ventures with Zimmer Biomet, Inc and AtriCure, Inc. Other authors report no conflict of interest.

Background and Aim: Severity for pectus excavatum includes Haller index >3.25. An extremely high Haller index (≥8) may influence surgical approach and complications. This study reviews outcomes of high Haller index patients after repair.

Method: A single institution retrospective analysis was performed on adult patients with Haller index ≥8 undergoing pectus excavatum repairs. For outcomes, a propensity-matched control group with a Haller index ≤4 was utilized.

Results: In total, 74 cases (mean age 34.3 ±11.1 years, Haller index 12.8 ±4.9; 59% females) were included. A minimally invasive repair was successful in 85%. A hybrid procedure was performed in the remaining 11 patients to repair fractures of the ribs and/or sternum, as well as when osteotomy and/or cartilage resection was required. In comparison with the matched cohort (Haller index ≤4), high Haller index cases had longer operative times (171 vs. 133 minutes, p<.001), more frequently required Hybrid procedures (15% vs. 2%, p=0.005), experienced higher incidences of rib (24% vs. 3%, p=0.001) and sternal fractures (13.5% vs. 0%, p=0.003), and had increased repair with 3 bars (53% vs. 19%, p<0.001). There were no significant differences between the groups for length of hospital stay or postoperative 30-day complications (pleural effusion, pneumothorax, pericardial effusion, bleeding, and uncontrolled pain) **(Figure)**.

Conclusions: Patients with an extremely high Haller index can be challenging cases with greater risks of fracture and need for osteotomy/cartilage resection. Despite this, minimally invasive repair techniques can be utilized in most cases without increased complications when performed by an experienced surgeon.


Haller Index ≤ 4
Haller Index ≥ 8
Peri-Operative Outcomes
Complexity
Duration of Surgery
Bars Needed
Risk of Fractures
Post-Operative Outcomes
No significant difference in:
Length of hospital stay
Post-operative complications

Beyond the Chest: A Novel Approach to Assess Cardiovascular Strain in Pectus Excavatum Patients

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i. Background and Aim

In severe instances, Pectus Excavatum (PE) can lead to significant cardiopulmonary complications, including cardiac compression and rotational displacement. Along with thoracic indices, corresponding cardiac markers aim at quantifying the degree of cardiac compression induced by PE. Nonetheless, these indices are largely underutilized in clinics due to their lack of interpretability.The study aims to introduce new automated measures for assessing cardiac function in PE, aiding surgeons in identifying surgical candidates.

ii. Method

The proposed open-source method was implemented in Python 3.10. Main automated steps included: (i) computation of traditional slice-based thoracic indices alongside a novel Volumetric Correction Index (VCI); (ii) quantification of established 2D cardiac indices, by optimizing cardiac segmentation to eliminate extraneous contributions from adjacent structures; (iii) extraction of two new cardiac markers: (i) the Cardiac Depression Ratio (CDR) and (ii) the Cardiac Depression Factor (CDF), which comprehensively characterize cardiac morphology and volumetric compression, respectively (Figure 1).

iii.Results

Our pipeline was tested on 43 pathological patients [36 males 7 females, age 13.27 ± 2.71 (mean ± SD), 5–18 years, HI 5.64± 3.21 (mean ± SD)] and 15 healthy controls. The automated computation of thoracic indices in Python agreed with the previous version implemented in MATLAB (Wilcoxon test, $p < 0.05$). Additionally, the newly introduced cardiac indices exhibited statistically significant distinctions between pathological and control groups (paired t-test, $p < 0.05$). Moreover, a normative optimal cutoff (20.20%) for the Cardiac Depression Ratio (CDR) was established in discriminating patients and controls through Receiver Operating Curve (ROC) analysis.

iv.Conclusions

The new proposed indices introduce an innovative system of semi-automatic estimation of cardiac compression in pediatric patient with PE, with potential relapses on pre-surgical

assessment. Despite the preliminary nature of these results, this work serves as a foundation for the future development of new, more comprehensive, robust, and reliable markers for assessing the overall status of PE condition.

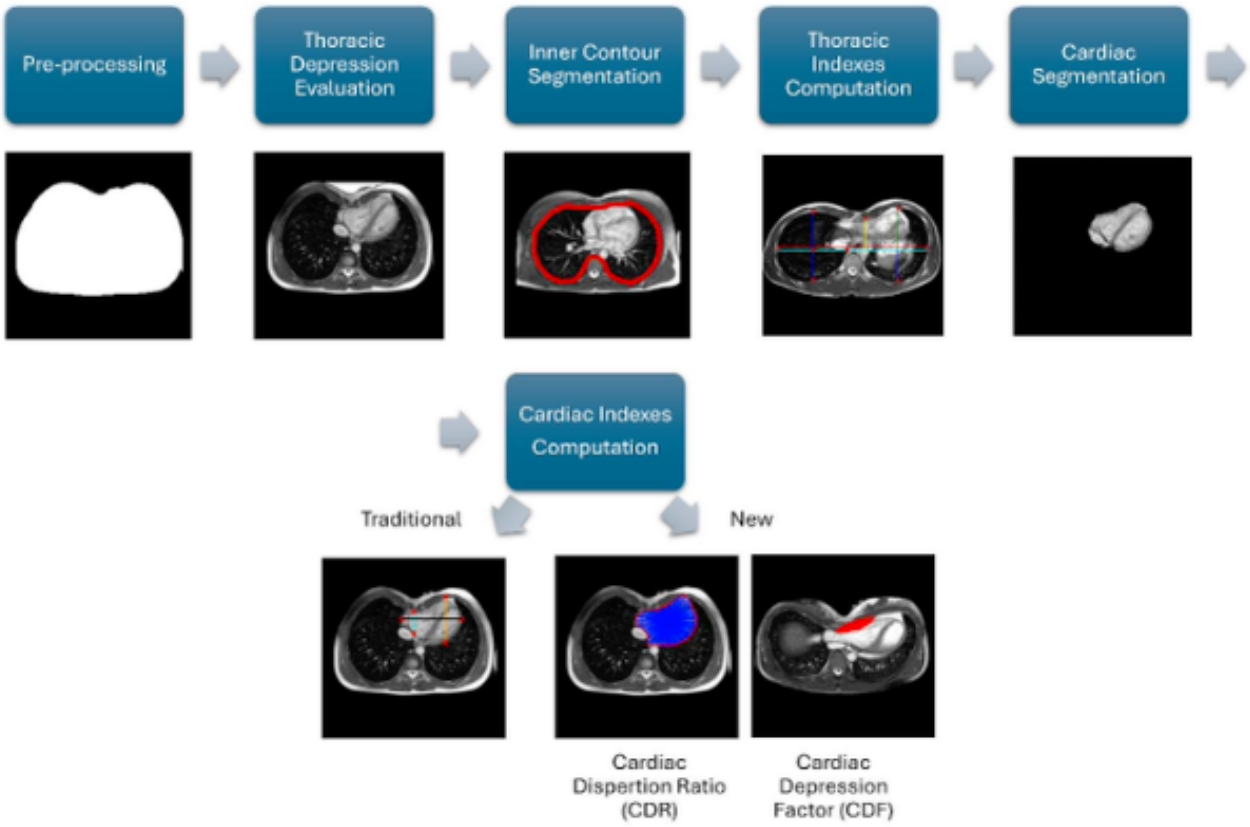

Figure 1. Image analysis framework is composed of six interconnected elements.

Efficacy of the Nuss Procedure in Patients with Asymmetric Pectus Excavatum

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Conflicts of interest: No

Background and Aim: The Nuss procedure is widely recognized as the standard procedure for pectus excavatum (PE). Nevertheless, its efficacy in correcting asymmetrical depressions, particularly those with sternal torsion, has yet to be thoroughly evaluated. This study investigates the modifications in sternal torsion angles before and after the Nuss procedure, as well as their influence on rectifying asymmetry in pectus excavatum.

Method: We examined the medical records of 243 individuals with PE who underwent the Nuss procedure at our institution. Pre- and post-operative CT scans were available for analysis. Patients were divided into two groups based on their sternal torsion angle: symmetric (within 5 degrees) and asymmetric (greater than 5 degrees). The degree of asymmetry was further classified as mild (5-15 degrees), moderate (15-25 degrees), or severe (over 25 degrees). We calculated the percentage of improvement in sternal torsion angle and utilized multiple regression analysis to determine the factors influencing the correction of asymmetry.

Results: The patients had a median age of 22 years, and males made up 87.2% of the group. Of those, 64.6% had asymmetric PE. After the operation, all groups showed improvements in the median sternal torsion angle: the mild group went from 10.3 to 4.7 degrees (-54.4%), the moderate group from 19.2 to 9.6 degrees (-50.0%), and the severe group from 32.2 to 16.5 degrees (-48.8%). Inserting three or more bars in the thoracic cavity (P=0.01) and patient age under 20 years (P=0.04) were significant factors that enhanced the correction of asymmetry.

Conclusions: The Nuss procedure has proven to be a successful method for correcting asymmetrical PE, especially in patients under 20 years old and those who have received three or more bars. Nevertheless, achieving full correction in cases involving severe asymmetry can still present a challenge, highlighting the importance of further developing surgical techniques.

Alternative treatment of pectus excavatum the method of choice?

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Background: Many experts report that vacuum bell therapy has shown comparable results and is an alternative treatment method for patients who prefer non-surgical correction of deformity.

Methods: We select the device individually for each patient, depending on the height and degree of deformation of the chest. The size of the device must exceed the size of the pectus excavatum to prevent spontaneous leakage of the bell. To fully understand the essence of the deformation of the child's chest, the following data are needed: date of birth, height, weight, chest circumference at the deformation level, the distance between the areoles, computed tomography data of the chest organs. Below are examples of photographs of a boy with PE and MSCT scans of the same patient (Fig. 1).

Results: Over the period 2018-2024, we observed 3,525 children and were convinced that this method is effective and safe, and can also used as an alternative to surgical treatment. The best results were in children from 7 to 15 years old. In our experience, an alternative treatment method is effective from 4 to 20 years in boys and from 4 to 14 years in girls. In females, skeletal formation proceeds at a faster pace and by the time puberty is completed (13-17 years old), the elasticity of the chest decreases sharply, which is a relative contraindication to vacuum bell therapy, in these cases surgical intervention is necessary.

Conclusions: With timely treatment of patients, especially before the complete formation of the skeleton and the development of gross deformation, Vacuum Bell can completely correct the anomaly that has arisen, rid a person of both physical ailment and psychological problems. Nass surgery is necessary for patients with a Haller index of more than 3.5-4; older age group (≥22 years); lack of effectiveness from Vacuum Bell.

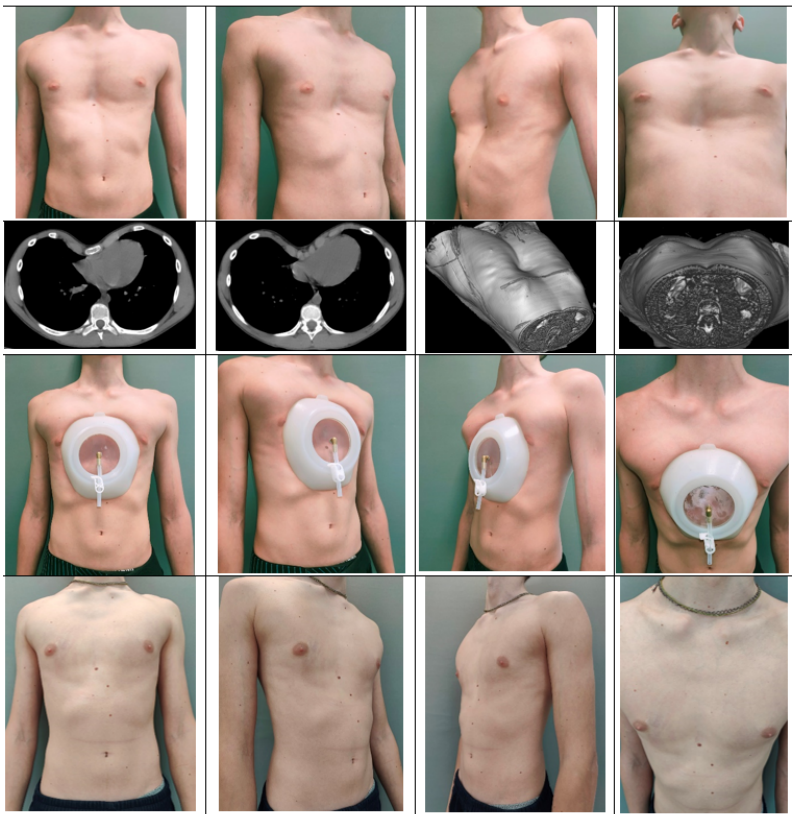

Fig. 1. Photo of the patient with PE before, after and during wearing the bell.

An early drop in Pressure does not correlate with a higher success rate in pectus carinatum patients using a dynamic compression system.

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Introduction: Pectus carinatum (PC) patients are treated primarily by non-operative management using a Dynamic Compression System (DCS) with an established standard treatment algorithm. We observed that, in a subset of PC patients, the Pressure of Correction (POC) decreased significantly within 15 minutes of application of the device suggesting a more pliable chest wall. We intended to determine whether this subgroup of patients had a higher success rate.

Methods:110 patients of PC undergoing treatment using DCS were observed over 15 months. Patients were divided into 2 groups according to the drop in POC after 15 minutes of application of device employing a threshold of 15%. Group A included patients with a drop in POC <15% and Group B with a drop in POC >15%. All patients were treated using the same treatment algorithm and followed closely till the treatment was considered successful, defined as attainment of POC of 0 psi. The progressive decline in POC during the treatment period was compared with baseline POC of each patient.

Results:89% were males with a mean age of 13.7±2.2 years. Baseline mean POC was 7.17±2.3 psi, dropping to 6.21±2.1 psi after 15 min of device use ($P<0.0001$). Group A had a higher baseline POC as compared to Group B (A: 7.5±2.5 vs B: 6.5±1.9, $p=0.03$). However, the success rate of treatment was similar irrespective of baseline or percentage of pressure drop after 15 minutes of device use (A: 77% vs B: 92%; $p=0.11$).

Conclusion: Current DCS treatment algorithm leads to similar success rate regardless of early drop in POC. Further research is needed to assess whether in some subset of patients, a different treatment algorithm can expedite success without increasing the adverse effects.

LIFE-THREATENING SPONTANEOUS PNEUMOTHORAX AFTER PECTUS EXCAVATUM REPAIR DUE TO BUFFALO CHEST: ARE CONGENITAL BLEBS AN UNDERSTIMATED RISK FACTOR?

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Background and Aim: With mini-invasive repair of pectus excavatum (MIRPE), a communication between the two pleural cavities is created, known as “buffalo chest”, which is a potential risk factor for bilateral pneumothorax, as occasionally reported in the literature. Moreover, few papers reported an increased incidence of congenital blebs associated with Pectus excavatum (PE), which can be expected, as both patients with PE and those predisposed to develop spontaneous pneumothorax (SP) tend to share a Marfanoid habitus. Our aim is to analyze the incidence and clinical presentation of SP after MIRPE, discussing the role of congenital blebs in PE patients.

Method: We investigated retrospectively the incidence of SP (not related to surgery) at least one month after MIRPE in our patients operated from 2005 to January 2024: clinical presentation, treatment, and outcomes were evaluated.

Results: Among 810 patients undergoing MIRPE, 6 (0.74%) experienced SP, in 4 cases unilateral (2, 12, 28 and 36 months after MIRPE) and in 2 bilateral (1 and 19 months after MIRPE). In all cases but one, blebs were demonstrated as the cause of SP. All 4 unilateral SP presented mild respiratroy symptoms and had blebs treated with thoracoscopic bullectomy/pleurodesis. Both patients with bilateral SP experienced cardiac arrest: one (affected with Marfan syndrome) was promptly treated at our institution's emergency department with bilateral drain, underwent bilateral thoracoscopic bullectomy/pleurodesis and fully recovered. The other patient (without previous collagen disease diagnosis) passed away at a peripheral hospital and the presence of blebs was suspected but not demonstrated.

Conclusion: After MIRPE, bilateral SP is probably due to the presence of iatrogenic buffalo chest. Bilateral SP may represent a life-threatening emergency. Our results could indicate the need of investigating (and treating) the presence of apical blebs before MIRPE

Thoracoscopic intercostal nerve thermal radiofrequency ablation (INTRA) for postoperative pain relief after the Nuss procedure. Is it safe and effective?

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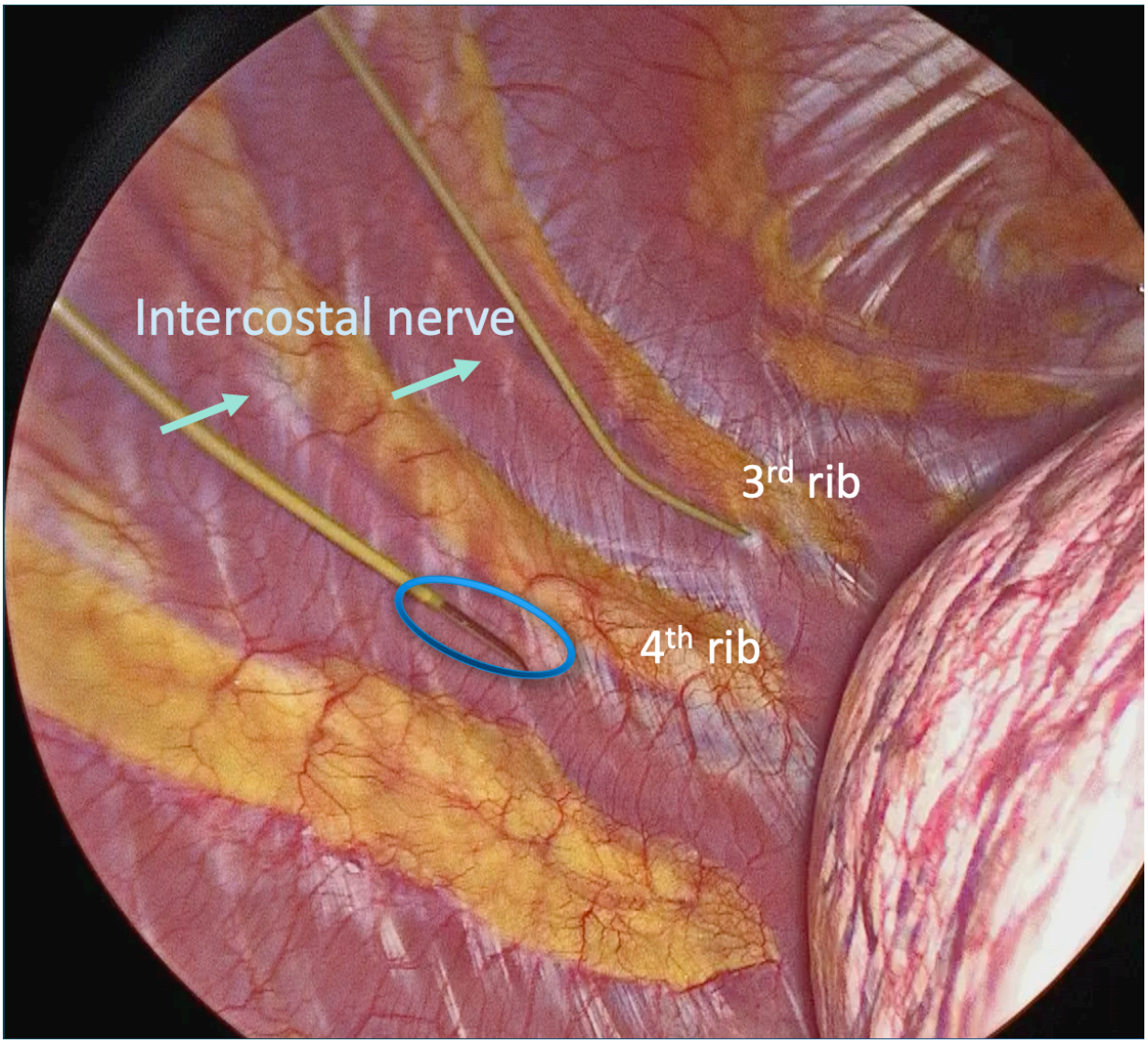
[Purpose] Cryoanalgesia has been reported to be effective for postoperative analgesia in Nuss surgery. However, it cannot be used in Japan because it is not covered by insurance. On the other hand, thermal radiofrequency ablation is already an established treatment for chronic pain, but there are no reports of this technique being used as a measure for postoperative pain. We report on the safety and efficacy of thoracoscopic intercostal nerve thermal radiofrequency ablation (INTRA) during the Nuss operation.

[Materials and methods] INTRA was performed on 132 Nuss surgery cases (M: 111, F: 21) between April 2022 and March 2024. Median age was 17 (12-55) and mean Haller index was 5.04 ± 1.99. The Top Lesion Generator (TLG-20) was used, and three 20G Pole needles were used simultaneously under thoracoscopy immediately after the start of surgery. The needles were inserted into the bilateral third to seventh intercostal spaces and thermal ablation was done at 70 to 80 degrees for 60 to 120 seconds. The following items were reviewed: procedural complications related to INTRA, postoperative complications, records of outpatient analgesic prescriptions, and the presence of skin hypersensitivity or blunting in cases followed up more than 3 months postoperatively.

[Results] The mean operative time was 106 ± 34 min. Postoperative complications included one hemothorax, one pneumothorax and one pleural effusion; there were no complications related to the INTRA technique. Epidural anesthesia was not used except in four initial cases. 95% of patients were discharged on postoperative day 6 as planned. Within the first postoperative month, 60% of patients no longer required oral NSAIDs. Skin paresthesia gradually improved by three months postoperatively and no-one subsequently complained of skin discomfort. Hypersensitivity was complained of in six cases in the early postoperative period, but all cases subsequently improved. No cases of neuropathic pain developed.

[Conclusions] INTRA could be performed safely, and postoperative analgesia was found to be acceptable without epidural anesthesia. No short- or long-term complications of INTRA were observed. The effective conditions: temperature and time of thermal radiofrequency for intercostal nerves are open to further investigation. INTRA can be recommended for use as an alternative therapy for cryoanalgesia.

Fig. 1 INTRA procedure under thoracoscopy



Vacuum Bell Therapy for Pectus Excavatum: Long-term experience at a single center

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Background and Aim: Vacuum bell therapy for pectus excavatum is a favorable option for those not appropriate to participate in surgery or who opt for conservative management. In the current study, patients undergoing this therapy were assessed for factors associated with an excellent outcome.

Methods: A single-institution retrospective chart review was performed from November 2012-April 2023 to assess outcomes of patients who underwent vacuum bell therapy. (IRB 15-01-WC-0024) Patients were categorized by demographics and results. Excellent outcomes include ≥100% improvement from an average standard chest depth of 0.51cm. Patient age at initiation of therapy was categorized into 4 groups: <8, 8-12.9, 13-17.9, and ≥ 18. Statistical analysis was done using odds ratios, chi-square, and paired t-testing. Results were reported using p-values, with <0.05 demonstrating significance.

Results: 431 patient records were reviewed, with 153 excluded due to limited intake data or loss to follow up. The total number included for analysis was 278; of these, 247 (89%) were male. Characteristics of initial depth </=1.5 cm and chest wall flexibility were statistically associated with an excellent outcome (OR=2.9, p=0.008 and OR=5.1, p=0.0003). Excellent correction was statistically more likely in patients 8-12.9 (OR = 2.2, p = 0.039). 42 of 278 patients (15%) elected for surgical correction, with only 2% of these coming from the excellent or good correction groups.

Conclusions: Excellent correction for pectus excavatum via VBT was achieved in a small proportion of patients, with improved outcomes in those initiating therapy at a younger age, with a mild defect, and with increased chest wall flexibility. These data may be used to help determine those more likely to achieve complete correction from a nonsurgical approach and guide decisions towards treatment methods.

Table 1: Characteristics Associated with Outcome

Patient characteristics	Excellent (31)	Not excellent (247)	Odds ratio (95% CI)	Lower Limit CI	Upper Limit CI	p-value
initial age </= 11	14	70	2.08	0.97	4.45	0.058
initial depth </= 1.5	21	103	2.94	1.33	6.50	0.00789
flexibility	24	99	5.13	2.13	12.35	0.0003
use over 12 mon	22	147	1.66	0.74	3.76	0.22395
symmetric	23	140	2.20	0.95	5.10	0.06678
cup shape	22	130	2.20	0.97	4.97	0.05747
suction pressures 3 or 4	21	147	1.43	0.65	3.16	0.38575
daily use > 60 min	23	174	1.21	0.52	2.82	0.69864

Importance of immediate postoperative pneumothorax after MIRPE

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Objective: This study aimed to share clinical experiences with case series of concomitant PSP and PE and to emphasize the importance of evaluating these two conditions together.

Methods: In this single-center study, we conducted a retrospective records review to identify patients who were diagnosed and treated (including surgical or conservative treatment and follow-up observation) for the patients who had a surgical correction of PE between Jan 2015 and Mar 2023.

Results: Among a total of 451 patients with PE, there were 12 (2.7%) who had concurrent diagnoses of PE and PSP and who underwent surgery for PSP, PE, or both. Narrowing down the scope and analyzing it for the most common age (15-25 years old) group for pneumothorax, among a total of 156 patients with PE, there were 11 (7.1%). Three patients experienced bilateral spontaneous pneumothorax after PE surgery: two were discovered during hospitalization, and one occurred five years later.

Conclusions: The incidence of PSP in 15- to 25-year-old patients undergoing PE surgery was 7.1% (11 out of 156 patients), highlighting the importance of careful monitoring for PSP before PE surgery, and vice versa. Additionally, we should be aware that postoperative bilateral spontaneous pneumothorax can occur due to transient buffalo chest.

15 years of vacuum bell therapy for pectus excavatum: long-term outcomes and influencing factors

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Declaration of interest: Presenting/corresponding author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Background: Long-term results and factors affecting outcomes of vacuum bell therapy for pectus excavatum are relatively unknown.

Methods: We conducted a retrospective study on patients (<18y) treated with vacuum bell therapy between May 2008 and October 2021. Primary outcome was treatment success; secondary outcomes were analysis of daily time spent on treatment, treatment duration, complications, long-term follow-up, treatment for patients awaiting a Nuss procedure, treatment for female patients, and factors affecting outcomes.

Results: Of 259 patients treated with vacuum bell therapy, 18.9% (n=49/259) were still being treated, 17.4% (n=45/259) were lost to follow-up and 63.7% (n=165/259) completed treatment, with a 52.1% (n=86/165) success rate . Median follow-up was 64.0 months (interquartile range 48.0-87.0). More time spent daily on vacuum bell therapy, total treatment duration, and overnight use led to a higher success rate (P=.002, P<.001, P<.001 resp.). Complications (22.8%, n=59/259) were minor, recurrence occurred in 2.3% (n=2/86) of patients. Of the patients treated while awaiting a Nuss procedure, 26.7% (n=4/15) no longer required the Nuss procedure. Breast growth made 39.3% (n=11/28) of female patients quit treatment. Deeper deformities (P=.02, P=.009), flexible chest wall (P=.007) and symptomatic pectus excavatum (P=.02) resulted in lower success rates.

Conclusions: Vacuum bell therapy is successful in up to 52.1% of patients. Overnight vacuum bell use and treatment while awaiting a Nuss procedure should be encouraged. Older patients with a stiff chest wall can be successfully treated with prolonged treatment. For female patients watchful waiting or early treatment, to prevent challenges during breast growth, is preferred.

Clinical study and genetic analysis of patients with chest wall deformities associated with Marfan syndrome and Loeys-Dietz syndrome

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Objective: To analyze clinical manifestations and gene mutations in Marfan syndrome (MFS) and Loeys-Dietz syndrome (LDS), and explore differences; and analyze postoperative recurrence risk in pectus excavatum patients with MFS and LDS, aiming to provide management references.

Methods: Seventeen patients suspected of MFS or LDS were examined. Exome sequencing and clinical data collection were conducted. Patients were divided into MFS and LDS groups based on diagnostic criteria. Clinical features and gene mutations were analyzed. Thirteen patients with pectus excavatum were assessed for surgical outcomes.

Results: Of 17 patients, 13 had MFS and 4 had LDS. MFS patients had lower BMI than normal children. Pectus excavatum, scoliosis, and aortic dilation were common. All patients carried gene mutations. Recurrence after Nuss procedure was observed in 3 patients, associated with age and bar placement duration.

Conclusion: Clinical manifestations of MFS and LDS overlap. Exome sequencing validated FBN1 and TGFBR2 gene roles. Novel mutations were identified. Nuss procedure effectively treated pectus excavatum. Recurrence rates were influenced by age and bar placement duration.

Keywords: Pectus excavatum, Nuss procedure, Marfan syndrome, Loeys-Dietz syndrome, FBN1, TGFBR2

Just a Number: Haller Index Does Not Correlate with Severity of Pectus Excavatum Symptoms and Impact on Quality of Life

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Conflicts of interest: none

Background: The Haller index (HI) is widely used to calculate the deformity severity of pectus excavatum (PE). We assessed the relationship of HI to quality of life (QoL) and symptomatic complaints in patients with PE.

Methods: We prospectively collected data on patients with PE managed in a dedicated pediatric chest wall program at a single institution from March 2018 to March 2024. Surveys were administered at intake and included questions regarding patient demographics, comorbidities, disease duration, interventions, symptoms, and QoL assessments. Patients' QoL was assessed across five domains: pain, embarrassment, ability to play sports, ability to socialize, and disrupting activities. QoL surveys were administered on a Likert scale from 1 (no impact on QoL) to 10 (severe impact on QoL). Patients also answered questions about their symptoms in 5 domains: sternum/breastbone pain, pain over ribs, shortness of breath, heart palpitations, and exercise intolerance. Patients rated severity of their symptoms "none (0)", "mild (1)", "moderate (2)" or "severe (3)". Patients' QoL and symptom score responses were summed to calculate total QoL and total symptom scores. HI was compared to the total QoL and total symptom scores.

Results: Survey data from 198 patients were available for analysis, with a mean age of diagnosis of 9.2 years(SD 4.9). Most patients were male (85.8%), with a mean height of 166.7 cm (SD 15.6) and weight of 53.6 kg (SD 15.6) at intake. Mean HI was 3.86 (SD 1.26). 98 patients had funnel depth available for analysis, with a mean of 2.26 cm (SD 0.77). The average total QoL scores was 8.25 (SD 8.51). The most prevalent QoL domains impacted were embarrassment (n=130) and pain (n=104), with mean scores of 3.23 (SD 3.33) and 1.87 (SD 2.36), respectively. The average total symptom score in our cohort was 2.26 (SD 2.62). Shortness of breath and exercise intolerance were the most common reported symptoms, experienced by 97 and 84 patients, respectively, with mean symptom severity scores of 0.74 (SD 0.88) and 0.60 (SD 0.84). On bivariate analysis, HI did not correlate with total QoL ($r(196)=0.051$, $p=0.477$) or symptom scores ($r(196)=0.101$, $p=0.156$) or any individual domain.

Conclusion: Patients with PE report significant symptoms and impact on their QoL. The severity of symptoms and QoL in patients with PE are not associated with the severity of the PE as measured by HI, suggesting that HI alone does not adequately capture PE patients' experience with their disease.

	Quality of Life [Scale 1-10]					Symptoms [Scale 0-3]				
	Pain	Embarrassment	Sports	Social	Disrupting Activities	Sternum Pain	Pain Over Ribs	SOB	Heart Palpitations	Exercise Intolerance
n	104	130	97	47	46	49	52	97	41	84
Mean	3.56	5.00	3.97	3.88	3.53	1.38	1.35	1.51	1.5	1.52
SD	2.36	3.33	2.75	2.03	1.88	0.65	0.67	0.88	0.66	0.84

Table 1: Quality of Life and Symptom Impact of Pectus Excavatum

n= number of patients reporting symptom >0, SOB= shortness of breath, SD= standard deviation

PurePectus Bars: Learning Curve

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Funding: N/A

Conflicts of interest and Source of Funding:
DN has patents related to Pure Pectus and receives royalties. LM, DN, and BP are educational consultants for Atricure.

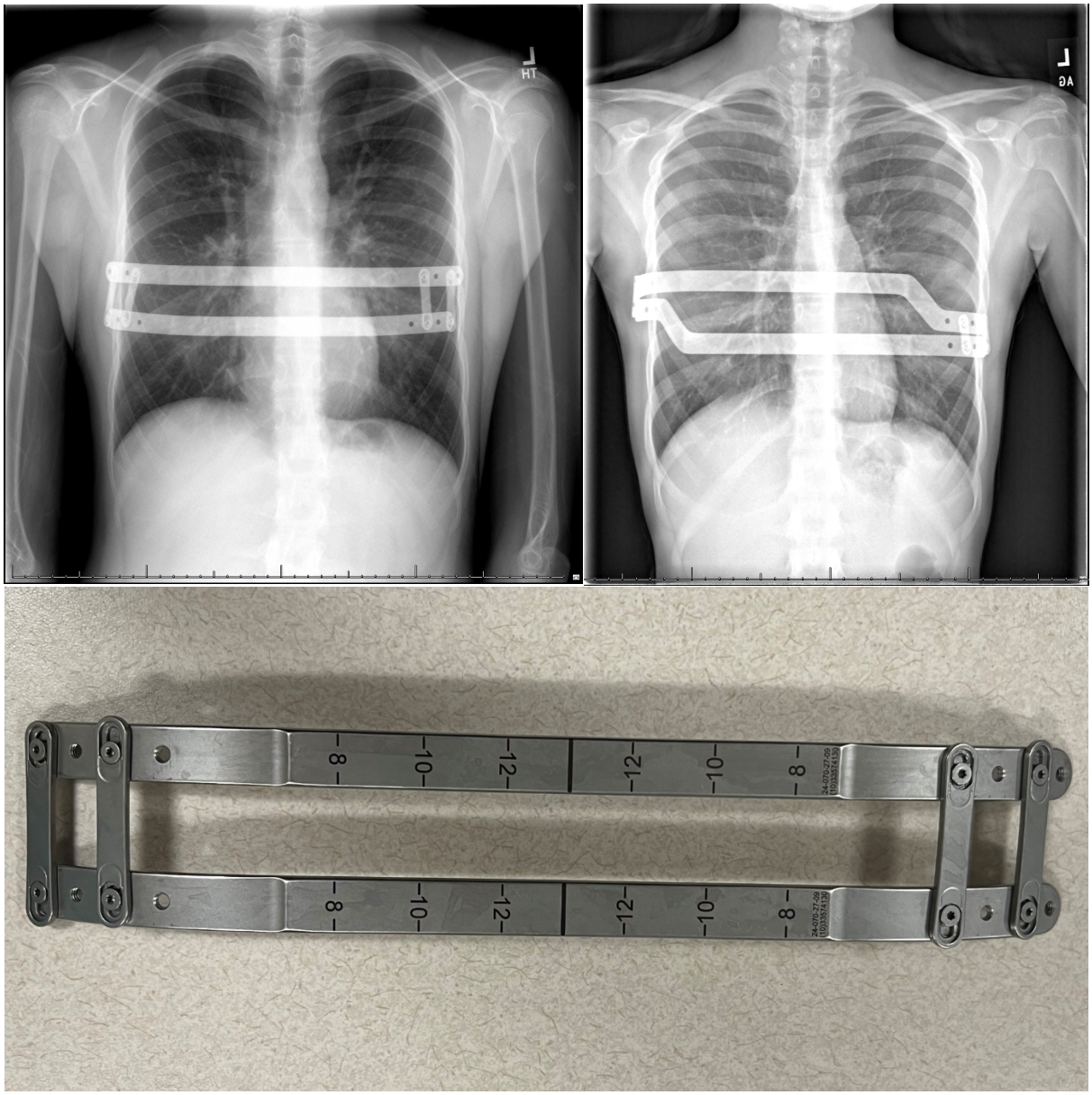
No funding was received for conducting this study.

Bar rotation and migration is a persistent problem in repair of pectus excavatum with Nuss bars. A new titanium system, PurePectus (KLS Martin) aims to prevent bar migration and rotation and allows additional bars without requiring larger incisions. We report our initial use of the system.

Methods: A retrospective chart review was performed September to December 2023. Demographic, radiographic, intraoperative, hospitalization and postop data were collected.

Results: 23 patients had PurePectus bars placed; median age 15.9 (range 12-22 years). Sternal elevation, thoracoscopic mediastinal dissection and cryotherapy was performed in each. In 23 patients, 51 bars were placed, with 98 connector plates used. Mean operative time for 2 bars was 119.5 min (100-146); time for 3 bars 147.4 min (137-200). The number of connector plates varied from 3 to 8 per case. The average length of stay was 1.43 nights (range 1-4 nights). One patient had malignant hyperthermia intraoperatively. There were no postoperative complications in 7 months of follow-up; no bar migrations or rotations in any of the patients.

Discussion: New skills required including measuring the length of connector plates using a caliper and partially connecting the plates on one side prior to securing on the contralateral side to optimize bar position. One screwdriver was broken in the plate due to angled removal. In this case, the connector was removed in situ by snapping it off and a new connector was used. Allowing for enough bar length external to the exit site is important in placing the Z-bars to prevent the Z-section from entering the chest. The z-bars were best suited for patients with medial pectus ridges and medial entrance/exit sites. No increase in incision length was needed for 2 or 3 bar insertion patients. As the first center to implant these bars, several lessons were learned, but without increase in complications or operative time.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Results of Vacuum Therapy in Pectus Excavatum Patients

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The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

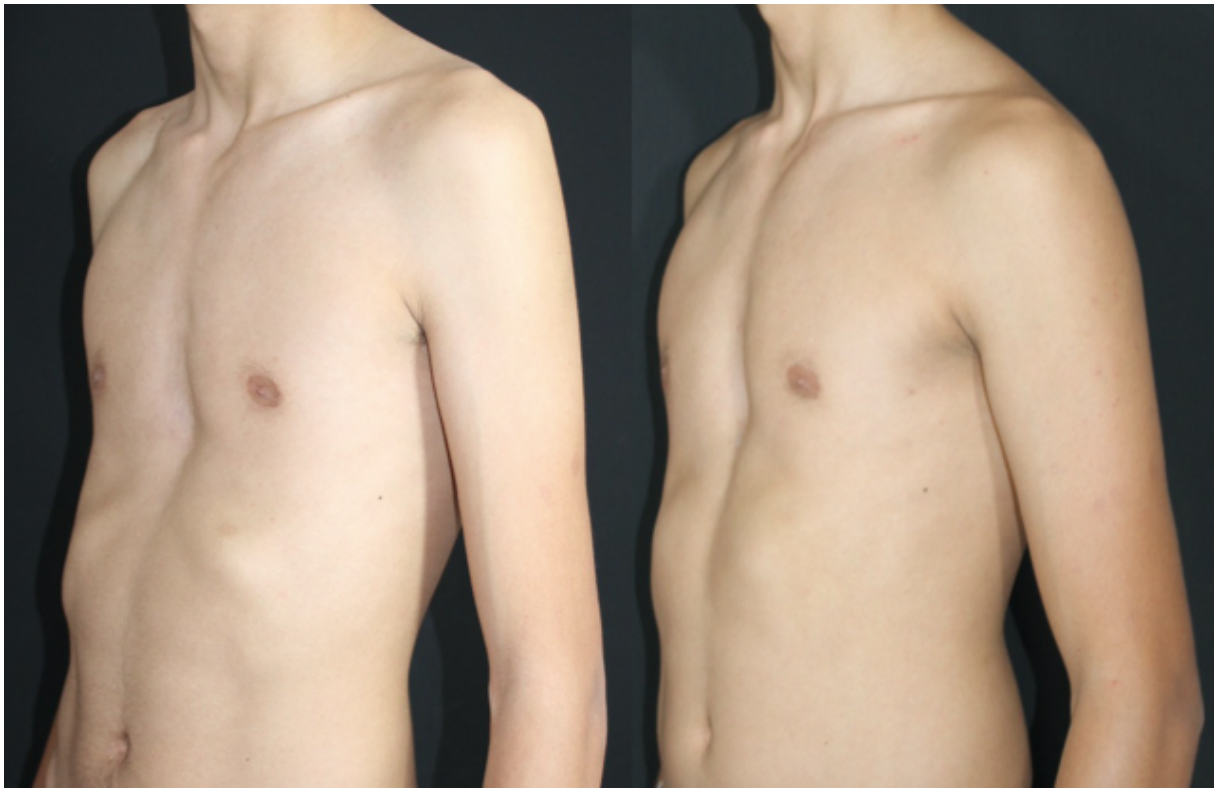
Introduction: Pectus excavatum (PE) is the most common deformity of the chest wall and is mostly operated for cosmetic reasons in young adults. This study presents the results of patients who underwent vacuum therapy for PE.

Materials and Methods: Between September 2019 and March 2024, vacuum therapy was recommended for 227 patients due to PE. Vacuum therapy was started in 183 of these patients. Patients are recommended to use the vacuum for 30 minutes in the mornings and 30 minutes in the evenings during the first week. The application duration was increased to 1 hour in the mornings and 1 hour in the evenings in the second week. The ultimate application duration was reached at the first month as 2 hour in the mornings and 2 hour in the evenings.

Results: There were 151 (82.6%) male and 32 (17.4%) female patients. The mean age of the patients was 11.4 (±3.35) years. The mean depth of the deformity was recorded as 2.65 (±0.98) cm at the beginning of the treatment. In 64 patients, a 34,9% reduction in pectus depth was detected during controls after an average of 11.3 (8-17 months) months. In 31 (16.9%) patients, there was not enough change in depth despite 12 months of use. Recurrence was detected in 7 (3.8%) patients. Treatment was started again. 12 (6.5%) patients were excluded from the study due to irregular vacuum use. 11 (16.9%) patients wanted to have surgery during follow-up. Follow-up continues with routine outpatient clinic controls. We have 58 patients who are still under treatment (Picture). Petechiae and pain in the application area were observed in 17 (9.2%) patients.

Discussion and Conclusion: In patients with pectus excavatum presenting for cosmetic and psychological reasons in childhood, it is possible to achieve satisfactory results by eliminating surgical risks with vacuum therapy.

Keywords: Pectus excavatum, Vacuum therapy



Effect of vacuum bell therapy on subcutaneous fat of chest wall in patients with pectus excavatum

Presenting Author: Qian Zhang

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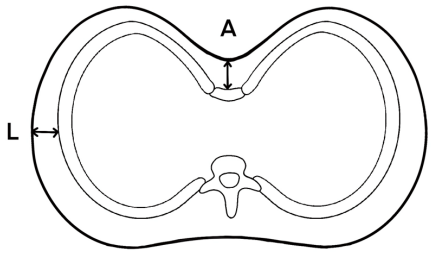
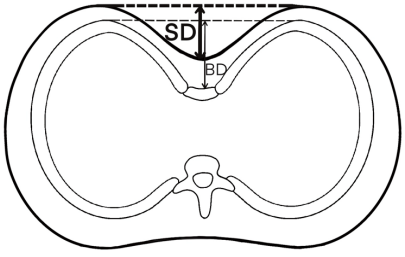
Background and Aim: The thickness of subcutaneous fat of the chest wall treated with vacuum bell can cover up the true depression in patients with pectus excavatum, when measured only from the body surface. The purpose of this study was to investigate the impact of this thickness of fat on treatment evaluation.

Method: Patients treated with vacuum bell from January to June 2022 in our center were retrospectively analyzed. The Haller index (HI), anterior chest wall fat thickness (A), lateral chest wall fat thickness (L), depth of body surface depression (SD), and depth of bone depression (BD) were measured by CT before the start of treatment and 1 year after treatment. The influence rate of vacuum bell was calculated by measuring the change of fat thickness before and after treatment to reflect the influence of vacuum bell on the growth of fat.

Results: A total of 41 patients were enrolled, with a median age of 6.4 years (1-14years). The average HI before and after treatment was 3.6±0.7 and 3.2±0.5, and the Haller index of 10 cases was still aggravated after treatment, and the effective rate of real suction cup treatment was 75.6%. The subcutaneous fat of the anterior chest wall was thickened in 95.1% (n=39) patients, and A before and after treatment was 4.0±1.9mm and 7.5±3.2mm respectively. The average influence rate of vacuum bell was 100% (33%-267%). The mean improvement of BD and SD before and after treatment was 1.7±3.9mm and 4.0±3.3mm respectively.

Conclusions: The use of vacuum bell will thicken the fat of chest wall, and only evaluating by measuring the body surface will cover up the true depression. Compared to the lift of the sternum and ribs, the increase of the fat in depression area will give an additional improvement in appearance.





Innovative Surgical Repair of Severe Pectus Carinatum Using 3D Surgical Planning and Advanced Rib Fixation Techniques

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,
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Introduction: Pectus carinatum is characterized by a protruding sternum. Treatment typically involves bracing, with a 70% success rate given adherence. Severe cases may require surgery, with options including the Ravitch, Abramson, and modified Ravitch/Hybrid procedures. We present a case of a patient with severe pectus carinatum not amendable to brace that was repaired with a modified Ravitch incorporating techniques learned in the adult rib plating experience.

Case presentation: A 16-year-old male with severe pectus carinatum, unfit for bracing, underwent operative repair coordinated by a multidisciplinary team using a 3D-printed chest wall model for pre-surgical planning. During surgery, cryoablation was used to minimize post-operative pain. Dissection, osteotomy, and cartilage resection were guided by pre-operative practice on the 3D model. Titanium and PEEK plates secured the reconstructed chest, with adjustments made in situ for optimal fit. The procedure, which involved meticulous tissue handling and fixation, resulted in a stable reconstruction, confirmed by postoperative imaging. The surgery lasted 366 minutes, with a total operating room time of 465 minutes and a blood loss of 250 ml.

Conclusions: This case illustrates the effective application of 3D surgical planning and modern rib fixation methods in treating severe pectus carinatum. Key success factors included a multidisciplinary approach, advanced plating techniques, and the use of 3D models for precise pre-operative planning. The integration of these strategies resulted in a satisfactory short-term outcome and a promising technique for managing complex chest wall deformities in the future.

POSTER PRESENTATIONS

Presenting author is in blue bold

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22. **It is quality that counts rather than quantity**
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POSTER PRESENTATION ABSTRACTS

A new criteria proposal for determining the number of bars to be placed in a patient with pectus excavatum

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Background. The decision on the number of bars to be placed in a patient with pectus excavatum depends on the surgeon's expertise. As patient satisfaction is the priority and the main complaint is cosmetic, it is crucial to determine the correct number of bar placements. This study aims to introduce a severity index that determines the ideal number of bars required for maximum satisfaction.

Method. The records of the *Chest Wall Deformities Clinical Database* between September 2018 and March 2024 include 365 patients who underwent minimally invasive repair of pectus excavatum. 78 out of 365 patients were enrolled in this study and received preoperative chest computerized tomography. We divided the patients into three groups based on the number of bars they received. Group I received one (n=24),Group II had two (n=37),Group III had three bars(n=17). Haller index(HI), correction index(CI), asymmetry index(AI), costosternal angle,sternum slope ratio,length and density of sternal body were calculated.These values were correlated with the number of bars that were placed.A severity index is created to determine the number of bars to be placed.

Results. We found that there was an inverse relationship between the density of the sternal body and the number of bars. The density was found to be statistically significant between Group I and III($p=0.039$). Sternum slope ratio, costosternal angle, and CI were statistically significant between Groups I and III($p<0.05$). Length of sternal body,HI,and AI did not show any significance.

Conclusion. HI, CI and AI are indices that are used to calculate the severity of the excavatum.This study is the first report to address the use of the indices and new parameters to determine the

appropriate number of bars needed during surgical correction.Using these parameters can prevent surgical complications, such as inadequate sternum elevation, bar rotation, and intercostal muscle tears, due to an insufficient number of bars.

Assessment of positional changes in thoracic structure by the Nuss procedure as a useful countermeasure against recurrence after bar removal

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Background and Aim: An advantage of the Nuss procedure is increased thoracic thickness in addition to concave deformity improvement. However, the position of the sternum often becomes displaced after bar removal, thereby reducing the thickness of the entire chest wall. Thoracic cage thickness is influenced by sternal angle as well as the angle of the ribs relative to the body axis. However, reports on post-operative changes in thoracic cage structure following the Nuss procedure are primarily based on the Haller index, with few addressing the precise changes in thoracic morphology. The present investigation focused on thoracic cage thickness by evaluating sternal position changes before and after Nuss procedure treatment using an original index based on thoracic angles.

Methods: In 68 enrolled patients with pectus excavatum, we calculated sternal angle and costal position using mid-sagittal plane 3D CT images at pre-bar insertion, immediately before bar removal (mean age: 13 years [range: 8-25 years]), and 6 months after bar removal. We then divided the patients into pre- and post-puberty treatment groups for statistical comparisons.

Results: The sternum and costal positions shifted downward after bar removal but remained elevated compared with pre-bar insertion. Reducing the angle of the manubrium along the head-foot axis (sternoclavicular joint; SCJ) was most affected by this shift (pre-bar removal: 25.7±5.2° vs. post: 23.1±5.2°, $p<0.0001$). No significant changes were observed in rib angle before and after the procedure. The association between angle variation in all joints was comparable between the pre- and post-puberty treatment groups, although rib angle was significantly larger in the pre-pubertal group at all measurement points (all $p<0.05$).

Conclusion: The Nuss procedure primarily changes SCJ angle, with no remarkable alterations in rib angle. As rib angle gradually decreases with age after adolescence, considering this factor may assist in more optimal timing and better outcomes.

Compressive external bracing in Pectus Carinatum : Results of 1302 patients-Turkish experience

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BACKGROUND and AIM: Pectus Carinatum is the second most common chest wall deformity causing psychological problems. There has been a growing interest in the conservative treatment of the disease in the recent years. Here, we present results of pectus carinatum patients who were treated with compressive external bracing therapy (CBT).

METHODS: 1302 patients who were treated with compressive external bracing between 2017-2024 were reviewed from a database. Data including demographics, type of the deformity, duration of the treatment time, complications, and patient satisfaction were recorded. We used pressure for initial correction (PIC) as an indication for brace therapy and identified 10 psi as a cutoff point for a thorax suitable for the compressive external bracing.

RESULTS: Among 1302 patients; Of them, 1043 were male (80.1%) and 259 were female (19.9%) and the whole series has a mean age of 13.7 years (1-57). 989 patients (76%) had a symmetric pectus carinatum and 313 patients (24%) had asymmetric deformities. 220 (16.9%) patients had scoliosis, 111 (8.5%) had kyphosis, 22 (1.7 %) had Poland Syndrome as accompanying anomalies. Additionally, 24 patients (1.8%) had a history of Ravitch Sternoplasty and 16 patients (1.2%) had a previous Abramson procedure. We had 140 (10.7%) patients who abandoned or had problems with compliance in the whole series. Quality of life questionnaire revealed 93.4 % satisfaction in patients who completed the treatment

CONCLUSION: Compressive external bracing is associated with satisfactory results in the treatment of pectus carinatum. It enables us to treat more patients by being non-surgical and having less morbidity than the surgical options.

Ellipsoid model of normality - The goal for correction of Pectus Excavatum

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Introduction: A number of measures are commonly used to evaluate the depth of depression and asymmetry of the sternum and the chest wall in pectus excavatum. Surgical techniques designed to eliminate the anatomical appearance of the defect, assume that a normality is achieved. Physiological data indicates that in but a limited number of patients is the goal achieved. In this paper I wish to present a theoretical model of the normal chest shape that would allow planning of surgical treatment.

Materials and Methods: Previous prospective analysis of 72 patients with pectus excavatum with a protocolised pre-operative assessment by CT Scan and CPET was undertaken prior to surgical treatment. In 20 post-operative CPETs were performed to evaluate the improvement in physiological function. Variability in the quality of postoperative physiological results, Type A and B, achieving greater improvement than Type C caused the anatomical measures of pectus depression and the target for correction to be re-examined. A theoretical examination of indices of pectus excavatum severity were evaluated and examined as to the utility of providing goals for surgical planning. A novel model of the normal contour of a chest wall, an Ellipsoid Model, provides a method to design a template for guiding intraoperative correction.

I wish to discuss the theoretical characteristics of the, how it may be used to define what an anticipated normal contour of any individual patient may be, and thus allow planning of surgery.

Conclusion: The theoretical principles provide a model for individualised patient therapy, however the model requires further investigation to confirm the model matches normality, and that use of a surgical template provides improved surgical results.

Scapula Alata, a Rare Complication After Minimally Invasive Repair of Pectus Excavatum

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BACKGROUND AND AIM: While paralysis of the brachial plexus has been reported after surgical correction of pectus excavatum through the nuss procedure, reversible neuropraxia of the long thoracic nerve is unprecedented. This report details a rare case of long thoracic nerve injury following minimally invasive repair of pectus excavatum.

METHODS (Case Presentation): A male in his early 30s underwent minimally invasive repair of pectus excavatum. As per standard procedure, a 10mm 30-degree thoracoscope, inserted via a right midaxillary trocar in the 4th intercostal space, was used for intrathoracic visualization. Post-discharge, the patient experienced right upper back pain requiring prolonged opioid usage and limited functional activities due to right scapular winging. Electromyography revealed mild polyphasic potentials of the right serratus anterior muscle which confirmed long thoracic nerve injury possibly attributable to trocar placement.

RESULTS (Treatment and Outcome): The patient received conservative treatment, including physiotherapy for one year followed by independent exercises. After 21 months, the patient achieved a balance in daily life activities with acceptable pain levels. Two-and-a-half years post-surgery, he could perform light-weight activities, though some above shoulder movements still caused a burning sensation around the right scapula. Nuss bar removal was planned within the next six months.

CONCLUSIONS (Take Home Message): This case highlights a rare instance of right long thoracic nerve injury post-Nuss procedure, with partial recovery after two and a half years. Surgeons should be mindful of patient positioning to avoid nerve-related complications and keep the possibility such complications in mind in patients with persistent postoperative pain. Furthermore, special care about trocar placement should be undertaken.

New technique for sternal cleft repair with osteoconductive material in a young adult patient

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Background: Sternal cleft is a rare congenital anomaly of the sternum, resulting from incomplete fusion of the ventral portion of the sternum in embryonic life. Due to thoracic flexibility in children, repair is preferably performed in the neonatal period. In adolescents and adults, prosthetic material is used to approximate or fill the cleft space. Several correction techniques have been described, mainly using autologous cartilage, providing an anatomical substrate for osteogenesis.

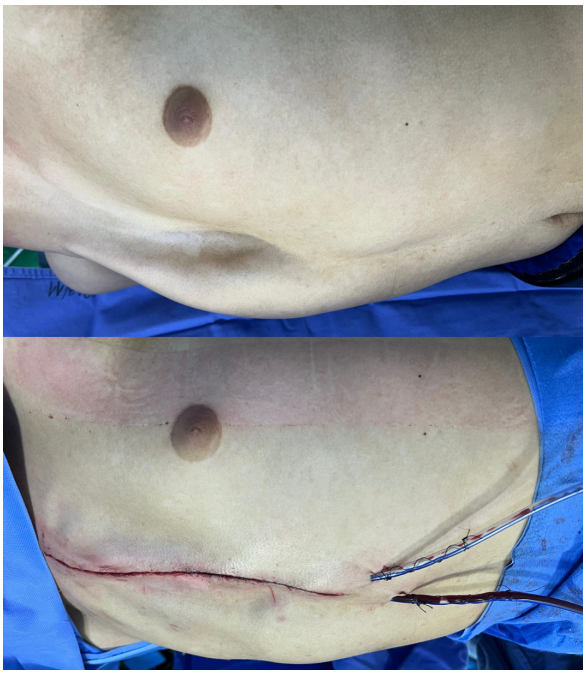
Methods and Results: Case report of a 19-year-old patient with a sternal cleft diagnosed in childhood. He presented with a partial superior "V" shaped sternal cleft, with protrusion of the right sternal bar and retraction of the left, allowing visualization of cardiac pulsations beneath the skin.

Proposal: Chondroplasty of the rudimentary sternum and placement of a pre-molded osteoconductive biomaterial prosthesis.

Technique: Midline longitudinal incision, identification of major vessels and heart under thin film and pericardium; release of perichondrium from the lateral bars, with bilateral subperichondral chondrectomies. Fixation of the perichondrium of the lateral bars with polypropylene mesh. Placement of Vitagraft® sternal prosthesis on the mesh, fixed to the stumps of the cartilages. Closure of the perichondral beds of the resected cartilages; placement of two suction drains at the surgical site; approximation of pectoralis muscles to cover the prosthesis; Closure of subcutaneous tissue and skin.

The patient was discharged on the 7th postoperative day without complications. He continues to be followed up in the outpatient clinic, maintaining stability of the thoracic wall.

Conclusion: Correction of sternal cleft with osteoconductive material, composed of β-TCP (β-Tricalcium Phosphate) and PLGA (Polylactic-co-Glycolic Acid), a biocompatible and pre-molded material in sternal shape, promotes rigid reconstruction from implantation, serving as a bone matrix and being fully absorbed by the body in approximately 12 months, proving to be a good option for addressing cases of sternal cleft.



Early bar removal after MIRPC: indications, outcomes and recurrence rates in a multicenter international retrospective study

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BACKGROUND AND AIM: Although it is achieved to keep the bars minimum 2 years after MIRPC, unfortunately early bar removal is inevitable under certain circumstances. We hereby share our multicenter experience in early bar removal surgery after MIRPC.

METHODS: Patients with a history of MIRPC, who had undergone early bar removal in the last 20 years, were included in the study. Data were retrospectively collected from the databases of Marmara University, Istanbul and University Medical Center, Mainz. Early bar removal is defined as removal of the bars less than 2 years following MIRPC. Modified QOL Single Step Questionnaire was used to assess self-esteem and QOL.

RESULTS: 303 patients had undergone MIRPC in both centers for the last twenty years. Among them, 52 (17.6%) patients with a mean age of 9.5 years (3-21.5) were enrolled into the study. Mean time from MIRPC to bar removal were 11.7 (1-23) months. Mean length of hospital stay was 4.25 (2-18) days. We had to perform early bar removal due to overcorrection in 13 (25%), patients demand in 12 (23%) patients, intractable pain in 9 (17.3%) patients, metal allergy in 5 (9.6%) patients, wound infection in 5 (9.6%) patients, recurrence in 3 (5.7%) patients, steel wire breakage in 3 (5.7%) patients and bar dislocation in 2 (3.8%) patients. 15 (%28.8) patients had recurrence in the whole series. 12 patients completed the QOL questionnaire. Of them, 8 commented as satisfaction with corrected deformity while 4 reported unsatisfaction with no change in the deformity.

CONCLUSION: Although MIRPC is the mostly accepted surgical treatment option by being minimally invasive and having satisfactory results, it should be kept in mind that early bar removal rates are high compared to MIRPE. It is also important to inform patients in detail in the decision making of the selection for the treatment modality.

Results of External Compressive Bracing Application in Pectus Carinatum Patients - Oral Presentation

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The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

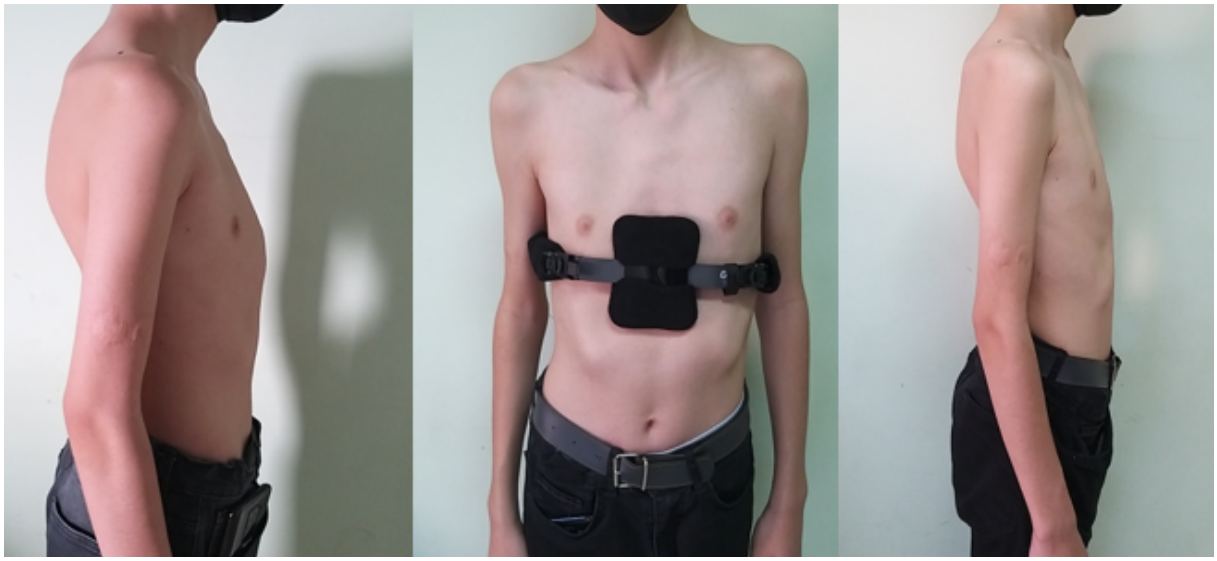
Introduction: Pectus carinatum (PC) is a chest wall deformity, known as pigeon chest, characterized by varying degrees of anterior protrusion of the sternum and sternocostal cartilages. It is the most common chest wall deformity after pectus excavatum. This study presents the results of patients who underwent external compressive bracing for PC.

Materials and Methods: Between September 2019 and March 2024, external compressive bracing was applied to 328 patients due to PC. The results of 328 pectus carinatum patients were evaluated retrospectively. First week, patients were recommended to start with low compression pressures at least 12 hours per day. At the end of 1 month, the targeted compression level of orthosis adjustment was reached.

Results: 35(10.6%) of the patients were male and 293(89.4%) were female and the mean age of the patients was 14.1±2.58. Carinatum pressures were recorded on average 7.83±2.56 kg/cm at baseline. Treatment was restarted in 8(2.43%) patients due to recurrence. 18(5.48%) patients could not complete the treatment protocol due to irregular use, and 5(1.5%) patient decided to get operated. We have 92(28.04%) patients who are still under treatment. The only morbidity of the treatment was ecchymosis in the application area in 15(4.57%) patients. 194(59.1%) patients successfully completed their treatment. At the end of 1 year, only 11(3.35%) patients could not achieve the desired appearance despite treatment.

Discussion and Conclusion: External compressive bracing has entered our daily practice and replaced surgical treatment of PC. We believe that this method, which has high treatment compliance and successful results, is a technique that can be used safely in the treatment of carinatum.

Key Words: Pectus Carinatum - External Compressive Bracing



Lung transplantation with concomitant severe pectus excavatum

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According to an ISHLT consensus, severe chest wall deformities are often considered a contraindication for lung transplantation. In patients with pectus excavatum defects with H.I. > 5, expected associated impairment of the chest compliance may lead to a high risk of postoperative respiratory complications and significant morbidity and mortality. In addition, asymmetry of the chest and scoliosis of the spine make size-matching difficult. Minor chest wall deformities do not require a concomitant correction with a Nuss bar or Ravitch procedures; they can be addressed by repositioning of the mediastinum or by unilateral size-reductions of the donor lung.

Herein, we report of three patients that received a bilateral lung transplantation with concomitant pectus excavatum repair. Clamshell incision was the preferred operative approach. Elasticity of the chest wall was determined by simple Valsalva maneuver before patients were listed in order to define best surgical approach to correct the deformity. All patients received a size-reduced double lung transplant and the chest wall deformity was corrected either by a Nuss in one patient or modified Ravitch procedure in the other two patients. No cryoablatio was performed but special attention was taken for not injuring the intercostal bundle. Perioperative course was complicated by prolonged weaning with tracheostomy in two of the three patients but all three patients were discharged without major complications. In one patient prolongation of the ECMO support was necessary once chest was closed after the defect was corrected.

This case series demonstrates that patients with pectus excavatum with high H.I. can be transplanted and a combined approach is feasible for selected patients. For a good size match of the donor lungs, increased chest dimensions after the repair should be considered.

Impact of costal cartilage ossification on pectus excavatum surgery

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Background and Aim: Pectus excavatum (PE) is a congenital chest wall deformity that is typically treated in schoolchildren and adolescents. However, at our hospital, we also frequently treat adult patients with PE. Unfortunately, treatment for adult patients with PE can be challenging due to the bone hardening and plasticity of the thorax. Therefore, we conducted a study to evaluate the ossification of costal cartilage and its clinical characteristics, including treatment outcomes, in patients who underwent PE surgery at our hospital.

Method: We quantitatively measured the ossified area of costal cartilage in 97 patients with PE who underwent surgery from 2016 to 2019. We then determined the ossification rate of the costal cartilage and examined its correlation with clinical data. The ossification rate was calculated by reconstructing preoperative CT images in 3D using Zio station2®.

Results: Our study found that the median age of patients was 24 years, with 88 men and 9 women. The median costal cartilage ossification rate was 1.7%, which was positively correlated with age, surgical time, and blood loss. However, there was no correlation between the rate of costal cartilage ossification and the rate of improvement in the Haller Index (an indentation index) or respiratory function.

Conclusions: Our findings suggest that surgery for PE becomes more challenging in adult patients due to the progression of costal cartilage ossification with age. For cases with significant ossification, surgeons may need to develop alternative surgical techniques for treating PE.

Optimizing Efficacy of Vacuum Bell Therapy for Pectus Excavatum: Compliance is Key

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Background and Aim: Pectus excavatum (PE) is the most common congenital chest wall deformity. The vacuum bell (VB) is a non-operative alternative to repair. We reviewed our center's experience with VB for PE to identify variables associated with improved therapeutic success.

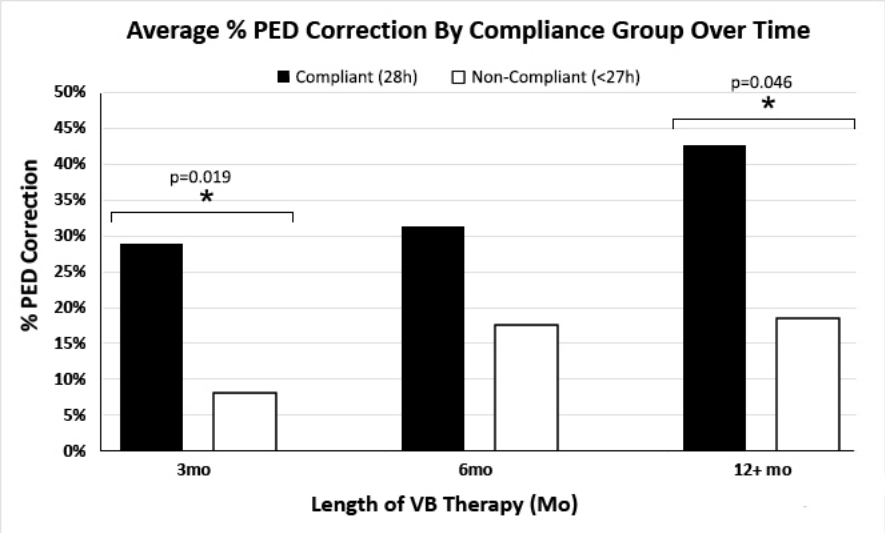
Method: We conducted a single-center retrospective review of patients with PE treated with VB from August 2020 to August 2023. Data were collected on demographics, VB type, Haller Index (HI), Pectus Excavatum Depth (PED), and patient-reported hours of usage per week. PED correction percentages were compared between patients who were fully compliant with prescribed therapy (28h/week) and patients who were non-compliant (<27h/week). Multivariable linear regression identified factors predictive of PED correction.

Results: Fifty-seven patients (86% male) initiated VB therapy. Of these, 22 (38.6%) were compliant and 35 (61.4%) were non-compliant. There was a significant difference in PED correction between compliant and non-compliant groups (28.0% vs. 16.0%, $p<0.001$). Age, sex, height, weight, VB type, HI, initial PED, and months of treatment were not significantly different. After 3 and 12 months of usage, compliant patients had significantly higher PED correction compared to non-compliant patients ($p=0.019$ and $p=0.046$, respectively) (**Figure 1**).

On multivariable linear regression, hours of VB usage per week was the strongest predictor of PED correction ($\beta=0.348$, $p=0.023$). Days of treatment and lower HI also significantly predicted PED correction ($\beta=0.337$, $p=0.036$ and $\beta=-0.324$, $p=0.043$, respectively), while height, weight, age, sex, and initial PED were not significant predictors. On multivariable linear regression for compliant patients only, no variables were significant predictors of therapeutic success.

Conclusions: Although age and initial pectus excavatum depth are thought to affect vacuum bell efficacy, our data demonstrates that when compliance with therapy is factored, these variables do not significantly predict therapeutic success. For a highly compliant patient, vacuum bell therapy can be effective regardless of age or severity.

Figure 1:


Average % PED Correction By Compliance Group Over Time
Compliant (28h)
Non-Compliant (<27h)
% PED Correction
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
p=0.019
*
p=0.046
*
3mo
6mo
12+ mo
Length of VB Therapy (Mo)

Structured assessment of cardiolpulmonary exercise tests in the assessment of Pectus Excavatum

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INTRODUCTION: Exercise dysfunction arising from pectus excavatum (PE) may be severe and disabling, yet the ability to quantify and characterise the physiological has remained a challenge. Cardiopulmonary exercise testing (CPET), a valuable tool in the assessment of exercise dysfunction arising from cardiac or respiratory pathologies, provides an opportunity to assess the impact of PE. In this paper I wish to present a structured and standardised method for performance CPET tests and analysis of CPET reports.

METHODS and PRESENTATION: Patients with clinically severe pectus excavatum were investigated prior to surgical treatment. Within a structured protocol that included a CPET and pulmonary function tests, each patient was investigated to evaluate the physiological abnormalities. In this paper I propose to present a structure by which evaluation of individual patients CPET results may be examined and reporting of test results in an MDT undertaken. Title headings that will be presented are as follows: Standardisation of CPET performance and algorithms; Setting exercise intensity targets; Stratification of measures of cardiopulmonary dysfunction to determine severity of anomalies.

I will present the standardised method for determining full engagement in the exercise protocol, examine whether there is evidence of cardiac dysfunction and evidence of respiratory compromise. This data will be used to form a baseline against which the impact of treatment would be evaluated and physiological outcome determined.

CONCLUSION: The data has demonstrated that 92% of patients have a confirmed physiological explanation for exercise dysfunction, >50% and >70% exhibited compromised O2 consumption and ventilation. Utilisation of the standardised protocol facilitates individualised assessment of patients and provides a template for multi-disciplinary discussion the results.

Malignant Hyperthermia during the Nuss procedure

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Declarations
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Dr. McMahon is an educational consultant for Atricure

Malignant Hyperthermia (MH) is a potentially deadly genetic condition causing skeletal muscle hypermetabolism after exposure to a volatile anesthetic or succinylcholine. Roughly 1 in 30,000 children have an MH reaction to general anesthesia. Onset can occur any time after induction, even into the postoperative period. Hypercarbia, tachycardia, and muscle rigidity are the early signs, with hyperthermia as a later finding. The only known treatment is Dantrolene (Ryanodex).

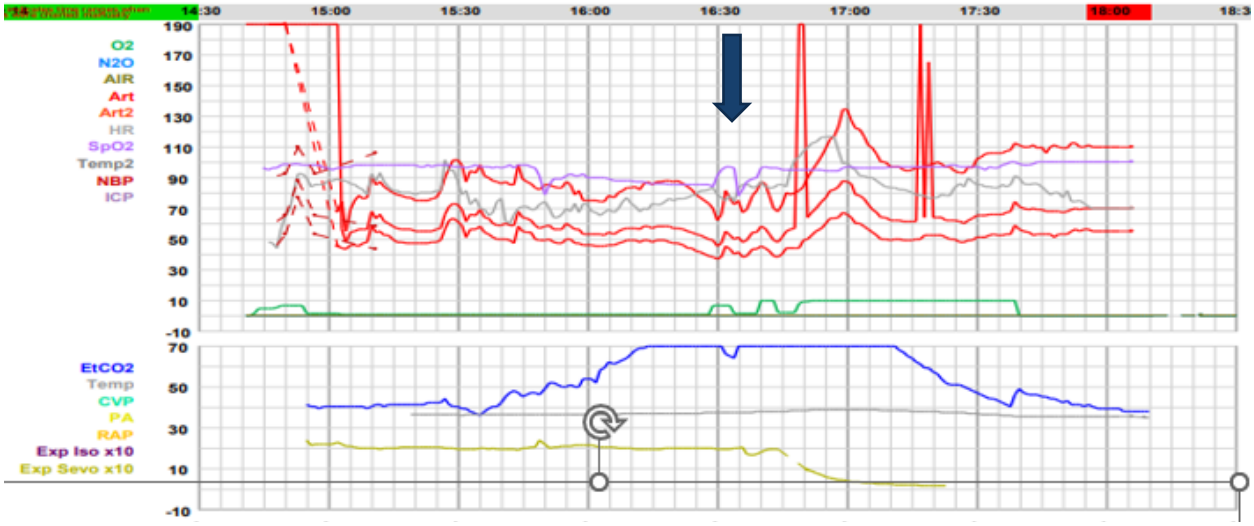
We report a case of a teenager who developed MH while undergoing repair of pectus excavatum (PE).

Case: A 14-year-old male with no family history of anesthesia complications and a severe PE (Haller Index of 4.8 and Correction Index of 33%) underwent a standard 2-bar Nuss procedure. The left lung was selectively intubated. Dissection of subpectoral pockets bilaterally, sternal elevation, thoracoscopic transmediastinal dissection and nuss bars placement were performed uneventfully. Cryoablation was completed on the right. There was significant difficulty recruiting the right lung. Albuterol was given with slow response to bagging. The patient's temperature quickly rose from 36.5 to 38.5 C and the MH protocol was activated – the patient was chilled with ice and cooling blankets, given cold IV fluids and Dantrolene X 3. The highest temp recorded was 40.1 C. Cryoablation was completed externally on the left. The patient was transferred to the PICU and extubated on POD1. Per protocol, he was given two more doses of Dantrolene on POD1. His CKMB rose to a peak of 4,000 IU/L at 33 hours then trended back to normal.

He tested positive for RYR1 which is associated with autosomal dominant MH susceptibility.

He recovered well and 4 days postop he was discharged. His pain was well-controlled, with equal areas of numbness on the chest bilaterally.

The common signs of MH are confounded during the Nuss procedure. Single lung ventilation and CO2 pneumothorax cause hypercarbia. Muscle relaxants masked the muscular rigidity. The absence of tachycardia cannot be explained. Hyperthermia is a late sign.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10
-10
EtCO2
Temp
CVP
PA
RAP
Exp Iso x10
Exp Sevo x10
70
50
30
10
-10

Postural disorders and chest deformations

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Background: In several studies of patients with PE, the coexistence of scoliosis was evaluated and it was concluded that the incidence of scoliosis in patients with PE was higher than in the general population. It was found that adolescent idiopathic scoliosis and PE may have similar genetic etiology, and the prevalence of scoliosis among patients with PE is higher than the prevalence among the general population (Fig.1).

Results: People with deformities of the spine and chest in most cases have many psychosocial problems – a high level of anxiety, self-doubt, indecision, low self-esteem, problems in interpersonal relationships, low mood. As a result, neurotic personality development with an inferiority complex may form, phobias, depression of varying severity, and suicidal risk may arise. At school, during physical education classes, sports competitions, dancing classes, in the pool, locker rooms, and medical examinations, others often notice a physical disability, look at it, ask questions, and sometimes laugh at a teenager with deformities of the spine and chest. As a result, a teenager begins to avoid such situations and may even refuse to visit the beach and pool, play sports, dance, move away from peers who, not understanding the reasons for such behavior, take offense, decide that he does not want to be friends with them or begin to consider him strange, "stupid".

Conclusions: In adolescents with deformities of the spine and chest, under the influence of an external defect, a negative perception of their own body image is formed, which leads to a decrease in self-esteem, increased anxiety and the actualization of depressive manifestations in the structure of a psychoemotional state. After alternative and surgical treatment, qualitative changes in the formation of one's own body image, a decrease in anxiety levels, and the disappearance of signs of depressive manifestations are observed.

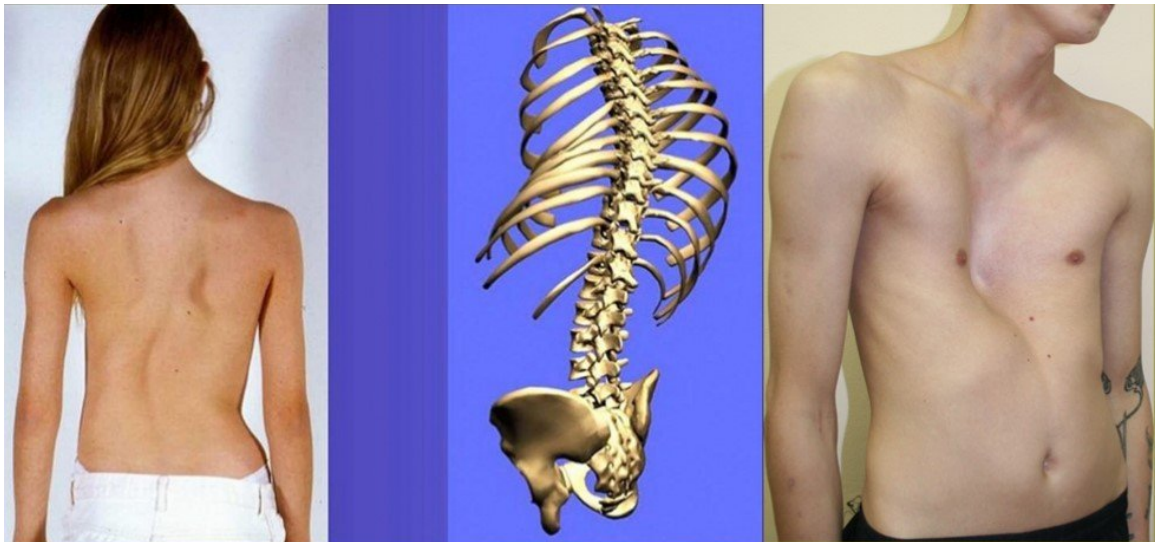

Fig. 1. Combination of scoliosis and PE

Three cases of bilateral pneumothorax due to Iatrogenic Buffalo Chest

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Conflicts of interest: No

Background and Aim: Pectus excavatum (PE) and spontaneous pneumothorax (SP) are more common in young males compared to other demographics. Previous research has suggested that SP occurs more frequently after PE surgery, but the clinical features of SP following this procedure are not yet clear. This study aims to identify the clinical characteristics of patients who experienced bilateral pneumothorax (BP) following PE surgery.

Methods: We conducted a retrospective analysis of patients who developed BP after PE surgery between 2014 and 2023. Our study was approved by the Institutional Review Board (#20200089).

Results: Out of 460 patients who underwent PE surgery, three developed BP within two to four months after the Nuss procedure. All three patients are male, younger than 30 years old, and with BMIs below 17. The Haller Index ranged from 3.16 - to 7.0, Correction Index ranged from 0.35 – to 0.56. VATS bullectomies were performed due to continuous air leakage. Identifying the bulla before the Nuss procedure was challenging in all cases. The development of BP was suspected to be due to iatrogenic Buffalo chest. In two cases, VATS bullectomies were performed on one side only, while in one case, on both sides due to the discovery of a left-side pneumothorax after surgery on the right side. Pneumothorax has not recurred in any of the cases over 17 months after bullectomies.

Conclusions: We experienced three cases of BP following 460 PE surgeries. Surgery for BPs following the Nuss procedure is more complex compared to surgery without PE surgery. The iatrogenic Buffalo chest due to Nuss procedure makes the detection of the affected side and intraoperative air leakage to a challenging task. As a result, performing a bullectomy at the time of PE surgery may be a more favorable approach.

A pilot study of multi-modal pain management for same-day discharge after minimally invasive repair of pectus excavatum in children

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Background: Despite advancements in minimally invasive repair of pectus excavatum (MIRPE) with the Nuss procedure, postoperative pain control remains a challenge. We report on a multimodal regimen using bilateral single-shot paravertebral blocks (PVB) and bilateral thoracoscopic intercostal nerve (T3-T7) cryoablation, leading to significant reduction in length of stay (LOS) and high rate of same-day discharge.

Methods: This comparative pilot study included MIRPE patients at a single center from 2019 to 2020. Patients underwent bilateral PVB with catheter for continuous infusion (Group 1, n=12), bilateral PVB-catheter and right-side cryoablation (Group 2, n=9), or bilateral single-shot PVB and bilateral cryoablation (Group 3, n=17). Retrospective cohorts (Groups 1 and 2) were compared to the primary study group (Group 3). The primary outcome was LOS with focus on same-day discharge, and the secondary outcome was decreased opioid usage.

Results: LOS was shorter in Group 3 vs. Group 1 (median 0.7 days vs. 4.4 days respectively, $p<0.001$). Eleven of 17 MIRPE patients (65%) who received bilateral single-shot PVB and bilateral cryoablation (Group 3) were discharged on the evening of surgery. The 6 remaining Group 3 patients were discharged the following day with no overnight complications or interventions. Median opioid use on the day of surgery was lower in Group 3 vs. Group 1 (25 mg vs. 49.2 mg, $p=0.006$).

Conclusion: These findings demonstrate the feasibility of multimodal peri-operative pain management for same-day discharge after MIRPE. Future multi-institutional studies are needed to prove the superiority of this approach to established methods.

Implementation of a clinic for pediatric patients with thoracic wall malformations in San Juan de Pasto, Colombia

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During the last two decades, consultation and evolution of science have favored development of strategies aimed at the identification, diagnosis, treatment, and follow-up of pediatric patients affected by acquired and congenital deformities of the thoracic wall.

Objective: Our objective is to know statistical result of our medical practice in the process and create epidemiological base that does not exist in our region.

Methods: descriptive analytical observational study. After 18 years of work dedicated to the care of these patients in 2021 the surgeons of Los Ángeles Children's Hospital Foundation Pasto, Colombia, decided to establish a clinical program that would favor the comprehensive care of these patients, considering aspects such as the incidence of these pathologies in our region and the experience we have accumulated as a surgical team together with the specialties and working groups that support us,

Results: During the period March 2006 April 2024, 741 patients were treated, 408 are male 333 female, 329 with pectus excavatum and 412 with carinatum, 733 are insured by the state and 8 are privately. Between March 2006 and April 2024, we operated on a total of 357 patients, 292 with pectus excavatum using the Nuss technique and 65 with of pectus carinatum using mixed Abramson and Ravitch techniques. In January 2021, we began placing pressure devices in pectus excavatum, and currently, we have 26 patients under treatment. From December 2021 to April 30, 2024, we have 23 patients undergoing treatment for pectus carinatum using a dynamic compressor. Our work is supported by a team that includes surgery, pediatrics, cardiology, pulmonology, orthopedics, anesthesiology, physiatry, genetics, endocrinology, critical care, respiratory and physical therapy, psychology, and nutrition, all specialized or subspecialized in pediatric patients and belonging to our institution. The detailed statistics and conclusions are outlined in the full presentation.

Early Results of Polymer Cerclage System in Pectus Carinatum Surgery

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The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

Introduction: Pectus carinatum (PC) is a chest wall deformity, known as pigeon chest, characterized by varying degrees of anterior protrusion of the sternum and sternocostal cartilages. Although many modifications have been noted in the Abramson technique, the bar is generally fixed to the ribs with metal instruments. This procedure may cause pain and fractures in the ribs. The polymer cerclage system, used in femur fractures and sternal closures, has been used to fix the bar to the ribs in minimally invasive pectus carinatum surgery. Early results of the surgical technique applied successfully in 2 of our patients are presented. This study presents the new modification of minimal invaziv repair of PC.

Materials and Methods: Two male patients, aged 16 and 17, underwent surgical treatment with a minimally invasive technique for the correction of pectus carinatum. After the ribs determined for the surgical procedure were rotated, the ribs on the unilateral were prepared by passing through the stabilizer with a single polymer cerclage system. When the desired correction was achieved, the polymer cerclage system was fixed with the band lock system (Figure).

Results: The operation time was 72 and 85 min, and the length of hospital stay after the surgery was 2 and 3 days. The follow-up of patients who are in the 7th and 8th months post-operatively continues without any problems.

Discussion and Conclusion: We think that the polymer cerclage system can be safely used as a modification in the minimally invasive surgical technique of pectus carinatum instead of fixing the ribs with wire.

Key Words: Pectus Carinatum – Abramson

Minimally Invasive Relief: Laparoscopic Rib Resection for Slipping Rib Syndrome

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Keywords: Slipping rib syndrome, MIS, Chest-wall deformities.

Abbreviations:SRS: Slipping Rib syndrome

Funding: The study had no funding. The authors have nothing to disclose.

Background and Aims: Slipping rib syndrome (SRS), characterized by hypermobility or displacement of the costal cartilages, can manifest as debilitating chest pain. While conservative management is often attempted, surgical intervention may be warranted in refractory cases. We present a case report of a patient with SRS who underwent laparoscopic rib resection to address the defectuous rib and alleviate symptoms.

Methods: A 14-year-old female presented with 2-year recurrent sharp chest pain exacerbated by movement. Clinical examination revealed tenderness over the lower rib cage with positive Hook manoeuver consistent with SRS. CT scan confirmed rib subluxation and ruled out other pathology. After failed conservative treatment, laparoscopic rib resection was performed. Patient is placed in the supine position. A 12 mm umbilical port is used for the camera, and two 5 mm trocars are used in the left iliac fossa and right hypochondrium. Under laparoscopic guidance, a percutaneous needle, introduced at the level of the cartilage to be resected, is identified. The costal cartilage is denuded using electrocautery and resected over a length of 4 cm. The piece is removed through the umbilical trocar.

Results: The patient experienced immediate relief of symptoms postoperatively. Patient was discharged 24 hs postoperatively. Follow-up assessments at 1 and 6 months revealed sustained improvement in pain scores and functional status. Clinical examination demonstrated resolution of rib subluxation. No perioperative complications were reported. The patient reported a significant improvement in quality of life and resumption of daily activities without limitation.

Conclusion: Laparoscopic rib resection offers a minimally invasive approach for addressing SRS refractory to conservative management. This case highlights the effectiveness of laparoscopic techniques in identifying and resecting defectuous ribs, leading to significant and sustained symptom relief. Further studies are warranted to evaluate the long-term outcomes and comparative effectiveness of laparoscopic versus open-surgical approaches in the management of SRS.

Surgical correction of Pectus Excavatum

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Background: Pectus excavatum (PE) is the leading one among congenital malformations of the chest, and, according to a number of authors, occurs in 0.06-2.3% of the population. The disease manifests itself not only as a cosmetic defect, but also as a violation of the function of the cardiovascular and respiratory systems. The deformity increases with the age of the child, and the clinical manifestations progress. Surgical correction of PE requires highly specialized orthopedic care.

Methods: For the period 2018-2023, 3912 patients with a PE were corrected. Of these, 240 patients are citizens of Uzbekistan. Men - 3018, women - 894. The age ranged from 2.5 to 59 years old. 392 (10%) patients underwent Nass surgery in various modifications. Installation of 2 bars: 360 patients, of which X-bar - 20 patients. Installation of 3 bars: 23 patients. Installation of 1 bar: 9 patients. In other cases, 3,520 (90%) patients underwent correction of PE using Vacuum Bells.

The results: The degree of PE was determined by the Haller index. As already mentioned above, 264 (67.4%) patients had grade III deformity, the remaining 128 (32.6%) patients had grade II deformity. When collecting anamnesis, it was revealed that in 144 (36.8%) patients, manifestations of PE were observed, according to parents, from an early age. During the period of active growth (from 7 to 15 years), chest deformity began to manifest itself in 248 (63.2%) patients. 263 (67%) children had impaired posture, 92 (23.4%) patients had grade 1 scoliosis.

Conclusions: To prevent partial recurrence of PE in the long-term postoperative period, it is advisable to perform thoracoplasty in children over the age of 12 years. If an alternative treatment method can be used in boys under 20 years of age, then surgical intervention is preferable in girls over 14 years of age due to anatomical and physiological characteristics (Fig. 1).

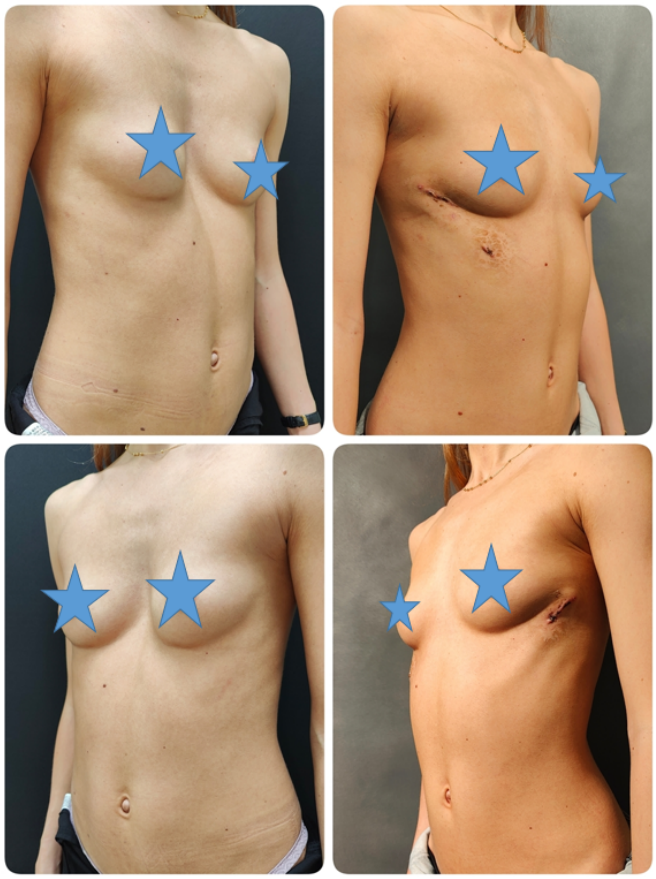

Fig. 1. Photo of a 16-year-old patient in comparison: left before surgery, right after surgery.

It is quality that counts rather than quantity

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For surgical repair of Pectus excavatum (PE), the Nuss procedure is considered today as the "gold standard" and will be performed with increasing frequency worldwide. In particular in centers of excellence, the method experienced numerous modifications such as routine thoracoscopy and/or sternal elevation, increasing safety of the procedure. Placement of multiple bars and/or the so called cross-bar technique were introduced to correct complex chest wall deformities. Standardized pain management, the introduction of cryoanalgesia and a standardized postoperative physiotherapy program including deep breathing exercises facilitate establishing an enhanced recovery after surgery (ERAS) process. Pectus surgeons practicing in small countries with low population are requested one the one hand to deliver excellent results comparable to high volume centers, but on the other hand to identify, adapt and introduce new modifications.

We report on our experience with the introduction and routine use of intraoperative sternal elevation, application of the cross bar technique to correct complex deformities and the introduction of thoracal cryoablation as routine standardized pain management in our chest wall unit. Summarizing our experience, we may conclude that it is quality that counts rather than quantity.

MIRPE With Subxiphoid Incision For Pectus Excavatum With Severe Adhesions Due To Previous Sternotomy Or Pectus Surgery

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OBJECTIVES: Minimally invasive treatment of pectus excavatum can be challenging in patients with a history of sternotomy or previous pectus surgery. Adhesions between sternum and heart makes Nuss Procedure riskier than the regular cases. We hereby report our results in patients who underwent Nuss procedure with subxiphoid incision.

METHODS: 36 patients who were treated with MIRPE with subxiphoid incision between 2017-2024 were reviewed from a database.

RESULTS: Among 36 patients; 31 (86.1%) were male and 5 were female (13.9%). Median age was 20 (7-35). 22 (61.1%). Median Haller Index was 3.8 (2.6-2.4). 14 (38.8%) had a history of previous MIRPE, 13 patients (36.11%) had a history of Ravitch surgery, 4 (11.1%) had severe adhesions without any specific cause, 3 (8.3%) had severe deformity and 2 (5.5%) patients had sternotomy due to MVR. We repaired the deformity with 1 bar in 27 (75 %) patients, with 2 bars in 8 (22.2%) patients and with 3 bars in 1 (2.7%) patient. Wound infection (4 patients – 11.1%), and nickel allergy (1 patient –2.7%) were the leading complications. Up to date, bars of 27 (75%) patients had been removed as planned. Median time interval between MIRPE and bar removal was 35 months (9 -50).

CONCLUSION: The MIRPE with subxiphoid incision is a safe, simple modification of the Nuss procedure for patients with severe retrosternal adhesions. This procedure prevents death due to cardiac perforation by enabling dissection under direct visualization.

Pectus Carinatum treatment with the use of our Ecuadorian Compression Brace
39 patients treated since 2016

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Background and Aim: We started treating patients with PC with a compression brace in August 2010. We were first to use Martinez-Ferro's FMF brace in Ecuador. First patient was a 13 year old girl. For the public hospital I worked in that time, it was too expensive to acquire the FMFs.

For us, it was more affordable to correct PCs with the Abramson´s technique. We did thirteen Abramson´s from 2011 to 2015.

In year 2016 we developed our own brace, and since then we have used it in 39 patients. We present our results.

Method: All patients were treated in private practice. The main author retired from the public hospital in January 2015.

Physical exam was used to assess flexibility of chest wall. Treatment pressure was applied by adjusting side straps. The first application made by physician. Pain or discomfort was the guide to pressure applied.

Daily use was prescribed starting with four hours and increasing time one hour each following week. We recommended use for 12 hours daily.

Controls were scheduled at one and two months for evaluation and increase in pressure.

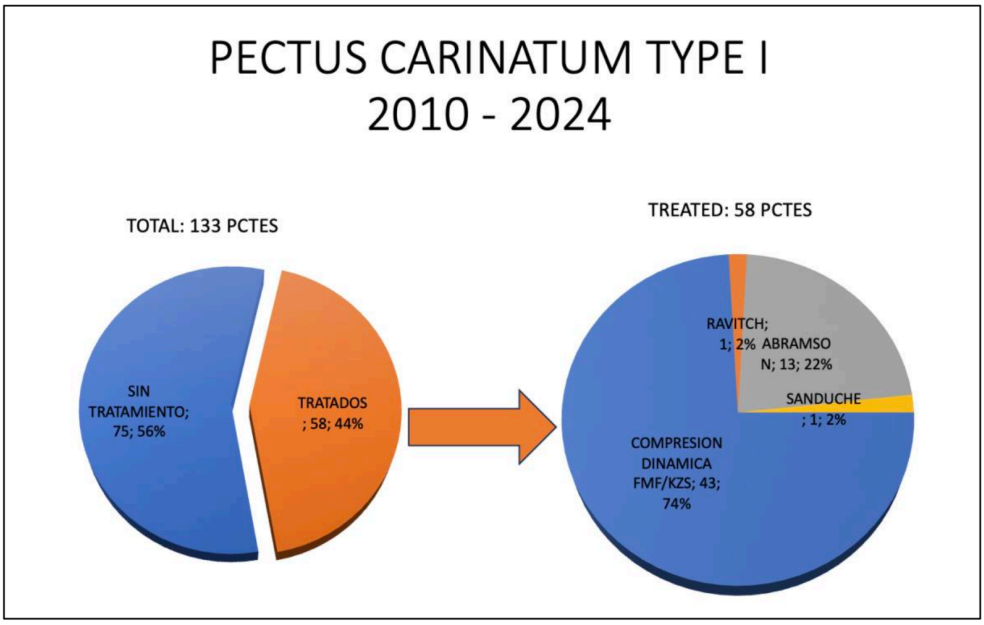
Results: We present results of PC patients treated with the Ecuadorian compression brace. Initial number of patients was 39. Final number of patients for Study 27. Not coming to at least one control was cause of discharge. 81% were males. Age range was between 5 and 18 years, with 12,7 years average. Protrusion was from 1,5 to 3,5 cm. with 2,75 cm. average. Laterality of defect was: Right 55,6%, Center 40,7%, Left 3,7%. Correction had good and excellent results in 81,4 % of patients.

Conclusion: Our compression system is a low-cost effective tool for treatment of Pectus Carinatum patients in Ecuador. We were able to achieve an important percentage of correction in Pectus Carinatum patients.

Keywords: Pectus Carinatum, Compression Brace, Ecuadorian compression brace.

PACIENTE #	EDAD	AP	PT.	PT.	%	LATERALIDAD	CM	SEXO	T CONTROL EN
22	13	2	18,5	16,5	100%	C	0	M	420
23	11	3	19	17,5	50%	I	4	F	180
24	18	4	25	24	25%	C	0	M	30
25	14	3	22,4	19,84	85%	D	2	M	180
26	18	2	19	18	50%	D	2	M	60
27	13	4	22	20	50%	D	2	M	720
28	11	3	18	17	33%	C	0	F	90
30	12	3	20	17,5	83%	C	0	M	90
31	11	1,8	18	16,5	83%	C	0	M	90
32	13	3	18	18	0%	C	0	M	30
33	13	1,5	21	19,5	100%	D	1	F	360
34	5	3	16	13	100%	C	0	M	240
35	12	3	17,5	15	83%	D	1	F	120
37	9	2	17	15	100%	D	3	M	1080
38	12	2	22	20	100%	D	1,5	M	270
39	14	4	22	19	75%	C	0	M	210
40	13	2	19	17	100%	D	2,5	M	450
41	11	2,5	18	15,5	100%	D	2	M	420
42	15	2	18	17	50%	D	4,6	M	270
43	14	2	19	17	100%	D	2	F	720
45	12	3,5	19,5	16	100%	D	3	M	690
46	16	3	27	25	67%	D	4	M	120
47	14	2,5	21	18,5	100%	D	3	M	120
50	14	3	19	17,5	50%	D	3	M	360
53	13	3	21	18,5	83%	C	0	M	270
54	10	3,5	18,5	18	14%	C	0	M	120
56	13	3	18	18	0%	C	0	M	30

27 cases treated with the Ecuadorian compression brace since 2016



PECTUS CARINATUM PATIENTS: TREATMENT MODALITIES APPLIED

Evaluation of mechanical impact according to fastening method of metal bar using finite element method-based simulation in minimally invasive repair of pectus excavatum

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Background and Aim: In minimally invasive repair of pectus excavatum (MIRPE), fastening of metal bars is very important because of complications. The fastening method such as ethibond suture & stainless wire, has been chosen based on the surgeon's preference and experience. To select appropriate fastening method, mechanical forces at bars after MIRPE are helpful, measurement of which, however, is clinically difficult. This study evaluated the mechanical impact according to fastening method of metal bar using finite element method-based simulation.

Method: A 3D model of the chest wall, including the intercostal muscles, was extracted from the preoperative chest CT images of 15-year old male with pectus excavatum, and a 3D model of a metal bar was located, then rotated according to real operation using ANSYS 2024 R2. The fastening was performed 4 times at each ends. The physical quantities at the fastening points were measured according to the number of wraps of the stainless-steel wire and movement of chest wall during respiration.

Results: The average maximum equivalent stress in the wire at each fastening point at full expiration was mean 679.98 MPa for single wrap, mean 408.42 MPa for double, and mean 268.05 MPa for triple. At full inspiration, the average maximum equivalent stress was mean 643.36 MPa for single, mean 386.49 MPa for double, and mean 253.61 MPa for triple.

Conclusions: As the number of fastening wraps increase, the loads on the wires show a tendency to decrease by approximately 35-40% with each additional wrap. The average maximum equivalent stress for single wrap exceeded the maximum tensile strength of the wire, while for triple wraps, it was about half of that value. Therefore, in this case, a single wrap of the stainless-steel wire poses a high risk of wire breakage and consequent complication, while triple wraps would be safe.