Update of Minimally Invasive Repair of Pectus Excavatum

Hoseok I
Department of Thoracic & Cardiovascular Surgery
Pusan National University Hospital

2024-6, Seoul
38th KTCVS Spring Meeting

- My personal, conservative
- Recently published, not super-new

- Diagnosis
- Evaluation
- Surgical technique
- Follow up

Contents

- Function, preop.
- Index, Haller
- Surgery
  - Fixation of bar
  - High HI
- Preop. Planning
- Take-Home message

Acta Cardiol. 2024 May 23:1-5. doi: 10.1080/00015385.2024.2349827. Online ahead of print.

Unsophisticated assessment of the cardiopulmonary function in patients with pectus excavatum using the six minute walk test

Daniela Sanjurjo [1], Luzia Toselli [1 2], Gaston Bellia-Munzon [1], Maximiliano Nazar-Peirano [3], Maxroxia Vallee [2], Juan Farina [4], Gaston A Rodriguez-Granillo [5], Marcelo Martinez-Ferro [1]

- Retrospective
- 43 patients, PEX underwent a 6MWT
- VS. reference values, established for different populations, including a young and healthy South American

- mean age, 17.8 ± 6.7 years.
- mean max. distance walked:
  - 600.8 ± 67.6 m vs. 729.8 ± 67.5 m, $p < 0.0001$
- Sex adjustment, age adjustment, $p<0.0001$
- Conclusion: significant reduction in the maximum walked distance among patients with PEX compared to the predicted distance
- Limitation: postop. result ?

JOURNAL ARTICLE

A preliminary study on the normal values of the thoracic Haller index in children

Wan-Yi Song, Yu Zhou, Chun Wu, Zheng-Xia Pan, Yong-Gang Li ✉

European Journal of Cardio-Thoracic Surgery, Volume 65, Issue 5, May 2024, ezae143,
https://doi.org/10.1093/ejcts/ezae143

- Both preoperative correction planning and postoperative follow-up need to be based on the standard of normal thoracic growth and development

- Chest CT, January 2012 to March 2022
- randomly selected from Children's Hospital of Chongqing Medical University

- total of 19 groups: aged 0–3 months (1 group), 4–12 months (1 group) and 1 year to 17 years (17 groups)
- 50 males and 50 females,
- totaling 100 children in each group

- HI, in the plane where the lowest point of the anterior thoracic wall

- 1900 patients
- HI, transverse diameter and anterior-posterior diameter were positively correlated with age ($P < 0.05$).

- Using age as the independent variable and HI as the dependent variable,
  - best-fit regression equations:
    - HI-male = 2.047 * Age0.054($R2 = 0.276$, $P<0.0001$)
    - HI-female = 2.045 * Age0.067($R2 = 0.398$, $P<0.0001$).

- Males had significantly larger thoracic diameters than females,

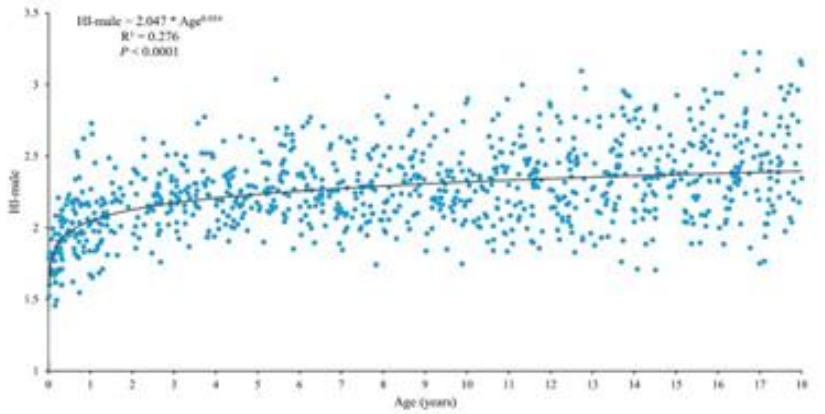
- little difference in the HI between the 2 sexes

A preliminary study on the normal value of the thoracic Haller index in children

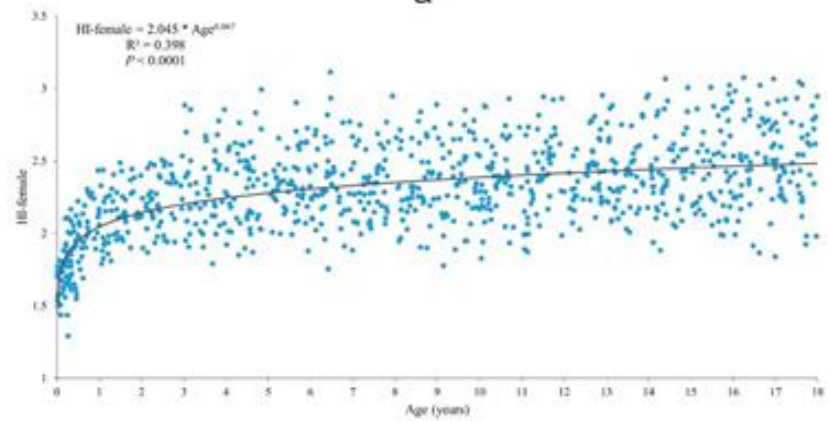
Summary

This study conducted a preliminary investigation of normal Haller index (HI) values among children to understand thoracic developmental characteristics.

Population: 1,900 children aged 0-17 years who underwent chest CT scans at our hospital in the past ten years, with no history or imaging findings of skeletal abnormalities of the chest or spine and no history of thoracic surgery. Method: HI was measured in the chest CT images and statistically analyzed using SPSS 26.0 software. Outcome: There are variations in the HI among normal children at different ages. The HI rapidly increases during the neonatal period, slowly increases during infancy, and stops increasing during puberty, with no significant differences between sexes.



a



b

Legend: The scattergram, best-fit equation, r, p values of HI-male (a) and HI-male (b) vs. age.

limitation

- Not serial

- But, in Korea?

J Laparoendosc Adv Surg Tech A. 2024 Apr 17. doi: 10.1089/lap.2023.0417. Online ahead of print.

Biocompatible Cable Ties Are an Alternative to Metal Stabilizers for Bar Securement During Minimally Invasive Pectus Excavatum Repair

- Background: Bar stabilization during minimally invasive pectus exc avatum repair (MIRPE) is critical to avoid dislodgement. Multiple te chniques are described including stabilizers, wires, and sutures.

- Sutures
- Metal wire
- Stabilizer
- Claw fixator
- Parallel bar with bridge, sandwich technique

- retrospective
- bar movement and outcomes
- existing techniques VS. ZipFix™, a biocompatible cable tie

- ≤20 years of age, MIRPE with ZipFix, Jan 2021 and Sep 2022

- vs. historical controls by same surgeons between Jan 2018 and Dec 2020 using stabilizers or PDS

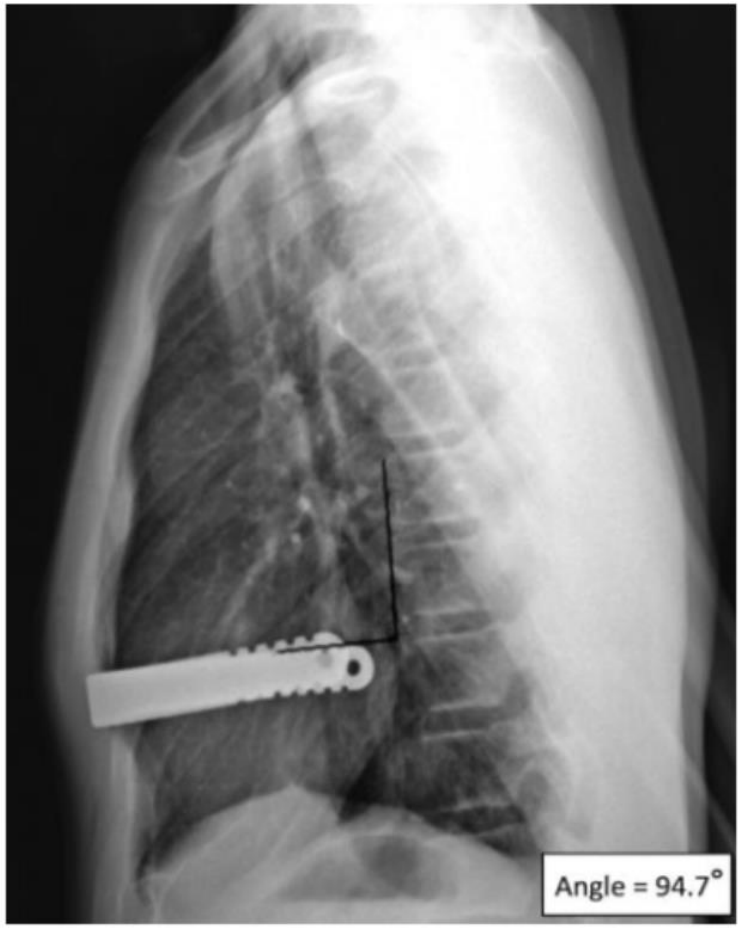


FIG. 1. Bar angle measurement. The angle is measured between the lines drawn along the upper border of the bar and the anterior vertebral line (i.e., along the anterior vertebral ligament.

- median 1-month follow-uptime, 35 (29–44) days
- median total follow-uptime, 210 (53–399) days
- One patient, with PDS, revision for dislodgement

TABLE 1. PATIENT CHARACTERISTICS WITH ZIPFIX VERSUS POLYDIOXANONE SUTURE VERSUS STABILIZERS

	Overall (n = *116*)	*ZipFix* (n = *45*)	*PDS* (n = *36*)	*Stabilizer* (n = *35*)	P
Gender					.12[a]
Male	93 (80%)	37 (82%)	25 (69%)	31 (89%)	
Female	23 (20%)	8 (18%)	11 (31%)	4 (11%)	
Age					.007[b]
Mean (SD)	14.8 (1.8)	14.8 (1.6)	14.1 (1.7)	15.5 (1.8)	
Median (IQR)	15 (14–16)	15 (14–16)	14 (13–15)	15 (14–17)	
Haller index					.42[b]
Mean (SD)	4.3 (1.3)	4.1 (0.8)	4.2 (1.2)	4.6 (1.8)	
Median (IQR)	3.9 (3.6–4.5)	4 (3.6–4.5)	3.8 (3.5–4.2)	3.9 (3.7–4.9)	
Presence of second bar	9 (8%)	3 (7%)	1 (3%)	5 (14%)	.18[a]
Presence of scoliosis	22 (19%)	6 (13%)	9 (25%)	7 (20%)	.41[a]
Pain control					<.001[a]
INC with INB	47 (41%)	43 (96%)	0	4(11%)	
Paravertebral block	69 (59%)	2 (4%)	36 (100%)	31(89%)	

[a]Chi-square test.
[b]Kruskal–Wallis test.
INB, intercostal nerve blocks; INC, intercostal nerve cryoablation; IQR, interquartile range; PDS, polydioxanone suture; SD, standard deviation.

TABLE 2. DEGREE OF BAR MOVEMENT WITH ZIPFIX VERSUS POLYDIOXANONE SUTURE VERSUS STABILIZERS

Degree of bar movement	*Overall*	*ZipFix*	*PDS*	*Stabilizer*	P *value*
Bar 1 delta (month—dc)					.01[a]
Mean (SD)	4.3° (3.9)	3.5° (3.1)	6.3° (5)	3.4° (2.5)	
Median (IQR)	3.3° (1.6, 6.3)	2.3° (1, 5.2)	5.5° (2.5, 9)	3.3° (1.3, 4.8)	
Bar 1 delta (last CXR—dc)					.015[a]
Mean (SD)	6.2° (4.8)	5.4° (5.9)	8.4° (6.7)	4.2° (2.8)	
Median (IQR)	4.9° (1.8, 8)	2.1° (1.3, 7.9)	6.5° (4, 11)	3.6° (1.7, 6.4)	
Bar 2 delta (month—dc)					.29[a]
Mean (SD)	3.4° (1.7)	3.7° (2.2)	1.5° (NA)	3.6° (1.9)	
Median (IQR)	2.7° (2.1, 4.9)	2.7° (2.5, 4.4)	1.5° (1.5, 1.5)	3.1° (2.5, 3.7)	
Bar 2 delta (last CXR—dc)					.57[a]
Mean (SD)	4.1° (1.97)	3.1° (NA)	6.4° (NA)	3.9° (2.4)	
Median (IQR)	3.2° (1.7, 6.4)	3.1° (3.1, 3.1)	6.4° (6.4, 6.4)	3.2° (1.7, 5.8)	

[a]Kruskal–Wallis test.
CXR, chest X-ray; dc, discharge; IQR, interquartile range; PDS, polydioxanone suture; SD, standard deviation.

- Conclusion:
  - ZipFix = metal stabilizers > suture stabilization alone
  - use of ZipFix may be preferred given its lower cost and ease of use
- Limitation
  - Measurement method
    - Position
  - Clinical significancy

Does a high Haller index influence outcomes in pectus excavatum repair?

Article in Press: Corrected Proof

Rawan M. Zeineddine MD, Michael Botros MD, Kenan A. Shawwaf MD, Ryan Moosavi MD, Mohamed R. Aly MD, M. Farina MD, Jesse J. Lackey CSFA, Beth A. Sandstrom RN and Dawn E. Jaroszewski MD

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- HI
  - normal chest: <2.0
  - mild excavatum: 2.0-3.2
  - moderate excavatum: 3.2-3.5
  - severe excavatum: >3.5

- extremely high HI (≥8) may influence surgical approach and complications

- A single institution retrospective
- adult patients with HI ≥ 8, pectus excavatum repairs
- propensity score-matched control group with HI ≤ 4

then multiplied by 100 to give the percentage of chest depression (Figure 2).

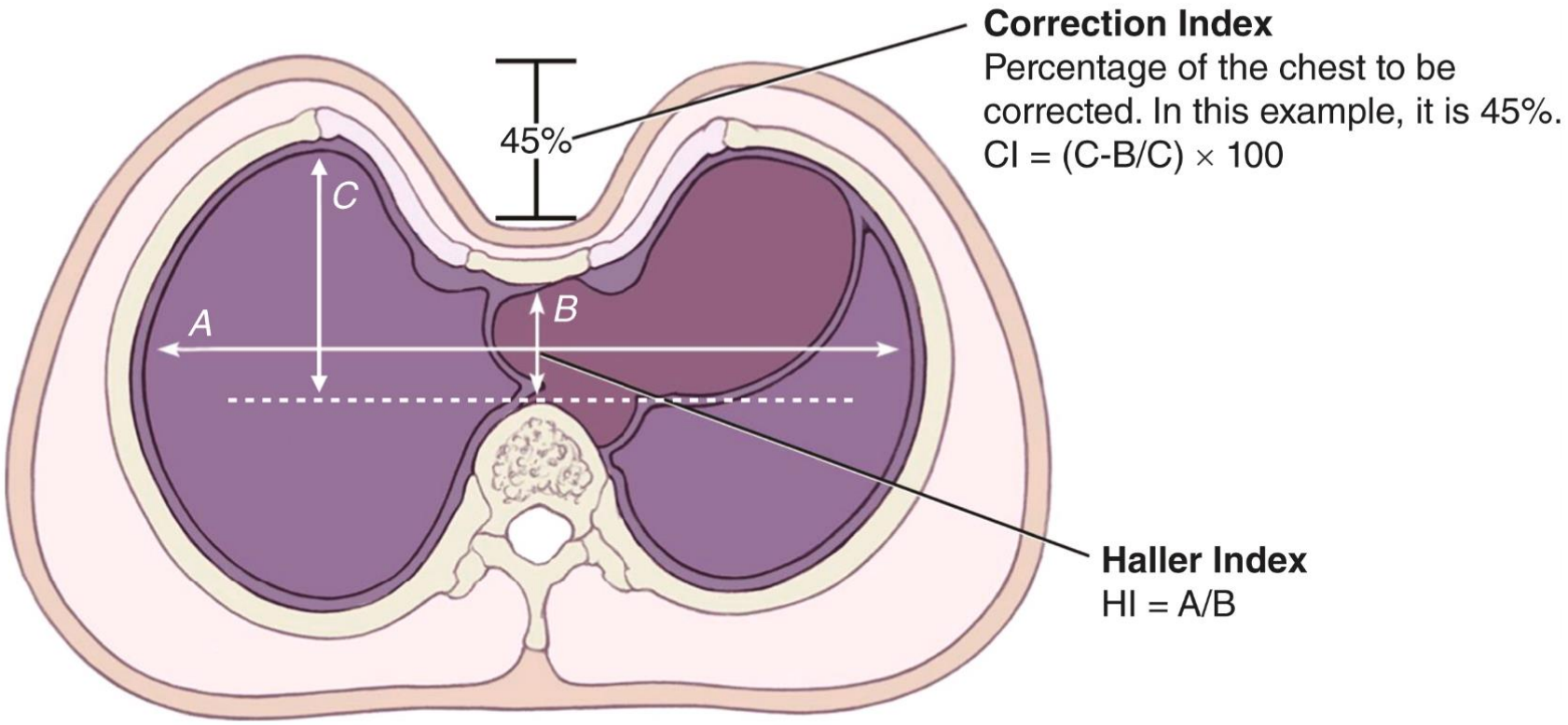
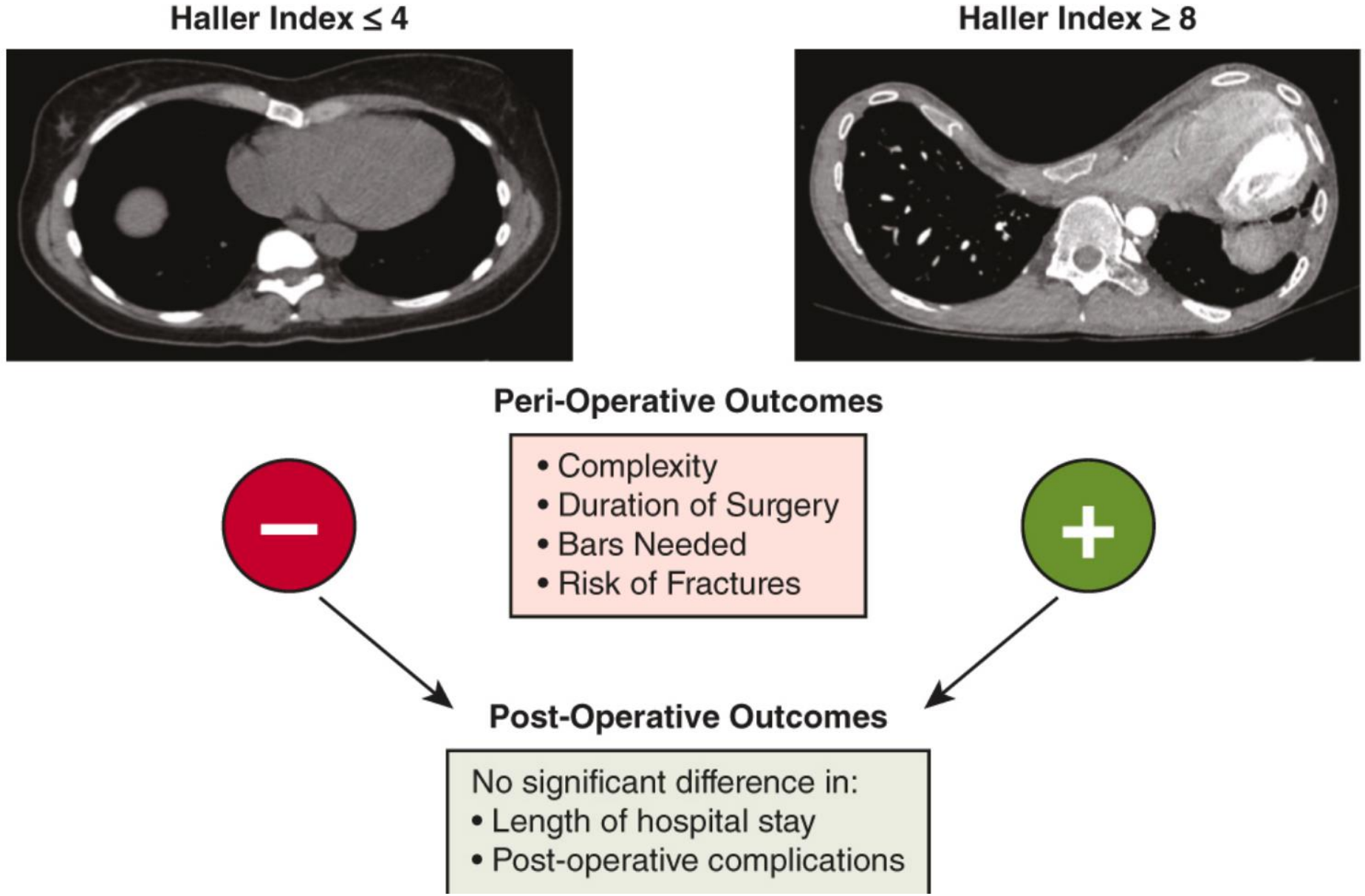


Figure 2

Haller index and correction index measurements

Intraoperative and postoperative outcomes in patients with extreme Haller index.



Intraoperative detail	HI ≥ 8 (n = 64)	HI ≤ 4 (n = 64)	*P* value
Age (y)	33.5 ± 10.9	33.0 ± 10.6	.67
Sex			>.99
Male	28 (44)	28 (44)	
Female	36 (56)	36 (56)	
Body mass index	21.7 ± 3.7	22.6 ± 3.5	.13
HI	13.1 ± 5.0	3.3 ± 0.6	<.001
Correction index	68.1 ± 13.3	29.9 ± 13.8	<.001
No. of bars used			<.001
2	32 (50)	52 (81)	
3	32 (50)	12 (19)	
Type of surgery			.005
MIRPE	54 (84)	63 (98)	
Hybrid	10 (16)	1 (2)	
Duration of surgery (min)	170.5 (IQR 135.7-224.7)	133 (IQR 94.7-178.5)	<.001

Duration of surgery (min)	170.5 (IQR 135.7-224.7)	133 (IQR 94.7-178.5)	<.001
No. of patients with any type of fracture	16 (25)	2 (3)	<.001
Both rib and sternal fractures	6 (9)	0 (0)	
Isolated rib fractures	8 (12)	2 (3)	
Isolated sternal fractures	2 (3)	0 (0)	
No. of patients with rib fractures	14 (22)	2 (3)	.001
1 fracture	6 (9)	0 (0)	
2 fractures	3 (5)	2 (3)	
3 or more fractures	5 (7)	0 (0)	
Rib fractures requiring fixation with			
Isolated plating	4 (6)	0 (0)	.01
Combined plating + FW/bar	4 (6)	1 (2)	
Isolated FW/bar	6 (9)	1 (2)	
Osteotomy/cartilage resection	10 (16)	0 (0)	.001
No. of patients with sternal fractures	8 (12)	0 (0)	.003
Sternal fractures requiring fixation with			
Plating	5 (8)	0 (0)	
FW	3 (4)	0 (0)	.003
Length of hospital stay (d)	3 (IQR 2-3)	3 (IQR 2-5)	.27

Complication	HI ≥ 8 (n = 64)	HI ≤ 4 (n = 64)	*P* value
Pleural effusion			.88
Req diuretics (CD minor)	6 (10)	4 (6)	
Req ER thoracentesis (CD major)	7 (11)	7 (11)	
Pain			
Causing discharged delay	10 (16)	10 (16)	>.99
Uncontrolled causing ER visit	3 (5)	1 (3)	.65
Pneumothorax			.56
Managed supportively (CD minor)	0 (0)	0 (0)	
Req ER visit with chest tube (CD major)	2 (3)	1 (2)	
Pericardial effusion			.32
Req diuretics (CD minor)	0 (0)	0 (0)	
Req ER visit and drainage (CD major)	1 (2)	0 (0)	
Bleeding			> .99
Req blood transfusion (CD minor)	0 (0)	0 (0)	
Req reoperation (CD major)	0 (0)	0 (0)	

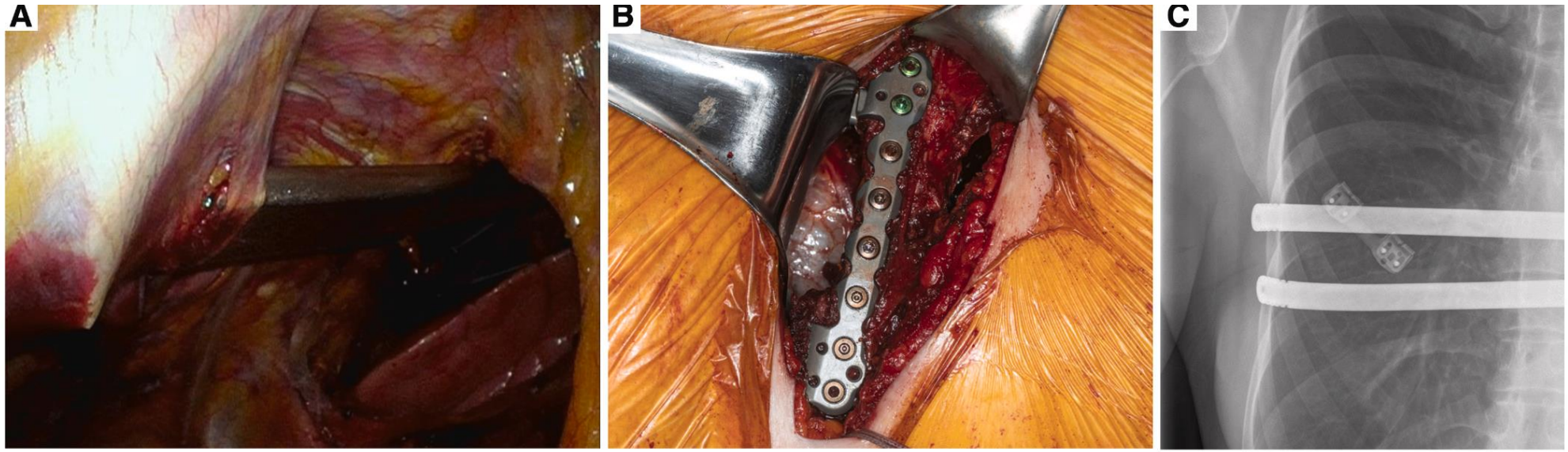


Figure 3

A, Thoracoscopic view of a lateral rib fracture that occurred after placement of the dissector. B, The lateral pocket incision was extended for access to the fracture and rib plating performed to reduce and stabilize the fracture. C, Chest radiograph of lateral plating and 2 Nuss bars in patient who experienced intraoperative rib fracture with a hybrid pectus excavatum repair.

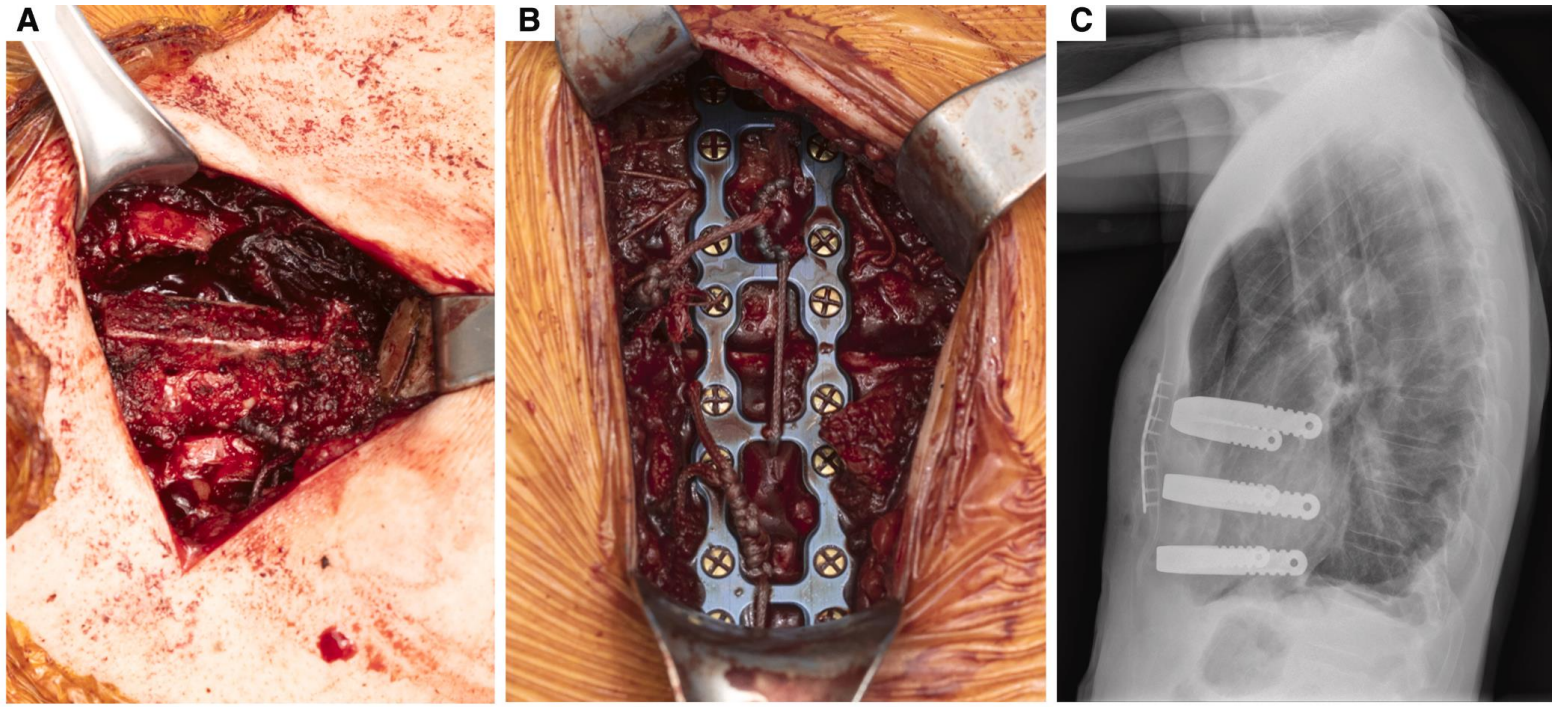


Figure 4

A, Midline incision showing a sternal fracture after passing of the pectus introducer during pectus repair. B, A titanium Biomet ladder plate (Zimmer Biomet Inc) is positioned to approximate and stabilize both ends of the sternal fracture. C Lateral chest radiograph after hybrid repair for sternal fracture showing sternal plating and underlying Nuss bars.

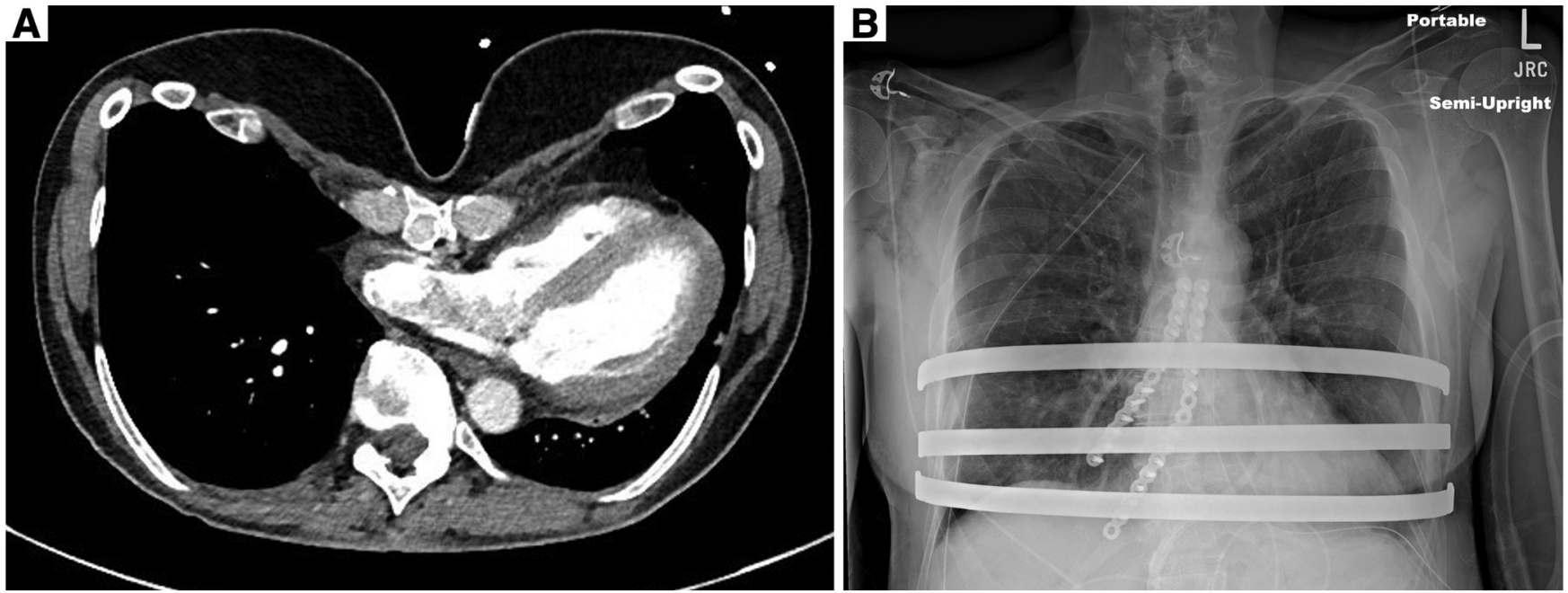


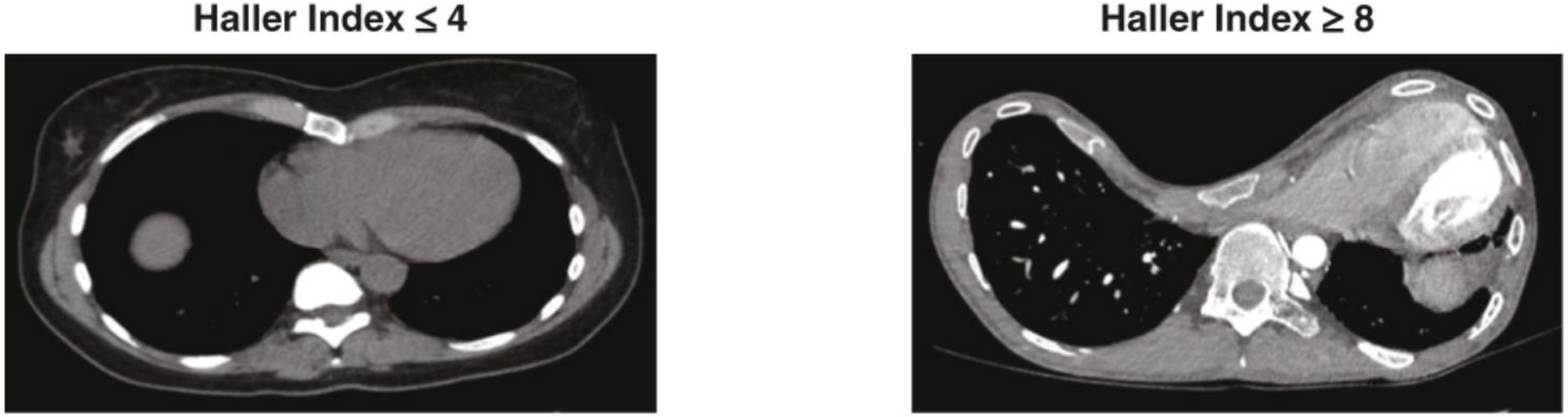
Figure 5

A, Preoperative computed tomography scan of a patient with severe Haller index. B, Osteotomy cuts of the lower ribs were required to elevate sternum and reattachment, and stabilization was performed with titanium plating. Three rib plates are seen on chest radiograph stabilizing the ribs to the sternum after osteotomy cuts.

Limitation

- retrospective nature, small sample size,
- potential selection bias,
- reliance on a single surgeon's expertise at a high-volume institution.
- learning curve effect, exceeded 10 years
  - predominance of severe cases in more recent years (58% of cases with HI ≥ 8 were done after 2018).
- change in postoperative pain control at the end of 2018, with the initiation of intercostal cryoablation.
  - cryoablation was more prevalent in high HI cases
- not matched for factors like sternal angle and asymmetry

Intraoperative and postoperative outcomes in patients with extreme Haller index.



Pain,
Additional procedure,
Case-by-case

Biomechanical Effectivity Evaluation of Single- and Double-Metal-Bar Methods with Rotation and Equilibrium Displacements in Nuss Procedure Simulations

Annals of Biomedical Engineering

Med Sci Monit. 2024; 30: e943705-1–e943705-10. PMCID: PMC11110638
Published online 2024 May 18. Prepublished online 2024 Mar 26. doi: 10.12659/MSM.943705 PMID: 38760925

New Computerized Planning Algorithm and Clinical Testing of Optimized Nuss Bar Design for Patients with Pectus Excavatum

Take-home message

- Various topics
- Multi-center
- Prospective
- AI