Comprehensive Assessment of Pectus Excavatum: Analyzing Chest Wall Anatomy, Cardiac Rotation, and Severity Classification for Enhanced Diagnosis and Treatment

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INTRODUCTION

- Approx. 88% of chest wall abnormalities are classified as pectus excavatum [1]
- Pectus excavatum is characterized by depression of sternum, costal cartilage, and ribs into the thoracic cavity [2]
- Deformities significantly vary in shape, symmetry, and severity [3]
- Symptoms include exercise intolerance, shortness of breath, and chest pain [1]
- CT scans are the optimal tool for grading severity of pectus excavatum and heart location [2]
- Due to diversity of pectus excavatum, individualized surgical planning is necessary

Objective: Evaluate correlation between cardiac rotation angle and pectus excavatum severity as well as create sex-specific models of severe pectus excavatum to aid diagnostic and treatment planning.

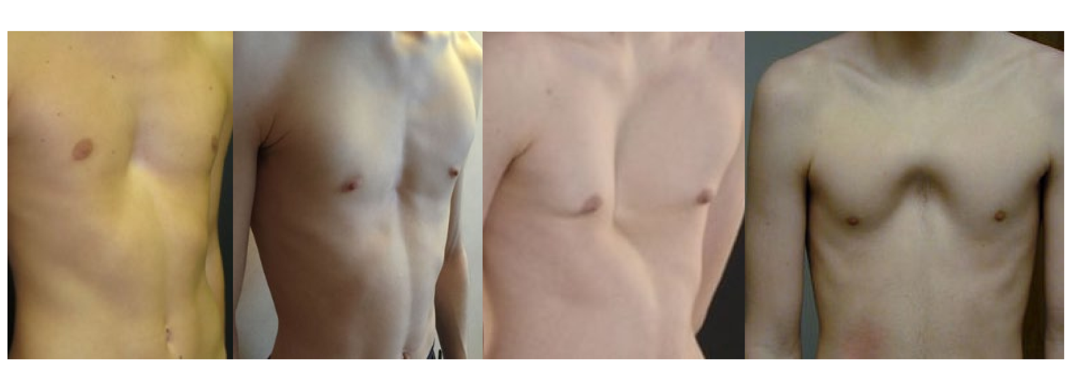

Fig 1. Pectus excavatum shape classification [4]

METHODS

- 49 scans mined using pectus excavatum and chest CT scan codes between 2013 and 2019
- 37 scans selected for use based on image quality
- Correction index = (max AP - min AP) / max AP
- Haller Index = max transverse D / min AP [5]
- Cardiac rotation angle = angle between cardiac apex and line between anterior vertebral corpus and spinous process [6]

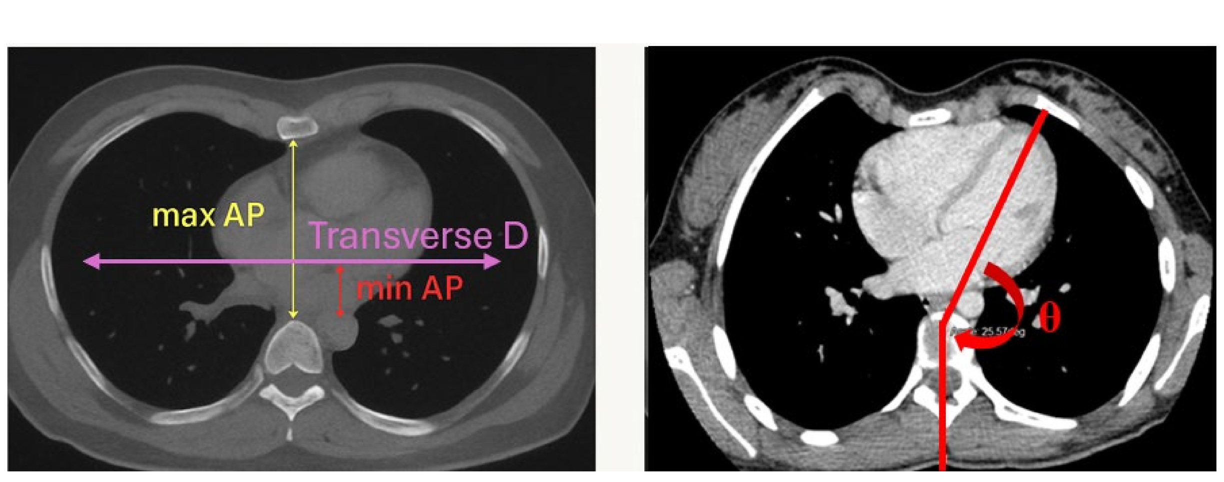

*Fig 2. **(A)** A diagram of Haller index and Correction index calculations in axial view. **(B)** A diagram of cardiac rotation angle measurement.*

METHODS CONT.

- Haller index [7]
  - Mild: 2.0 - 3.2 cm
  - Moderate: 3.2 - 3.5 cm
  - Severe: > 3.5 cm
- 3D models created and segmented in Mimics 23.0
  - Individual ribs, sternum, thoracic spine, costal cartilage, lungs, heart, liver, spleen, kidneys, and abdominal cavity

RESULTS

- Mean cardiac rotation angle calculated for each group:
  - Mild (n=15) : 39.3° ± 13.1
  - Moderate (n=7): 42.5° ± 13.6
  - Severe (n=15): 55.8° ± 13.2
- Tukey's HSD post-hoc test indicated the severe classification significantly differs from mild and moderate groups

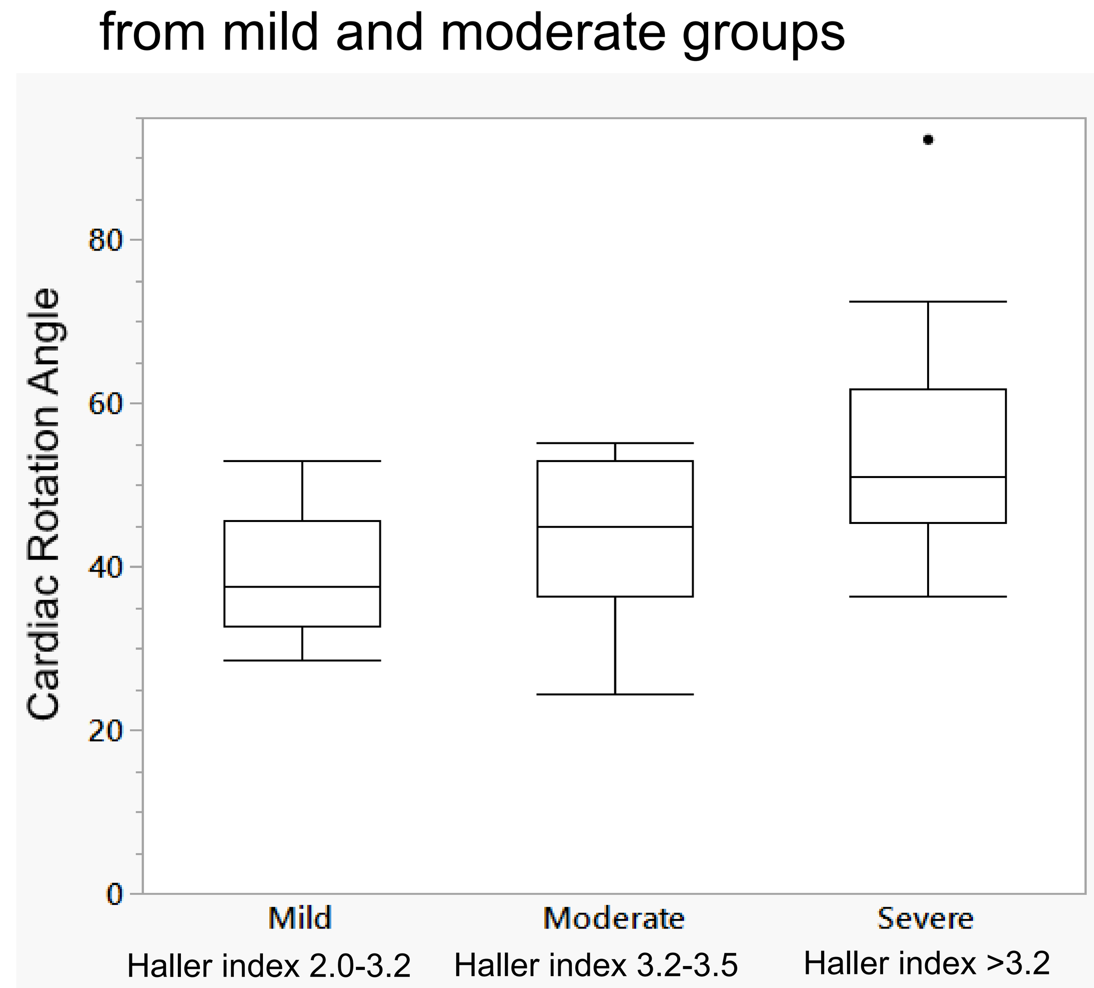

Fig 3. Cardiac Rotation angle at pectus excavatum severity classifications

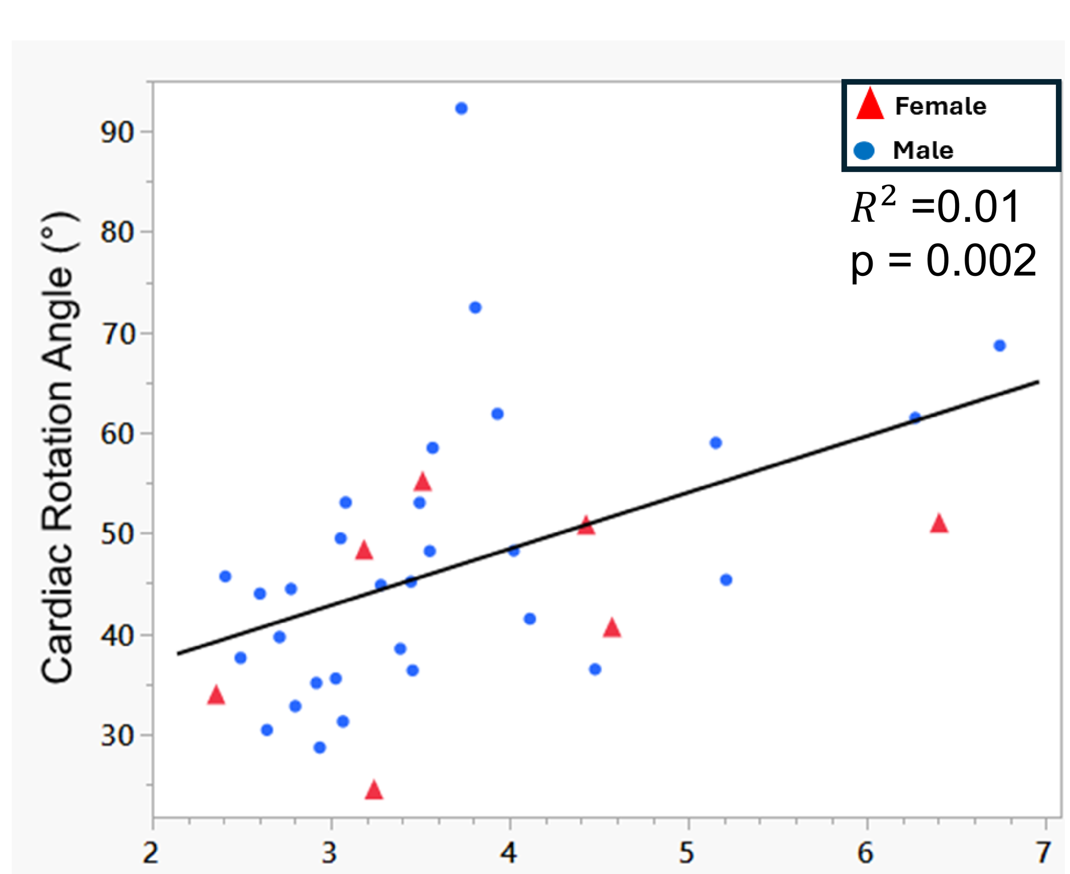

Fig 4. Scatter plot with line of fit for cardiac rotation angle vs. Haller index

RESULTS CONT.

- Significant positive association between cardiac rotation angle and Haller index (Fig. 4)
- Female representative model: age 15 with Haller index of 4.43 cm
- Male representative model: age 13 with Haller index of 4.02 cm (Fig.5)

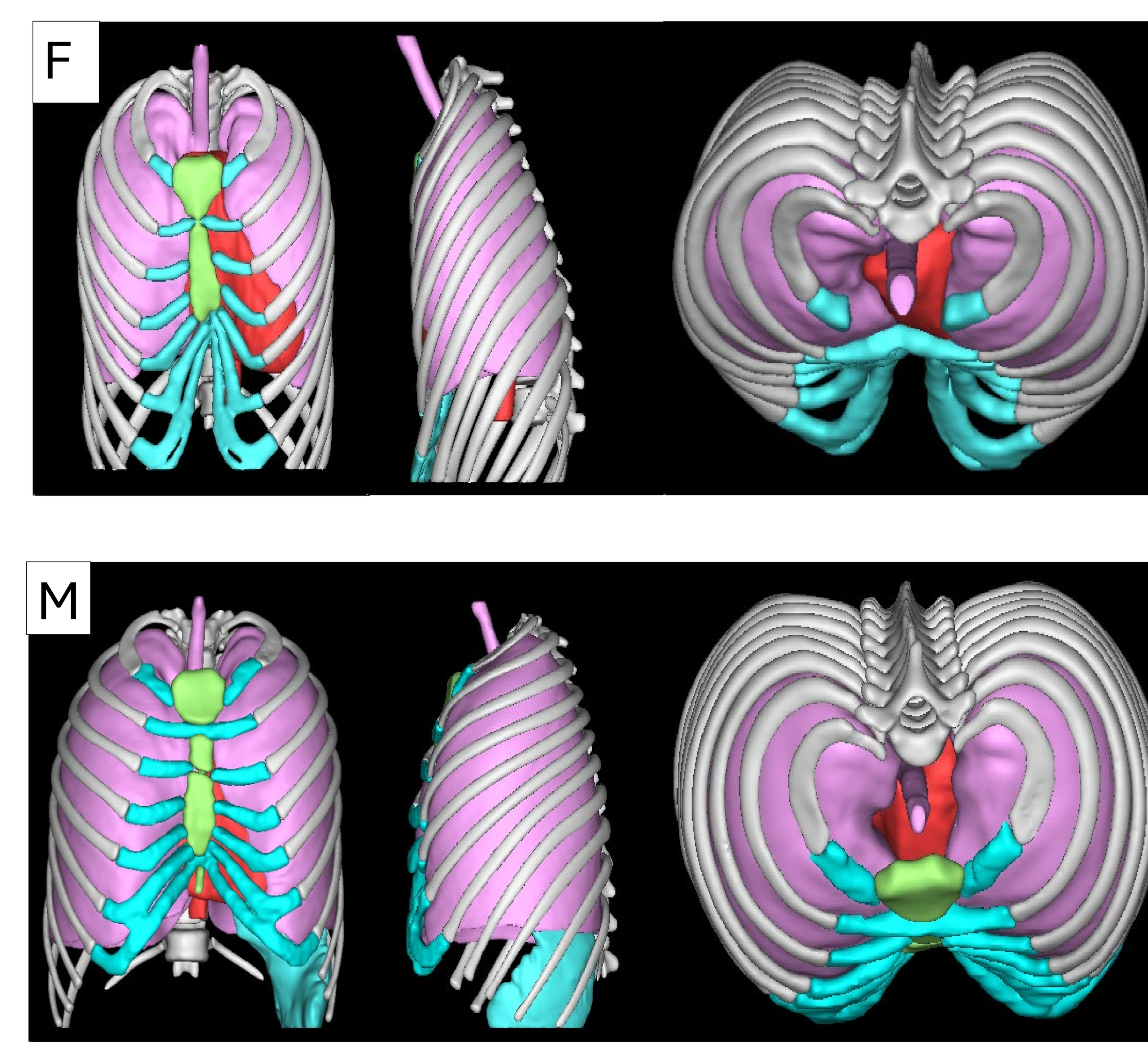

Fig 5. Complete female and male thoracic model (anterior, side, and top view)

CONCLUSION

- Severity of pectus excavatum is strongly associated with cardiac rotation angle
  - More severe deformity, the greater and more variable cardiac displacement
- Cardiac rotation angle showed a significant correlation with Haller index but not the correction index
- Sex-specific 3D thoracic models of severe pectus excavatum were developed to aid surgical planning and custom implant design

ACKNOWLEDGEMENTS

Funding: KLS Martin Group; National Highway Traffic Safety Administration (DTNH22-09-H-00242).

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