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An Anatomical Study of the Mediastinum with Emphasis on Pleural and Pericardial Cavities in Adult Human Cadavers

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KEYWORDS

Mediastinum, pleural cavity, pericardial cavity, cadaveric dissection, thoracic anatomy, Ayurvedic anatomy, Urah Shoola, Urah Kshata

ABSTRACT:

Background:

The mediastinum is a central thoracic compartment bounded by the pleural cavities and subdivided into superior and inferior compartments, the latter further containing anterior, middle (with the pericardial cavity), and posterior divisions. A thorough understanding of the mediastinum and its relationship with the pleural and pericardial cavities is essential for thoracic surgeons, radiologists, and anatomists. In Ayurvedic anatomy, regional thoracic pathology is also described under various conditions such as "Urah Shoola" and "Urah Kshata," though precise structural correlations have not been well-documented.

Objective:

To conduct a detailed cadaveric examination of the mediastinal compartments, pleural cavities, and pericardial cavity in order to document their dimensions, boundaries, contents, and interrelationships, and to explore correlations with classical Ayurvedic descriptions of thoracic anatomy and disease.

Materials and Methods:

This descriptive anatomical study was conducted in the Department of Rachana Sharir (Anatomy), Government Ayurvedic college & Hospital, Patna,Bihar and other medical colleges of the region, over a period of one year. A total of 120 adult formalin-preserved cadavers were dissected using a standardized thoracic dissection protocol. Observations included compartmental classification of the mediastinum, spatial relationships with the pleural and pericardial cavities, morphometric measurements, and documentation of any anatomical variations.

Results:

The superior and inferior mediastinum were clearly distinguishable in all specimens. The middle mediastinum, housing the pericardial cavity, demonstrated consistent anatomical landmarks. The pleural cavities showed symmetrical extent in 87% of cadavers, with anatomical variations such as accessory fissures or incomplete costomediastinal recesses found in 13%. The pericardial cavity was centrally placed with minor displacement in relation to the midline in some specimens. Morphometric measurements of the mediastinal compartments and cavity depths were recorded and found to vary within a physiological range. Correlation with Ayurvedic principles of Urah Sthana highlighted parallels in regional thoracic delineation.

Conclusion:

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This cadaveric analysis reinforces standard anatomical compartmentalization of the mediastinum and highlights the variability in pleural and pericardial cavity dimensions. The findings are clinically significant for thoracic procedures and diagnostic imaging. Correlative insight with Ayurvedic thoracic pathology offers an enhanced understanding of classical anatomical education in traditional medicine systems.

Introduction

The thoracic cavity is anatomically divided into three principal compartments: the two pleural cavities and the central mediastinum. The mediastinum functions as the central partition separating the left and right lungs, housing vital structures including the heart, great vessels, trachea, esophagus, thymus, lymph nodes, and associated neurovascular elements. It is further subdivided into the superior and inferior mediastinum, with the latter divided into anterior, middle, and posterior compartments. The middle mediastinum specifically encloses the pericardial cavity and heart, while the pleural cavities contain the lungs and are bordered medially by the mediastinum [1].

A precise understanding of the mediastinal and adjacent cavities is vital for surgical interventions, diagnostic imaging, and trauma management. Anatomical knowledge of the pleural reflections, recesses, and the pericardium's spatial relations is crucial in thoracic surgeries such as median sternotomy, pericardiocentesis, pneumonectomy, and minimally invasive procedures. Despite extensive coverage in standard anatomical literature, there remains a paucity of cadaver-based morphometric data from the Indian subcontinent, particularly from academic centers focused on Ayurvedic medical education [2].

The pleural cavity itself, though potential in nature, can become clinically relevant in pathological states like hemothorax, pneumothorax, and pleural effusion. Variations in pleural recesses such as the costodiaphragmatic and costomediastinal recesses influence both the drainage of fluid and lung expansion. The pericardial cavity, bordered by the fibrous and serous pericardium, is another critical anatomical domain, especially in pathologies involving pericardial effusion, tamponade, and congenital pericardial defects. Accurate knowledge of its boundaries, attachments, and relationships with adjacent structures such as the phrenic nerves and diaphragm is indispensable for clinicians and anatomists alike [3].

From an integrative anatomical perspective, classical Ayurvedic texts describe the thoracic region (Urah Sthana) and its disorders under entities such as Urah Shoola (chest pain), Urah Kshata (chest injury), and Hrit Shoola (pain near the heart). These clinical conditions, though described in a different paradigm, can be anatomically localized within the compartments of the mediastinum and its adjacent cavities [4]. However, direct structural correlation between modern and Ayurvedic anatomical classifications is seldom explored in a systematic cadaveric study.

The current investigation was designed to bridge this gap by performing a detailed cadaver-based anatomical study of the mediastinum and its relationship with the pleural and pericardial cavities. By examining 120 formalin-embalmed adult human cadavers over a one-year period, the study seeks to document key structural features, morphometric variations, and anatomical anomalies. Additionally, it attempts to interpret these findings in light of Ayurvedic anatomical principles, thereby contributing to the broader understanding of thoracic anatomy from both classical and contemporary perspectives.

Aim and Objectives

Aim

To perform a comprehensive anatomical evaluation of the mediastinal compartments and their relationship with the pleural and pericardial cavities in adult human cadavers, with the objective of correlating anatomical observations with clinical and classical Ayurvedic perspectives of thoracic pathology.

Objectives

1. To identify and classify the anatomical subdivisions of the mediastinum in cadaveric specimens.

2. To examine the anatomical relationships and spatial orientation between the mediastinum, pleural cavities, and pericardial cavity.
3. To record morphometric measurements of mediastinal compartments and cavity depths.
4. To document variations or anomalies in the pleural reflections, recesses, and pericardial positioning.
5. To assess laterality or asymmetry in pleural and pericardial structures.
6. To explore possible correlations between observed anatomical features and Ayurvedic concepts such as Urah Shoola, Hrit Shoola, and Urah Kshata.

Materials and Methods

Study design

This was a descriptive, cross-sectional, cadaver-based observational study conducted to evaluate the mediastinal compartments and their spatial relationship with the pleural and pericardial cavities.

Study setting

The study was carried out in the Department of Rachana Sharir (Anatomy), Government Ayurvedic college & Hospital, Patna,Bihar and other medical colleges of the region.

Study duration

The study was conducted over a period of one year , from October 2022 to September 2023

Sample size

A total of 120 formalin-embalmed adult human cadavers were included in the study. Both male and female cadavers were considered, provided they fulfilled the inclusion criteria.

Inclusion criteria

- Cadavers aged 18 years and above.
- Formalin-embalmed, intact thoracic region without visible post-mortem deformities.
- No evidence of major surgical intervention, trauma, or congenital thoracic deformities.

Exclusion criteria

- Cadavers with thoracic injuries, prior surgery, or gross anatomical deformities.
- Decomposed or poorly preserved specimens.
- Incomplete thoracic cavity due to dissection-related damage.

Dissection protocol

All dissections followed the standard procedures outlined in recognized anatomical manuals. After removal of the anterior thoracic wall and sternum, the mediastinal compartments were systematically exposed. The superior and inferior mediastinum were demarcated using the plane of the sternal angle (angle of Louis) and the lower border of the T4 vertebra. Further dissection was carried out to distinguish anterior, middle, and posterior subdivisions of the inferior mediastinum.

The pleural cavities were identified on either side and carefully inspected for recesses, pleural reflections, and costomediastinal relationships. The pericardial cavity was exposed by removing the fibrous pericardium, and its position, depth, and orientation relative to the mediastinum were recorded.

Parameters observed

1. Dimensional measurements of mediastinal compartments (length, width, depth).
2. Positional relationships between pleura, pericardium, and mediastinal contents.
3. Symmetry or asymmetry in pleural cavity extent.
4. Presence and extent of costodiaphragmatic and costomediastinal recesses.
5. Position and inclination of the pericardial sac relative to midline.
6. Occurrence of anatomical variations or congenital anomalies.
7. Observational alignment with classical Ayurvedic thoracic zones.

Data collection and analysis

Morphometric measurements were taken using standard measuring tapes and digital calipers. Observations were

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recorded in prestructured datasheets and verified independently by two anatomists. Quantitative data were entered into Microsoft Excel and analyzed. Results were expressed as mean ± standard deviation. Differences between left and right thoracic structures and between sexes were evaluated using t-tests or Chi-square tests as applicable. A p-value less than 0.05 was considered statistically significant.

Results

Overview

Out of 120 adult cadavers dissected, 78 were male and 42 were female. The mediastinum and its subdivisions were successfully identified in all specimens. The pleural cavities were symmetrical in most cadavers, while certain anatomical variations such as incomplete recesses, asymmetrical mediastinal shift, and pericardial displacement were noted in a limited number of cases. Morphometric data were collected for all major compartments and structures.

Table 1: Demographic Profile of Cadavers

Table 1 shows the age and sex distribution of cadaveric specimens included in the study.

Parameter	**Total (n = 120)**	**Male (n = 78)**	**Female (n = 42)**
Mean Age (years)	66.1 ± 7.3	67.4 ± 6.9	64.1 ± 7.7
Age Range (years)	49 – 79	50 – 79	49 – 76

All cadavers belonged to the elderly adult age group, with no significant age-related difference across sexes.

Table 2: Dimensions of the Superior Mediastinum

Table 2 presents morphometric values for the superior mediastinum.

Measurement	**Mean ± SD (cm)**	**Range (cm)**
Vertical Height	7.3 ± 1.1	5.5 – 9.4
Transverse Width	9.2 ± 1.3	7.0 – 11.5
Anteroposterior Depth	3.8 ± 0.6	2.9 – 5.0

Dimensions were consistent with standard anatomical references, showing minimal inter-specimen variability.

Table 3: Dimensions of the Anterior Mediastinum

Table 3 provides data on the anterior portion of the inferior mediastinum.

Measurement	**Mean ± SD (cm)**	**Range (cm)**
Vertical Height	4.2 ± 0.9	2.7 – 6.0
Transverse Width	6.1 ± 1.2	4.1 – 8.4

The anterior mediastinum showed significant variation, particularly in specimens with increased thymic remnant or fat deposition.

Table 4: Dimensions of the Middle Mediastinum

Table 4 outlines the measurements of the middle mediastinum which houses the pericardium.

Measurement	**Mean ± SD (cm)**	**Range (cm)**
Vertical Height	6.9 ± 1.0	5.2 – 9.1

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Transverse Width	8.4 ± 1.1	6.5 – 10.3

This region was centrally located and consistently measured, reflecting the stable anatomical location of the heart.

Table 5: Dimensions of the Posterior Mediastinum

Table 5 records data for the posterior mediastinal compartment.

Measurement	Mean ± SD (cm)	Range (cm)
Vertical Height	8.1 ± 1.3	6.1 – 10.4
Anteroposterior Depth	4.2 ± 0.7	3.1 – 5.6

The posterior compartment showed variation influenced by the descending aorta and vertebral angulation.

Table 6: Position of Pericardial Sac Relative to Midline

Table 6 details the alignment of the pericardial sac with respect to the midsagittal plane.

Position	Frequency	Percentage (%)
Centrally aligned	104	86.7%
Slight leftward deviation	14	11.7%
Rightward deviation	2	1.6%

Most pericardia were symmetrically placed; minor leftward deviation was more common than rightward.

Table 7: Pericardial Cavity Volume (Post-emptying)

Table 7 provides the average volume of the pericardial cavity measured after dissection and fluid removal.

Parameter	Mean ± SD (ml)	Range (ml)
Cavity Volume	22.5 ± 3.4	16 – 29

Measured volumes corresponded to anatomical norms and surgical reference ranges.

Table 8: Symmetry in Pleural Cavities

Table 8 shows the degree of symmetry in left and right pleural cavity dimensions.

Symmetry Status	Frequency	Percentage (%)
Symmetrical	104	86.7%
Left larger	9	7.5%
Right larger	7	5.8%

Most cadavers had symmetrical pleural cavities; minor asymmetries were not clinically significant.

Table 9: Presence of Pleural Recesses

Table 9 indicates the consistency of identifying the costodiaphragmatic and costomediastinal recesses.

Recess Type	Frequency	Percentage (%)
Costodiaphragmatic	120	100%
Costomediastinal	113	94.2%

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Incomplete/Missed	7	5.8%

Costodiaphragmatic recesses were universally present and well-defined.

Table 10: Pleural Adhesions or Anomalies

Table 10 outlines pathological or congenital alterations in the pleura.

Observation	**Frequency**	**Percentage (%)**
Pleural adhesions	5	4.2%
Accessory fissure presence	3	2.5%
Congenital pericardial defect	1	0.8%

These rare findings may influence clinical presentations in thoracic diseases.

Table 11: Thoracic Compartment Variability by Sex

Table 11 compares mediastinal measurements across male and female cadavers.

Parameter	**Male (Mean ± SD)**	**Female (Mean ± SD)**	**p-value**
Middle Mediastinum Width	8.6 ± 1.0	8.1 ± 1.2	0.03*
Posterior Depth	4.3 ± 0.6	4.0 ± 0.7	0.12

Statistically significant differences were observed in middle mediastinal width ($p < 0.05$).

Table 12: Ayurvedic Zonal Correlation with Anatomical Compartments

Table 12 relates observed structures to traditional Ayurvedic thoracic zones.

Ayurvedic Descriptor	**Anatomical Correspondence**	**Observed Frequency**
Urah Sthana	Mediastinum and pericardium	120
Hrit Sthana	Heart and central thoracic space	120
Urah Kshata/Shoola	Pleural boundaries and recesses	116

Cadaveric structures aligned well with the Ayurvedic thoracic region definitions.

Table 1 establishes the demographic consistency of the cadaver sample. Table 2 presents standard measurements of the superior mediastinum. Table 3 details anterior mediastinum dimensions, noting soft tissue variation. Table 4 shows middle mediastinum metrics, indicating positional consistency of the heart. Table 5 records deeper posterior compartment values with minor variation. Table 6 demonstrates that the pericardial sac was centrally aligned in most cadavers. Table 7 quantifies pericardial cavity volume within normal anatomical limits. Table 8 confirms that pleural symmetry was predominant. Table 9 confirms universal presence of costodiaphragmatic recess and frequent identification of costomediastinal recess. Table 10 reports minor anomalies, including adhesions and rare defects. Table 11 shows significant sex-based difference in middle mediastinal width. Table 12 supports correlation between observed anatomical zones and classical Ayurvedic thoracic descriptors.

Discussion

This study was conducted to evaluate the anatomical configuration, dimensions, and positional relationships of the mediastinum and its associated pleural and pericardial cavities through detailed cadaveric dissection. The analysis involved 120 well-preserved

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adult cadavers over a 12-month period, yielding valuable morphometric and observational data. The findings serve as an important contribution to both contemporary clinical anatomy and traditional Ayurvedic anatomical understanding [5].

The mediastinal subdivisions superior, anterior, middle, and posterior were clearly delineated in nearly all specimens. The superior mediastinum maintained a consistent pattern across cadavers, with minimal morphometric variability. The recorded vertical and transverse dimensions corresponded well with standard anatomical references, supporting their clinical utility during radiologic imaging and surgical planning. These dimensions are particularly relevant for identifying mediastinal masses, lymphadenopathy, and vascular anomalies in cross-sectional thoracic imaging [6].

The anterior mediastinum, which often contains residual thymic tissue or adipose deposits, showed more pronounced variability. This finding is consistent with studies that also noted similar variations, especially in elderly cadavers. Its reduced depth and flattened appearance in older age groups support known patterns of thymic involution and fatty infiltration [7].

The middle mediastinum, housing the pericardial cavity, was found to be symmetrically aligned in the majority of cadavers. Minor leftward displacement of the pericardial sac occurred in a small percentage (11.7%), possibly due to cardiac anatomical bias or post-mortem mediastinal shift. These findings are critical for guiding safe pericardiocentesis and interpreting cardiac silhouette abnormalities on chest radiographs. The average pericardial cavity volume (22.5 ± 3.4 ml) was within normal post-mortem expectations, and the fibrous pericardium's relations with the diaphragm and phrenic nerves were consistent with standard texts [8].

The posterior mediastinum exhibited deeper anteroposterior dimensions and was found to accommodate the descending thoracic aorta, azygos system, and sympathetic chains. In some cadavers, mild deviation of the esophageal course and vertebral angulation influenced posterior compartment depth. These variations can impact posterior thoracic surgical approaches such as esophagectomy or retro cardiac tumor resections.

The pleural cavities were symmetrical in the vast majority of specimens (86.7%). The costodiaphragmatic and costomediastinal recesses were well-defined in nearly all cases, although minor incompleteness or obliteration was observed in 7 cadavers. These findings emphasize the relevance of these recesses in fluid accumulation and drainage during pleural effusion, hemothorax, or hydrothorax management. Accessory fissures and pleural adhesions were documented in a few specimens and have potential implications for lobar identification during thoracoscopic surgery or chest tube placement [9].

Statistical analysis revealed a significant difference in the middle mediastinum's transverse dimension between male and female cadavers ($p = 0.03$). This difference likely reflects physiological variation in thoracic cavity size between sexes. However, other mediastinal measurements did not show notable sexual dimorphism.

Rare anomalies such as a congenital pericardial defect (0.8%) and accessory pleural folds (2.5%) highlight the importance of anatomical vigilance during thoracic surgery. These anomalies, although infrequent, can contribute to atypical clinical presentations or intraoperative challenges.

From an Ayurvedic perspective, the thoracic region described as Urah Sthana showed a strong anatomical parallel with the mediastinum and its compartments. The correlation of Urah Shoola (thoracic pain) and Hrit Shoola (cardiac pain) with the observed mediastinal and pericardial structures supports a structurally grounded understanding of classical disease localization. Cadaveric validation of these ancient conceptual zones enhances the integration of classical Ayurvedic teachings with evidence-based anatomical science [10].

The findings of this study align with existing cadaveric studies from Western and Indian institutions but expand upon them by incorporating Ayurvedic anatomical interpretations. Similar works by Rath et al. and Shukla et al. focused only on morphometry, while this study also contributes to the interpretative anatomical literature, bridging classical and modern anatomical frameworks.

The strengths of this study include its robust sample size, systematic documentation, and interdisciplinary framework. Limitations include the absence of radiological or histological correlation and restriction to a single institutional setting, which may limit generalizability to other populations or ethnic groups.

Conclusion

This cadaveric study confirms the predictable structural organization of the mediastinum and its subdivisions while also highlighting measurable variations in pleural and pericardial cavity dimensions. The observed anatomical patterns have direct relevance to thoracic surgery, clinical radiology, and emergency medicine.

The consistent presence of thoracic recesses and symmetrical cavity orientation provides a framework for safe procedural interventions. The identification of occasional anomalies, such as accessory folds and congenital pericardial defects, further underlines the importance of thorough anatomical awareness.

Additionally, the study reinforces the utility of classical Ayurvedic descriptions of thoracic regions when interpreted through anatomical dissection, demonstrating the potential for integrative anatomical education. Future research should aim to expand this approach through radiologic-anatomical correlations and comparative studies across diverse populations.

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