Morphometric Study of Epicardium and Myocardium Thickness in Adult Human Hearts

Noor Abbas Ramadan 1*, Elham Majeed Mahmood 1, Saad Ahmed Mohammed 1

Abstract
Background: Understanding the structural dynamics of the heart across diverse demographics sheds light on cardiac function, pathology, and therapeutic interventions. This study aimed to determine the histological and morphometric features of the heart’s layers, particularly the left atrium (LA) and left ventricle.

Methods: Heart samples were obtained from 32 cadavers, comprising both male and female individuals, across four age groups (≤ 29, 30-39, 40-49, and ≥50). These samples were sourced from the forensic center of Azadi Teaching Hospital in Kirkuk city between March 2023 and August 2023. Results: Morphometric analysis revealed that the mean thickness of the epicardium layer varied among the four age groups of the left atrium (LA), ranging from a minimum mean of 103.5 μm in females to a maximum mean of 928.5 μm in males. Similarly, the mean thickness of the myocardium layer of the LA ranged from a minimum mean of 1649 μm in females to a maximum mean of 3176 μm in males. In the left ventricle (LV), the minimum mean thickness of the epicardium layer across the age groups was 217.5 μm in females, while the maximum mean thickness was 1377 μm in males. The minimum mean thickness of the myocardium layer of the LV was 1666 μm in females, and the maximum mean was 4132 μm in males.

Conclusion: The study findings indicate that the myocardium layer of both the left atrium and left ventricle is thicker than the epicardium layer in individuals aged between 25 and 57 years. Furthermore, the thickness of both layers was observed to be thinner in females compared to males.

Keywords: Heart anatomy, Epicardium thickness, Myocardium thickness, Gender differences, Age-related changes

Introduction
The heart, a vital organ central to circulation, comprises intricate layers essential for its function. The investigation of histological and morphometric features of the heart’s layers, particularly the left atrium (LA) and left ventricle, holds significant clinical and physiological implications. Comprehensive knowledge of heart morphology aids clinicians in diagnosing and managing cardiovascular diseases. Abnormalities in the thickness and composition of cardiac layers can serve as diagnostic markers for conditions such as hypertrophic cardiomyopathy, myocarditis, and heart failure. By correlating histological findings with clinical presentations, healthcare professionals can tailor treatment strategies to individual patients, improving outcomes and prognosis.

Significance
This study demonstrated the heart layer morphology, providing insights into cardiac anatomy, age, and gender influences, aiding clinical diagnosis and treatment.

Editor Mohamed Khadeer Ahamed Basheer, And accepted by the Editorial Board Mar 08, 2024 (received for review Jan 10, 2024)

*Correspondence.
Noor Abbas Ramadan, Department of the human Anatomy and Histology College of medicine Tikrit University in Iraq.
E-mail: noorrama2021@gmail.com

Author Affiliation.
1 Department of the human Anatomy and Histology College of medicine Tikrit University in Iraq.

Please cite this article.
Noor Abbas Ramadan, Elham Majeed Mahmood et al. (2024). Morphometric Study of Epicardium and Myocardium Thickness in Adult Human Hearts, Journal of Angiotherapy, 8(3), 1-5, 9477

https://doi.org/10.25163/angiotherapy.839477
cardiac morphology, providing valuable insights with clinical and therapeutic relevance. The heart, a muscular tube, plays a pivotal role in collecting blood from various tissues and organs, including the lungs, and pumping it throughout the body. The left atrium, situated posteriorly within the heart chambers, exhibits muscular walls and distinct anatomical features, distinguishing it from the right atrium. Similarly, the left ventricle, divided into distinct sections, demonstrates a cone-like structure with varying thickness along its wall. The characterization of the left atrium (LA) and left ventricle, two essential components of the heart’s chambers, offers a comprehensive understanding of their anatomical distinctions. The identification of muscular walls and unique structural features within the left atrium, juxtaposed with the cone-like arrangement and varying thickness of the left ventricle, highlights the intricacies of cardiac architecture. Moreover, the histological examination of the myocardium, comprising cardiomyocytes and fibroblasts organized into sarcomeres, elucidates the cellular framework crucial for cardiac function (Weinhaus & Roberts, 2005). The presence of intercalated discs facilitating mechanical and electrochemical communication underscores the intricate coordination necessary for effective cardiac contraction and rhythm. The left atrium (LA), positioned posteriorly within the heart chambers, exhibits muscular walls with specific orientations (Ho et al., 2012). Conversely, the left ventricle, divided into inlet, exit, and apical regions, resembles a cone, with the right ventricle enveloping it (Ho, 2009). Within the left ventricle, two papillary muscles support muscular fiber bands, often containing Purkinje fibers (Greenbaum et al., 1981). Notably, the thickest region of the left ventricle lies at its base, gradually thinning towards the apex (Hill et al., 2015). Surrounding the heart, the epicardium, derived from the proepicardium, comprises a single layer of mesothelial cells contributing to embryonic heart development (Quijada et al., 2020). Additionally, the epicardium contains adipose tissue with paracrine and endocrine effects (Hawang et al., 2017). The myocardium, a complex tissue consisting of cardiomyocytes and fibroblasts, plays a crucial role in cardiac function (Bird et al., 2003). Cardiomyocytes contain myofibrils organized into sarcomeres, containing contractile proteins like actin and myosin (Avazmohamadi et al., 2019). Intercalated discs facilitate mechanical and electrochemical communication among myocardial cells (Pinali et al., 2015). Furthermore, the morphometric analysis of heart layers, including the epicardium and myocardium, unveils important demographic influences on cardiac morphology. By assessing thickness variations across age groups and genders, the study reveals correlations between structural parameters and physiological characteristics. Notably, the observed differences in myocardial wall thickness between males and females underscore the influence of sex on cardiac structure, aligning with previous research findings. Histological techniques, including sample preparation, fixation, sectioning, staining, and microscopic inspection, offer insights into heart morphology (Sampedro-Carrillo, 2022; Al-Sabaawy et al., 2021; Roth et al., 2022; Almangush et al., 2021). Microscopic examination reveals normal histological findings, with variations in layer thickness across age groups and genders (Legato & Leghe, 2010; ST Pierre et al., 2022). Understanding the histological and morphometric characteristics of human heart layers provides essential insights into cardiac anatomy and physiology. Further research elucidating demographic influences on heart morphology could inform clinical practice and therapeutic interventions. This study aimed to investigate the histological and morphometric features of these layers, focusing on the left atrium (LA) and left ventricle. Through a comprehensive analysis, we aimed to elucidate the structural dynamics of the heart across different age groups and genders. The delineation of structural dynamics across different demographics might enhance our ability to evaluate cardiac health and devise targeted therapeutic interventions.

Materials and methods

Study Design:
The current study conducted autopsies on 32 cadavers, including both male and female individuals, divided into four age groups (≤29, 30-39, 40-49, and ≥50). The cadavers were referred to forensic centers based on official documents from police stations and court pre-orders, with causes of death primarily attributed to trauma such as car accidents, shooting, stabbing, and falls from heights. The study was conducted at forensic medicine departments in Kirkuk and Salah-Aldin governorates, Iraq.

Sample Collection:
The target organ of the study, the heart, was accessed through routine longitudinal mid-sagittal incisions. This approach involved direct cutting of the skin, subcutaneous tissues, chest bones (sternum and ribs), and the pericardium. The fibrous pericardium was freed from the sternum by cutting the sternopericardial ligaments. Notably, the superior sternopericardial ligament was traced to the manubrium, while the inferior ligament was attached to the xiphoid process.

Microscopic Inspection and Descriptive Histology:
Microscopic investigation of heart sections included morphometric and descriptive histology. A light microscope was employed for this purpose.

Morphometric Technique:
The study focused on measuring the thickness of two heart layers, namely the epicardium and myocardium of the left atrium and
Table 1. The thickness of the epicardium and myocardium layer of the left ventricle in different age groups and sex

<table>
<thead>
<tr>
<th>Age Class (years)</th>
<th>Sex</th>
<th>Minimum Thickness of epicardium of left atrium (um)</th>
<th>Maximum thickness of the epicardium of the left atrium (um)</th>
<th>Mean</th>
<th>Minimum Thickness of the myocardium of the left atrium</th>
<th>Maximum thickness of the myocardium of the left atrium</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 29</td>
<td>Male</td>
<td>150</td>
<td>162.5</td>
<td>156.3</td>
<td>2700</td>
<td>2730</td>
<td>2715</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>99</td>
<td>108</td>
<td>103.5</td>
<td>1641</td>
<td>1658</td>
<td>1649</td>
</tr>
<tr>
<td>30-39</td>
<td>Male</td>
<td>187.5</td>
<td>190.5</td>
<td>189</td>
<td>2755</td>
<td>2774</td>
<td>2764</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>162</td>
<td>170</td>
<td>166</td>
<td>1777</td>
<td>1792</td>
<td>1784</td>
</tr>
<tr>
<td>40-49</td>
<td>Male</td>
<td>343</td>
<td>368</td>
<td>355.5</td>
<td>2923</td>
<td>2937</td>
<td>2930</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>237</td>
<td>242</td>
<td>239.5</td>
<td>2015</td>
<td>2026</td>
<td>2020</td>
</tr>
<tr>
<td>≥ 50</td>
<td>Male</td>
<td>925</td>
<td>932</td>
<td>928.5</td>
<td>3167</td>
<td>3185</td>
<td>3176</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>825</td>
<td>835</td>
<td>830</td>
<td>2190</td>
<td>2204</td>
<td>2197</td>
</tr>
</tbody>
</table>

Table 2. The thickness of epicardium and myocardium layer in different age groups and sex

<table>
<thead>
<tr>
<th>Age Class (years)</th>
<th>Sex</th>
<th>Minimum Thickness of the epicardium of the left ventricle</th>
<th>Maximum thickness of the epicardium of the left ventricle</th>
<th>Mean</th>
<th>Minimum Thickness of the myocardium in the left ventricle</th>
<th>Maximum thickness of the myocardium of the left ventricle</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 29</td>
<td>Male</td>
<td>450</td>
<td>470.7</td>
<td>460.4</td>
<td>2805</td>
<td>2818</td>
<td>2811</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>209</td>
<td>226</td>
<td>217.5</td>
<td>1660</td>
<td>1672</td>
<td>1666</td>
</tr>
<tr>
<td>30-39</td>
<td>Male</td>
<td>687</td>
<td>703</td>
<td>695</td>
<td>3100</td>
<td>3118</td>
<td>3109</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>354</td>
<td>362</td>
<td>358</td>
<td>1880</td>
<td>1892</td>
<td>1671</td>
</tr>
<tr>
<td>40-49</td>
<td>Male</td>
<td>858.7</td>
<td>872</td>
<td>865.4</td>
<td>3846</td>
<td>3864</td>
<td>3855</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>429</td>
<td>440</td>
<td>434.5</td>
<td>3650</td>
<td>3666</td>
<td>3658</td>
</tr>
<tr>
<td>≥50</td>
<td>Male</td>
<td>1371</td>
<td>1384</td>
<td>1377</td>
<td>4123</td>
<td>4142</td>
<td>4132</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1225</td>
<td>1244</td>
<td>1234</td>
<td>3725</td>
<td>3736</td>
<td>3730</td>
</tr>
</tbody>
</table>

Figure 1. (A) The epicardium layer of the heart. (B) the epicardium and myocardium layer. 1: subepicardial layer of the 2: adipose tissue in subepicardial layer 3: myocardium. (C) the cardiac muscles.
ventricle. The thickness measurements were compared between male and female specimens.

**Preparation of Heart Samples:**
Heart specimens were dissected into small pieces representing the epicardium and myocardium layers.

**Fixation of the Sample:**
The first step in sample preparation involved fixation using 10% buffer formalin saline for 48 hours according to the method of Sampedro-Carrillo, E. A. 2022.

**Dehydration, Clearing, Embedding, and Blocking:**
Specimens were washed in running tap water and dehydrated through graded concentrations of ethanol alcohol. Clearing was achieved using xylene, followed by embedding in melted paraffin and blocking in paraffin wax (Al-Sabaawy et al., 2021).

**Sectioning, Slide Mounting, and Rehydration:**
Tissue blocks were serially sectioned at 5 µm thickness using a manual microtome. Sections were mounted on slides from warm water and immersed in xylene, followed by rehydration through graded ethanol alcohol and tap water (Roth, D. M. et al., 2022).

**Staining:**
Routine staining with Hematoxylin and Eosin was performed according to method of Almangush, A. et al., 2021. Sections were de-paraffinized, hydrated, stained with Harris Hematoxylin, differentiated in 1% acid alcohol, blue-stained, counter-stained with 1% eosin, washed, dehydrated, cleared, and air-dried before mounting.

**Measuring Technique:**
The thickness of heart layers (epicardium and myocardium) was measured using Leica and XSZ-107bn microscopes. Measurements were taken at three different points for each specimen, and the mean value was recorded. The thickness of the each layer of the heart was measured three times and the mean value was taken. The histological examination and morphometric analysis of the heart layers were measured in the study.

**Results**

**Histological Findings**

**Epicardium Layer:**
Microscopic examination under a light microscope revealed normal histological findings of the epicardium layer. It consisted of a single layer of mesothelial cells with a layer of connective tissue beneath it. This connective tissue was rich in fat cells, blood vessels, and nerve supply (Figures 1(A) and Figure 1(B)).

**Myocardium Layer:**
The study demonstrated that the thickness of the heart wall primarily stemmed from its middle layer, the myocardium, in both males and females. The myocardium layer comprised cardiac muscles arranged in a regular pattern. These muscles appeared as branched striated muscles, interconnected via intercalated discs (Figure 1C). Some of these cells were binucleated. Between the cardiac muscles, there was connective tissue rich in blood vessels, nerves, and fat cells.

**Morphometric Histological Results:**
The study measured the thickness of the epicardium and myocardium layers of the left atrium and left ventricle.

**Left Atrium:**
The minimum thickness of the epicardium layer of the left atrium was 99 µm in females, while the maximum thickness was 932 µm in males. The minimum thickness of the myocardium layer was 1641 µm in females, and the maximum was 3185 µm in males aged ≥50. The myocardium layer of the left atrium was consistently thicker than the epicardium layer in all age groups and both genders.

**Left Ventricle:**
The minimum thickness of the epicardium layer of the left ventricle was 209 µm in females, and the maximum was 1384 µm in males. The minimum thickness of the myocardium layer was 1660 µm in females, while the maximum was 4142 µm in males aged ≥50. Similar to the left atrium, the myocardium layer of the left ventricle was thicker than the epicardium layer across all age groups and genders.

These morphometric histological findings are summarized in Tables 1 and 2, highlighting the differences in thickness between the epicardium and myocardium layers in the left atrium and left ventricle. Overall, the study provides detailed insights into the histological architecture of the heart layers, contributing valuable data to the understanding of cardiac morphology in different populations.

**Discussion:**
This study demonstrated the thickness of the epicardium layer of the left atrium and ventricle with the myocardium layer in adult Iraqi human cadaver hearts across different age groups and genders in Kirkuk, Iraq. There was no conflicting data regarding the measurement of heart layer thickness (epicardium and myocardium) in adult human hearts, particularly in Iraq and globally, utilizing Leica and XSZ-107BN light microscopes. The findings of the current study corroborate existing literature, demonstrating that the myocardium layer consistently exhibited greater thickness compared to the epicardium layer across all age groups and genders. Furthermore, the study revealed a correlation between the thickness of the epicardium and myocardium layers with age and sex. Specifically, the myocardium wall thickness of the left ventricle was influenced by sex, aligning with previous research (Legato, M. J., & Leghe, J. K. 2010). Additionally, it was observed that females tended to have thinner myocardial wall thickness compared to males, in agreement with findings (St Pierre, S. 2022).
Conclusion
In conclusion, this study contributes to understanding cardiac morphology by reaffirming the relative thickness of the epicardium and myocardium layers across different demographics. The observed correlations with age and sex underscore the importance of considering these factors in assessing cardiac structure and function.

Author contributions
N.A.R., E.M.M., S.A.M. developed the concept and the design of the study, analyzed the data, and wrote the draft of the manuscript.

Acknowledgment
Authors were grateful to their department.

Competing financial interests
The authors have no conflict of interest.

References