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MORPHOLOGICAL FEATURES OF FENESTRA AND NODULES ON THE AORTIC VALVE LEAFLETS OF HUMANS

Introduction

The aortic root serves as the anatomical connection between the left ventricle and the ascending aorta, playing a crucial role in cardiovascular function. It consists of the aortic valve leaflets, which are supported by the aortic sinuses (Valsalva), and the interleaflet triangles that lie between their basal attachments, ensuring structural integrity and optimal blood flow dynamics [1]. Nodules of semilunar leaflet of aortic valve are the fibrous thickenings located at the midpoints of the cusp. They ensure complete valve closure and, together with the semilunar lunulas, form the coaptation area to prevent backflow. Size and integrity variations can indicate underlying valve disease, with enlarged or calcified nodules leading to aortic regurgitation [2]. Fenestrae are small cusp perforations, are normal in small numbers; however, excessive size or quantity weakens cusps, potentially causing regurgitation or prolapse [3]. Increased fenestrae near commissures raise tear risks and insufficiency, highlighting the importance of fenestrae characteristics in maintaining aortic valve function and predicting disease [4]. This study examines the structural characteristics of semilunar leaflets, nodules, and fenestrae of semilunar leaflet of aortic valve, aiming to refine diagnostic accuracy and support the development of targeted therapeutic strategies in cardiology.

Goal

To establish the range of anatomical variations in aortic valve nodules and fenestrae by characterizing their variant anatomy, nodule location, and frequency of fenestrae occurrence.

Material and methods of research

Morphological and morphometric methods were used to evaluate the characteristics of aortic valves in 38 post-mortem human hearts (68,50 [52,00; 78,50] years old). Measurements included lunula lengths (left and right), nodule width, and nodule height. Data were compiled and analysed using Microsoft Excel and Statistica 10.0.

The results of the research and their discussion

The study found that the median nodule width across the aortic valve leaflets ranged from 2.00 to 4.00 mm, with notable variations among different leaflets. In terms of location, nodules exhibited distinct positional tendencies depending on the leaflet type. In the left coronary leaflet, nodules were predominantly shifted left in 43.75% of cases. In contrast, nodules in the non-coronary leaflet were more frequently shifted right (45.45% of cases), while those in the right coronary leaflet were centrally positioned in 37.84% of cases. These findings challenge the traditional assumption that nodules are always midpoint-centred, providing new perspectives on anatomical variability in aortic valve structures. The study identified five distinct nodule shapes within the aortic valve leaflets: brush/papillary, round, linear, small protrusion, and triangular. Notably, linear nodules were absent in the left coronary leaflet, while they were present in both the right coronary and non-coronary leaflets, suggesting structural variability across leaflet types. Among all observed shapes, brush/papillary and round nodules emerged as the most prevalent, appearing more frequently than other formations across all three leaflets. These findings highlight the diverse morphological

characteristics of aortic valve nodules, contributing to a more refined understanding of their structural differences and potential clinical implications.

The study revealed notable variability in lunula length across the aortic valve leaflets. The left lunula length demonstrated a range of 11.00–15.00 mm in the left coronary leaflet, 12.00–16.00 mm in the right coronary leaflet, and 12.00–16.00 mm in the non-coronary leaflet, indicating slight differences in structural adaptation across leaflets. The right lunula length, however, was generally greater, spanning 12.00–17.00 mm across all leaflets, suggesting an anatomical tendency for increased length on the right side. These findings emphasize the structural diversity of aortic valve components.

Moreover, the study found that fenestrae, or small perforations in aortic valve leaflets, were present in 26.32% of the examined valves, highlighting their structural variability. The left coronary leaflet exhibited the highest incidence of fenestrae at 13.16%, followed by the right coronary leaflet at 10.53%, and the non-coronary leaflet at 4.00%, indicating an unequal distribution across leaflets. Among the cases with fenestrae, 50% showed perforations in only one leaflet, while 20% exhibited fenestrae in two leaflets, and 10% displayed perforations across all three leaflets. These findings suggest that fenestrae occur naturally, but their distribution and prevalence could have implications for valve integrity and function, particularly in relation to structural weakening and potential regurgitation risks.

The study underscores the importance of morphological variability in aortic valve nodules, challenging the traditional perspective that nodules are exclusively midpoint centered. The observed positional shifts suggest structural adaptability, which may influence valve closure efficiency. Additionally, the presence of increased fenestrae near commissures raises concerns about potential tear risks, as these perforations can weaken leaflet integrity over time, possibly leading to aortic regurgitation.

Conclusions:

1. Nodule placement varies across leaflets – Nodules tend to shift left in the left coronary leaflet, right in the non-coronary leaflet, and remain centrally located in the right coronary leaflet, challenging the traditional midpoint-only assumption.

2. Brush/papillary and round nodules are most common – These two shapes predominate across all leaflets, while linear nodules are absent in the left coronary leaflet, suggesting structural specialization.

3. Fenestrae distribution is uneven – Left coronary leaflets exhibit the highest frequency of fenestrae, followed by right coronary and non-coronary leaflets, emphasizing structural vulnerabilities and potential clinical implications.

LITERATURE

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