Role of Interlaminar Fibers in Aortic Dissection Development: Evidence from a Rat Model [1]

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Summary

Aortic dissection (AD), the separation of aortic layers, is a life-threatening disease, and its formation mechanism remains unknown. In this study, we investigated the role of interlaminar fibers (IFs) in AD development. Rats were bred with 0.4% β-aminopropionitrile water to establish an AD model. Delamination tests and Elastica-Masson staining were performed to assess structural changes. As AD developed, the area fraction of IFs and delamination strength were reduced, with a significant correlation coefficient between these factors. These findings suggest that the loss of IFs weakens the aortic wall in the radial direction, leading to AD development.

Introduction

Aortic dissection (AD), the separation of the aortic media in the radial direction, is a life-threatening disease of the aorta. The mortality rates are reported to be 17.5% before hospital arrival and 21.4% within 24 hours of rupture [2]. Despite its high mortality, the mechanisms underlying AD development remain unclear. Interlaminar fibers (IFs), thin elastin fibers that run in the radial direction and connect adjacent elastic laminae, have been reported to decrease in the presence of AD [3]. This reduction in IFs may contribute to AD development.

We aimed to elucidate the role of IFs in AD development. We utilized AD-predicted rats, which subsequently developed AD, and measured the area fraction of IFs and the delamination strength of the aortic wall.

Methods

All animal experiments were approved by the Institutional Review Board for Animal Care at Nagoya Institute of Technology (Nos. 2022011, 2023007). Based on a previous study reporting that 6 weeks of 0.4% β-aminopropionitrile (BAPN) administration induces AD [4], male Slc:SD rats aged 4 and 7 weeks were administered with 0.4% BAPN water until they were 10 weeks old to establish the Pre-AD and AD groups, respectively. Age-matched control rats that were not administered BAPN served as the Control group. All rats were sacrificed at 10 weeks, and the thoracic aorta was excised.

A T-type delamination test was performed on descending aortic specimens following a previously described protocol [5]. For histological analysis, Elastica-Masson staining was conducted. Stained sections were imaged under a microscope, and the area fraction of IFs λ_{IF} was quantified.

Data are presented as mean ± standard deviation.

Results and Discussion

AD was observed exclusively in the ascending aorta within the AD group. Since no AD was detected in the descending aorta, delamination tests were performed on specimens that appeared normal.

The delamination strength was highest in the Control (19.9 ± 5.0 N/m) and decreased sequentially in the Pre-AD (15.9 ± 2.2 N/m) and AD groups (12.9 ± 2.5 N/m). The delamination strength in the Pre-AD and AD groups was significantly lower than in the Control group, indicating a gradual decline in the delamination strength with AD development.

A representative Elastica-Masson-stained image is shown in Fig. 1. The area fraction of IFs λ_{IF} was highest in the Control group (10.1 ± 1.8%) and decreased progressively in the Pre-AD (8.0 ± 1.2%) and AD groups (5.1 ± 1.2%). This result suggests a gradual reduction in IFs with AD development.

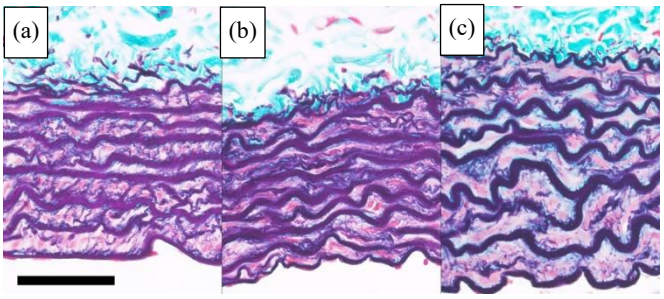

Figure 1: Elastica-Masson staining of (a) Control, (b) Pre-AD, and (c) AD groups. Bar in (a) = 50 μm.

The correlation coefficient between delamination strength and the area fraction of elastin was significant, indicating that the reduction in IFs contributed to the weakening of the aortic wall.

Conclusions

During AD development, the delamination strength and the area fraction of IFs decreased, with a significant correlation observed between them. These findings suggest that the reduction in IFs contributes to the weakening of the aortic wall in the radial direction, thereby leading to the AD development.

Acknowledgments

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References

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