Thoracic Aortic Aneurysm Profiling: Patient Groups and Biomechanics

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Summary

Diameter is used as a surrogate for the risk of dissection and rupture in thoracic aortic aneurysm (TAA) patients. Current surgical guidelines groups patients into categories based on known syndromes (Marfan, Turners, Ehlers-Danlos) and sporadic (acquired) groups based on aortic valve type (tricuspid or bicuspid). The work presents uses biomechanical data, histopathology and patient profiles of a cohort of patients followed at the MUHC aortic clinic to help improve surgical decision making.

Introduction

Current surgical guidelines for TAA patients rely on the aortic diameter for surgical intervention within each category. It is well established that using aortic size alone as a predictor of aortic dissection/rupture risk has significant limitations [1] and our own Clinic data shows an average diameter of dissection at <4.0 cm. There are many other important presenting features such as age, sex, aneurysm location, anthropometric information, clinical featuring and lifestyle that may have an impact on disease progression. Moreover, the disease is multifactorial with differences in aneurysm geometry, tissue remodeling, comorbidities, genetics and family history.

Methods

All patients involved in the study from the McGill University Health Centre (MUHC) aortic clinic. A cohort of 190 patients having undergone aortic resection surgery in our clinic for ascending aortic aneurysm repair were enrolled in accordance with the McGill Institutional Review Board. Patient characteristics (basic demographics, genetics, aortic dimensions, etc.), imaging data, the resected tissue, histology, and genetics were collected. *Ex vivo* testing was performed using tissue from the AscAo ring [2,3]. Four quadrant testing squares were tested on a TA ElectroForce planar biaxial tensile tester (TA Instruments, Eden Prairie, Minnesota) using hooked 4-0 silk sutures in a 37℃ bath of Ringer's lactate solution. A series of biaxial stretching protocols along their circumferential and longitudinal axes were used to determine the apparent modulus of elasticity and energy loss of the tissue. Tissue samples were processed for histopathology. An unsupervised machine learning algorithm (k-cluster analysis) to stratify our population. This analysis created a series of clinically significant patient groupings for which the tissue mechanical properties and histopathology were compared.

Results and Discussion

Cluster analysis of our patient cohort suggests four groups of patients. Three of these groups are similar to the groupings in the European and American guidelines for aortic disease management. The first group contains an overrepresentation of patients with bicuspid aortic valves and aortic stenosis and smaller aortic diameter ($P<0.01$). The second group features older patients with more risk factors, and high aortic diameter-height ratio ($P<0.01$). The third group was younger with few risk factors while being tall with syndromic featuring ($P<0.01$) along with higher incidence of positive genetic testing ($P<0.05$). A fourth group features patients with higher incidences of severe aortic root dilatation and aortic insufficiency with negative genetics ($P<0.01$). The second group (older patients, high aortic diameter/height) had the poorest mechanical properties when assessing energy loss ($P<0.0001$) while there was no significant difference in aortic tissue thickness between the groups. Normalizing by age shows the second group having the highest values of energy loss, with the rest of the groups being comparable to each other ($P<0.005$, $P<0.0001$). Histological analysis revealed higher collagen-elastin ratio in the second group compared to the first and fourth groups ($P<0.05$).

Conclusions

Surgical decision making for TAA patients can benefit from incorporating biomechanical data in the analysis of large cohorts.

Acknowledgments

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References

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