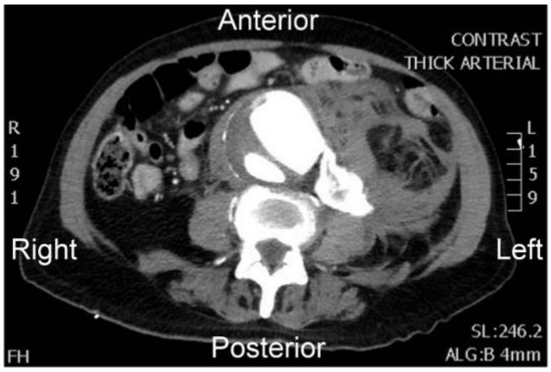
Biomechanics of Abdominal Aortic Aneurysms

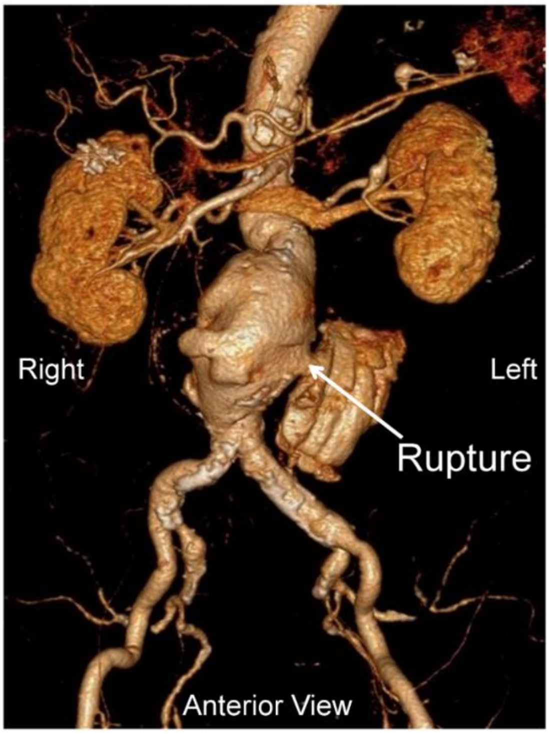
ABSTRACT

For scientific computations to be embraced by medical community, the methods we propose should be simple and usable by professionals with little knowledge of computational sciences (e.g. clinicians). In my opinion, vascular surgery is the prime candidate for the widespread deployment of computational biomechanics exactly because in this area simple and robust methods can be beneficially applied.

In this seminar I will focus on visualising and understanding the biomechanics of aortic aneurysms with the objective of assessing their structural integrity and subsequently their risk of rupture.

Abdominal aortic aneurysm (AAA) is a permanent and irreversible dilation of the lower region of the aorta. As the interplay between wall stress and strength is critically important for rupture risk assessment, it is desirable to be able to non-invasively estimate the AAA wall stress for a given patient, quickly and reliably.





It has been known for some time that, for a given AAA geometry, simple linear methods are sufficient to find internal forces (i.e. stresses) in the wall that balance the blood pressure load. It is however much more difficult to incorporate the effects of residual stress (i.e. the stress present in aortic wall in the absence of blood pressure load). One possibility for accounting for residual stress is assuming that Fung's uniform stress hypothesis is applicable to aneurysms. Inclusion of residual stress significantly alters the computed wall stress distributions and maximum values suggesting that published results neglecting the presence of residual stress may be invalid.

As so much research effort is invested in the stress analysis of aneurysms it is perhaps worth asking whether stress distributions correlate with clinically observed symptoms. Our results, obtained in collaboration with the University Hospital Leuven, indicate that this is not the case, suggesting that the wall stress alone is of little diagnostic value. Therefore stress levels must be supplemented by additional biomechanical quantities so that biomechanical analysis could help distinguish between patients at low and high risk of rapid progression of AAA disease and rupture.

Professor Karol Miller

BIOGRAPHICAL NOTE

Karol Miller is a Winthrop Professor of Applied Mechanics at The University of Western Australia and a Visiting Professor of Radiology at Harvard Medical School.

Karol was born and educated in Warsaw, Poland. He has MSc in aerospace engineering, PhD in robotics and DSc in biomechanics.

In 2002 Karol established the Intelligent Systems for Medicine Laboratory. ISML's mission is to work towards improving clinical outcomes through development and appropriate use of technology. It runs exciting research projects funded by the Australian Research Council, the National Health and Medical Research Council (Australia), the National Institute of Health (USA) and other national and international agencies. The overall objective of his research is to help creating methods and tools which will enable a new exciting era of personalised medicine. He is best known for his work on biomechanics of the brain. He is the world's most cited researcher in this area.

Karol's research and teaching have been recognised by multiple awards, including the Humboldt Research Award, NVIDIA GPU Computing Champion Award, the Simulation Industry Association Australia Award, the Sir Charles Julius Medal, the Polish Prime Minister Award, the UWA Faculty of Engineering Computing and Mathematics Teaching Award and the UWA Student Guild Choice Award.

Karol has been a member of National Health and Medical Research Council panel for medical technology (Investigator and Ideas grants), Australian Research Council College of Experts and Australian Research Council Medical Research Advisory Panel.

He is also Associate Editor of International Journal for Numerical Methods in Biomedical Engineering. Until 2020 he had served as Associate Editor of Annals of Biomedical Engineering.