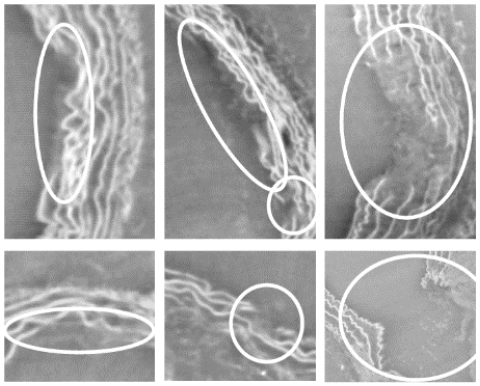
Propagation-based phase-contrast imaging of aortic dissection in mice: from individual elastic lamella to 3D analysis

Introduction

It is commonly accepted that aortic dissections originate from a tear in the intima followed by intramural layer separation. However, such an intimal tear is not always present on medical images and it is unknown to what extent side branches or vaso vasorum play a role in disease initiation [1]. These early events are very difficult to study since patient data is often lacking and incomplete. The use of pharmaceutically-induced mouse models allows for a controlled and fast induction of intimal and medial tears. Over the past 3 years, we have made use of synchrotron imaging to demonstrate that Angiotensin II (AngII) - infused ApoE^{-}/$^{-}$ mice, a popular model for aortic aneurysm, actually develop medial tears that progress into aortic dissections (AD) [2]. The aim of this work was to show the added value of propagation-based phase-contrast synchrotron imaging, with a resolution of 1.6 µm, in vascular pathology research. To that end we analyzed aortic medial ruptures in β-aminopropionitrile monofumarate (BAPN)/AngII-infused mice, a known mouse model for AD [3].

Methods

Aortic samples from n=10 BAPN/AngII-infused (for 3, 7 and 14 days) and n=3 control mice were scanned at X02DA (Tomcat) beamline of the Swiss Light Source in the Paul Scherrer Institute (Villigen, Switzerland). Phase propagation was performed at 25m source-to-sample distance, 25 cm sample-to-detector distance and at 21 keV. A scientific CMOS detector (pco.Edge 5.5) was used in combination with a 4x magnifying visible-light optics and a 20 µm thick scintillator. The effective pixel size was 1.625 x 1.625 µm^2.



Results

The figure shows representative images of ascending (top) and abdominal aorta (bottom) of day 3 (left), day 7 (middle) and day 14 (right) in BAPN/AngII-infused mice. A steep increase in the number of ruptures was already noted after 3 days. Medial ruptures through all lamellar layers, leading to false channel formation, occurred only in the thoraco-abdominal aorta and interlamellar hematoma formation in the ascending aorta could be directly related to ruptures of the innermost lamellae.

Conclusion

The advantages of this technique are (i) ultra-high resolution that allows visualization of individual elastic lamellae; (ii) quantitative and qualitative analysis of medial ruptures; (iii) 3D-analysis of the complete aorta; (iv) high contrast for qualitative information extraction; (v) earlier detection of (micro-) ruptures.

References

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3. Kurihara, T. *et al.* Neutrophil-Derived Matrix Metalloproteinase 9 Triggers Acute Aortic Dissection. *Circulation* **126,** 3070–3080 (2012).