

---

# Biaxial biomechanical properties of ex vivo perfused human thoracic aortas with and without stents

Masoud Yusefi\*<sup>1</sup>, Emmanouil Agrafiotis<sup>1,2</sup>, Heinrich Mächler<sup>3</sup>, Gerhard Sommer<sup>1</sup>, and Gerhard A. Holzapfel<sup>†1,4</sup>

<sup>1</sup>Institute of Biomechanics, Graz University of Technology – Austria

<sup>2</sup>Department of Biomedical Engineering, University of Michigan, Ann Arbor, MI – United States

<sup>3</sup>Department of Cardiac Surgery, Medical University of Graz – Austria

<sup>4</sup>Department of Structural Engineering, NTNU, Trondheim – Norway

## Abstract

Patient-specific modeling of endovascular repair is critical to improve clinical decision-making and allow improved surgical outcomes (1,2). Reliable simulations require an accurate representation of arterial material properties, particularly in areas affected by medical interventions such as stent placement. This study examines the immediate mechanical changes in the thoracic aorta after stent deployment, focusing on the altered mechanical properties near the stent struts.

Twelve non-diseased thoracic aortas (age 38–81 years, 4 females and 8 males, mean age  $62.6 \pm 11.7$  years) were obtained from Austrian donors via the Diagnostic and Research Institute of Pathology at the Medical University of Graz. Exclusion of obese donors minimized the variability associated with obesity. The Ethics Committee of the Medical University of Graz approved the use of human aortic specimens (32-451 ex19/20).

To reproduce the in vivo loading conditions of the aortic wall during TEVAR, a customized mock circulatory loop (MCL) that can simulate the human circulatory system was used (3). Before stenting, aortic specimens were subjected to preconditioning to ensure a repeatable mechanical response. TEVAR was then performed using a polyester thoracic stent graft (E-vita Thoracic 3G, JOTEC, Hechingen, Germany). After the intervention, the aorta was reattached to the MCL and perfused for eight hours to simulate continuous physiological loading. The aorta was then cut longitudinally and the stent graft was removed.

For the planar biaxial extension test, over 170 square tissue samples ( $10 \times 10$  mm) were prepared from areas with and without stents, avoiding regions with atherosclerosis and branching vessels. Tissue mechanics was captured using a biaxial tensile testing device in a PBS bath at  $37^\circ\text{C}$ . A stretch-controlled protocol with increments of 0.05 to rupture was used. Different stretch ratios between the longitudinal and circumferential directions (1:1, 1:0.75, 0.75:1, 1:0.5, 0.5:1) were used. At each stretch level, samples were subjected to four preconditioning cycles to achieve a consistent response, with the fifth cycle serving as the actual measurement.

We used the model proposed in (4), which included the contributions of the ground substance and symmetrically arranged collagen fiber families with non-symmetric dispersion

---

\*Speaker

†Corresponding author: holzapfel@tugraz.at

The model accurately represented both stented and unstented samples, showing significant mechanical differences between them and highlighting the localized effect of stent placement on the artery wall. These findings improve our understanding of the biomechanical behavior of stented arteries and contribute to more accurate patient-specific models that may support better clinical decision making.