Interaction of biomechanics with extracellular matrix components in abdominal aortic aneurysm wall

Objective: Little is known about interactions of extracellular matrix (ECM) proteins with acting mechanical conditions and material macroscopic properties in abdominal aortic aneurysm (AAA). We investigated ECM components in correlation to corresponding biomechanical properties and loads in aneurysmatic arterial wall tissue.

Methods: 54 tissue samples from 31 AAA patients (30; max. diameter Dmax 5.98±1.42 cm) were excised from the aneurysm sack. Samples were divided for corresponding immunohistological and mechanical analyses. Collagen I and III, total collagen, elastin, and proteoglycans were quantified by computational image analyses of histological staining. Pre-surgical CT-data were used for 3D-segmentation of AAA and calculation of mechanical conditions by advanced finite element analysis. AAA wall stiffness and strength were assessed by repeated cyclic sinusoidal and destructive tensile testings. Results: Amounts of collagen I, III and total collagen were increased with higher local wall stress (P=0.002, 0.017, 0.030, respectively) and strain (P=0.002, 0.012, 0.020,
respectively) AAA wall failure tension exhibited positive correlation with collagen I, total collagen and proteoglycans (P=0.037, 0.038, 0.022, respectively). α-stiffness correlated with collagen I, III and total collagen (P=0.011, 0.038 and 0.008), while β-stiffness correlated only with proteoglycans (P=0.028). In contrast, increased thrombus thickness was associated with decreased collagen I, III and total collagen (P=0.003, 0.020, 0.015, respectively), and AAA diameter was negatively associated with elastin (P=0.006). Conclusions: Our results indicate that in AAA increased locally acting biomechanical conditions (stress and strain) involve increased synthesis of collagen and proteoglycans with increased failure tension. These findings confirm the presence of adaptive biological processes to maintain the mechanical stability of AAA wall.

Stichworte: AAA, biomechanics, collagen, elastin, ECM, proteoglycans

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