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Biomechanical properties of postnatal porcine heart valves

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Objectives:

The biomechanical properties of heart valve leaflets during postnatal ontogenesis are essential for rational design of tissue engineered heart valves for pediatric patients. Here, we report postnatal changes of biomechanical properties of porcine mitral heart valves leaflets.

Method:

16 mitral heart valves leaflets (MVL) from pigs of different age groups (group A - 10 gays, group B - 1 month, Group C - 3 months and Group D - adult animals) have been analysed biomechanically (uniaxial tensile test in circumferential direction), histologically (H&E), histochemically (Movat staining and Picrosirius Red staining, Hsp47 mab) and morphometrically (valve leaflet thickness and cell density).

Results:

The mechanical properties of porcine MVL change gradually during postnatal development. Maximal stress of porcine MVL increases with age (A – 1.49 $\pm$ 0.38 MPa; B – 2.32 $\pm$ 0.42 MPa; C –2.9 $\pm$ 0.11 MPa; D – 6.38 $\pm$ 0.57 MPa). Maximal strain of MVL decreases with age. Modulus of elasticity of MVL significantly increases with age (A – 5.49 $\pm$ 0.72 MPa; B – 11.25 $\pm$ 0.21 MPa; C – 12.82 $\pm$ 0.51 MPa; D – 31.72 $\pm$ 1.83 MPa). These biomechanical changes are associated with significant postnatal accumulation of extracellular matrix, collagen and elastin synthesis.

Conclusions:

The porcine mitral heart valves during postnatal period gradually became stiffer and acquired typical for mature valvular tissue non-linear stress-strain behaviour. Reported biomechanical properties of normal porcine heart valves during postnatal development and understanding structural determinants of valvular tissue maturation process provide an important insight for heart valve tissue engineering.