Mechanical properties of passive rat cardiac trabeculae.

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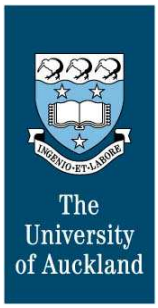

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Abstract

In this thesis, the mechanical properties of quiescent, intact, viable, rat right-ventricular (RV) trabeculae were investigated. The main objective was to determine if strain-softening, which is commonly reported during the deformation of passive cardiac tissue, is present in viable trabeculae. Strain-softening is typically manifested by a stiffer force-extension relation in the first deformation cycle relative to subsequent cycles, and is distinguished from viscoelasticity by a lack of recovery of stiffness, even after several hours of rest. The causes of this behaviour are unknown.

To investigate whether strain-softening is observed during uniaxial extensions of viable cardiac tissue, stretch and release cycles of 5%, 10% and 15% muscle length were applied at a constant velocity to trabeculae mounted in a mechanical rig. The rig was custom-built for the purpose. Muscles at 26°C and 0.5 mM Ca^{2+} were tested in random order in the presence and absence of 50 mM 2,3-butanedione monoxime (BDM).

Strain-softening was not observed in viable trabeculae undergoing physiologically relevant extensions, either in the presence or absence of BDM. However, strain-softening was readily apparent in non-viable trabeculae undergoing the same levels of extension, whether in the presence or absence of BDM. BDM had no effect on passive compliance of viable specimens, while its presence partially inhibited, but could not prevent, stiffening of the non-viable specimens. Loss of viability was accompanied by a uniform increase of dynamic stiffness. The presence of strain-softening during length extensions of non-viable tissue, resulted in a uniform decrease of dynamic stiffness. It is

therefore concluded that strain-softening is neither intrinsic to viable rat RV trabeculae nor influenced by BDM but, rather, reflects irreversible damage of tissue in partial, or full, rigor.

The addition of BDM was found to alter the dynamic stiffness and phase measured in intact viable quiescent trabeculae. In the absence of BDM, these alterations were calcium- and temperature-sensitive, whereas in the presence of BDM they were not. Therefore, the BDM-induced alteration of the dynamic stiffness and phase is attributed to the inhibition of spontaneous sarcomere activity.

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Table of Contents

List of Figures

List of Tables

List of Abbreviations and Symbols

°C	Degrees Celsius
ADP	Adenosine diphosphate
ATP	Adenosine triphosphate
AV	Atrioventricular
Ba^{2+}	Barium ion.
BDM	2,3-Butanedione monoxime
Ca^{2+}	Calcium ion
$[Ca^{2+}]_i$	Intercellular calcium concentration
$[Ca^{2+}]_o$	Extracellular calcium concentrations
CICR	Calcium Induced Calcium Release
D/A	Digital to Analogue conversion
FEM	Finite element modelling
F	Frequency (Hz)
f_{min}	Frequency at which muscle stiffness is a minimum.
Hz	Hertz
IndexXB	Index of cross-bridge cycling.
k_{100}	Stiffness at 100 Hz
k_∞	High frequency stiffness
LAD	Left anterior descending coronary artery
LAL	Left atrial ligation
N/m	Newtons per meter, or Pascals.
min	Minutes
ML	Muscle length
mM	milli molar
pHi	Intracellular pH.
PI	Physik Instrumente linear actuator
P_i	Inorganic phosphate.
PRBN	Pseudo random binary noise
RV	Right Ventricular
s	Seconds
SL	Sarcomere length
SNR	Signal to Noise Ratio
TnC	Troponin C
TnI	Troponin I
TnT	Troponin T