Acta Mechanica Slovaca 16(2): 74 - 76, 2012

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Article information
Article history: AMS-Volume16-No.2-00146-12
Received 6 February 2012
Accepted 15 March 2012

Mechanical Properties of Thoracic and Abdominal Arteries of Sheep

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KEY WORDS
Mechanical testing, biomaterials, mechanical properties of soft tissues.

ABSTRACT
An accretion dalliance is accorded by biotechnology, in general, and biomaterials, in particular, in determining the mechanical properties of different biological tissues comprising or composing the living creatures' bodies. Their microscopic and macroscopic structures are complex and mechanical tests can be of a major in studying their mechanical properties [1] [2] [3].
During operation, any blood circulation system is subject to an alternating blood pressure and the constituent organs behave differently. Amongst the rudimentary mechanical tests to characterize thoracic and abdominal arteries, and soft tissues as well - vital components of the blood circulatory system – we find the traction test.
This work focuses on the characterization of thoracic and abdominal arteries, located on the same trunk of a sheep, precisely determining Young's modulus, elasticity constraints, and deformations and break strain.

1. Introduction

Any soft tissues' pathologies are usually accompanied by an alteration in their mechanical properties [2] [3]. Mechanical properties of the arterial wall ensue from its characteristics of elasticity and contractility. These two factors are tightly correlated to the organization and the state of degeneration of cells and macromolecules that compose the vascular tissue [4] [5].

Due to the fact that tissue pathologies give raise to localized changes in the mechanical properties of the affected tissue, the alteration arterial wall's mechanical properties can be regarded as a parameter for the characterization of vascular tissue. This is what happens in atherosclerotic lesions cases, where the arterial wall thickens and loses its elasticity.

Knowing the mechanical properties of blood vessels has been, for long lasting, recognized as a chief aspect of understanding the cardiovascular system behavior. In 1808, Thomas Young described a relationship between the elasticity of blood vessels and circulatory hemodynamic.

Grand part of Young's researches are based on the nature of the elasticity and[3], in particular, the relationship between the elastic properties of arteries and the arterial wave propagation speed. His work on the elasticity nature led to the development of elasticity modulus concept that bears his name, however.

The elastic behavior of the arterial wall plays an important role in determining the speed of the pressure wave propagation. The benefit of mechanical tests is to identify the mechanical properties and characteristics of any material in such a fashion, diseases and issues like deformation, rupture and sudden swelling of the artery are averted.

2. Testing Methodology

The tensile (traction) test can precisely determine the targeted mechanical properties: Young's modulus E, the elastic limit σélast and breaking stress σr. To accomplish that, deformation and strain curves must be drawn. Deformation (Strain) measurements will be carried out by means of extensometer which comprises two blades where the gap between them constitutes the basis of measurement (useful length L).

Tensile tests on biological tissue will be made in a in-vitro way (inactive tissue) [6] [7] [8]. Three samples of a sheep thoracic artery will enable us to carry out three tests.

3. Test Conditions

-Room temperature (ambient temperature): 20°C
-Constant Test speed: 100 mm / min
-Zero clamp slippage.
-Sample specimen-artery tissue from a sheep, shape and dimensions are shown below.

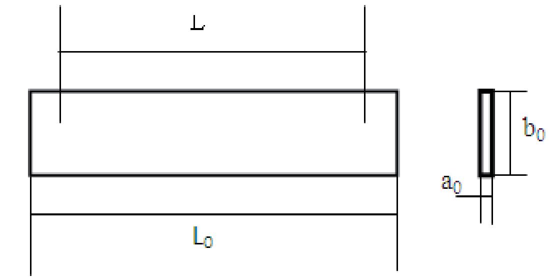

Fig. 1: *Physical mode.*

Effective specimen length L_0 = 100mm
Length between the jaws L = 80mm
Width b_0 = 20mm
Thickness of the specimen a_0 = 1mm
- Machine and features: brand ZWICK 1120, "power of 2.5 KN, jaws maximum displacement 1140 mm, displacement speed 100 mm / min.
- Software used: Test Expert Version 1.9

Table 1: *Mechanical properties obtained.*

N□ testing	a_0 Mm	b_0 mm	E N/mm^2	σ_{elast} N/mm^2	σ_{max} N/mm^2	ε_{max} %	ε_c %	σ_c N/mm^2	σ_r N/mm^2
1	1	20	1.22	0.125	0.76	68.41	118.08	0.054	6.43
2	1	20	1.31	0.130	0.84	71.15	122.80	0.060	7.428
3	1	20	1.28	0.127	0.81	69.78	120.44	0.060	7.2864

Table 2: *Mechanical properties obtained.*

	E (N/mm^2)	σ_{elast} (N/mm^2)	σ_{max} (N/mm^2)
average	1.27	0.12733	0.8033
Variance	0.0021	0.0000063	0.00958
standard deviation	0.0458	0.00251	0.09787

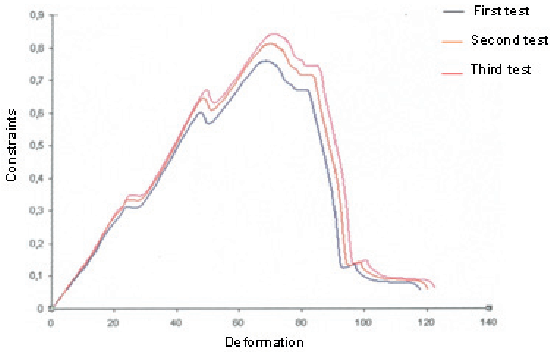

Fig. 2: *Stress-strain curves.*

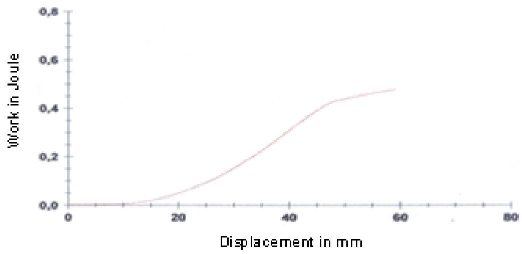

Fig. 3: *Working curve in Joule versus displacement.*

4. Concluding remarks

The shape of the obtained curve corresponds to the classic one of Euler. We perfectly can distinguish (discriminate) three parts: the elastic, almost straight, is characterized by stress and relatively low deformations, the curved section (portion) is featured by fairly high deformations and stresses , the third portion, as it is concerned, is characterized by an abrupt drop of effort corresponding to the maximum stress or tensile strength of the tissue.

The peaks and ranges of the curve imply a reorganization of the structure during the elongation process, because the tissue is made up of three layers (intima, media and adventitia).

The identified and measured features of the tests show that the stresses and deformations are low in the elastic region (ε <15%, up to 0127 N/mm^2 σ) and significant in the other two zones (up 71.15 ε % σ 0.803N/mm^2 up).

The dispersion (diffusion/ spread) found is rather significant, despite the short test. It is due to the nature of samples which are soft tissues with high contractility.

The activity (work) at the beginning of the displacement is almost nil, it begins to rise from a certain value, thence it finally stabilizes.

The deformation and the recorded activity on the sheep's artery show that the soft type tissue is a non-elastic material.

Nomenclature

L0: effective specimen Length
L: Length between jaws
b0: Width
a0: Thickness of the specimen
E: Young's Modulus
σ: Stress
σc: Conventional Stress
σr: Accurate Tensile stress
σelast: Elasticity stress
σ max: Maximum stress
ε: Deformation
εc: Conventional Deformation
ε max: Maximum deformation

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