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BIOMECHANICAL ANALYSIS OF "IN NATURA" SWINE PERICARDIUM COLLECTED IN TWO DIRECTIONS

(ANÁLISE BIOMECÂNICA DO PERICÁRDIO SUÍNO "IN NATURA" COLETADO EM DUAS DIREÇÕES)

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RESUMO

A utilização dos suínos como fonte de membranas biológicas para utilização em cirurgias humanas têm manifestado grande interesse há muitos anos, pois há muitas semelhanças anatômicas e fisiológicas. Esses materiais apresentam prós e contras referentes às capacidades de sustentação e reatividade no receptor e a busca por um modelo ideal é constante. Esta pesquisa tem como objetivo descrever a resistência biomecânica do pericárdio suíno fresco em duas direções diferentes de coleta, a perpendicular (PE) e a paralela (PA) ao maior eixo cardíaco. Vinte pericárdios suínos foram abertos da base até o ápice do coração e foram coletadas quatro amostras na direção PE e quatro na direção PA, e imediatamente levadas para análise biomecânica. A força máxima de ruptura (FMR) e o alongamento de ruptura (AR) na PE foi 18,78±5,62N e 4,89±3,45mm e na PA foi 18,94±6,19N e 3,23±0,84mm, respectivamente. O saco pericárdico suíno é menos elástico na direção PA e não houve diferença significativa entre a FMR das direções PE e PA.

Palavras-chave: anatomia, cirurgia, membrana biológica, resistência.

ABSTRACT

The swine is a source of biological membranes for human surgery and it has presented interest for many years, because of the anatomical and physiological similarities. This research aims to describe the fresh swine pericardium's biomechanical resistance in two different collection directions, the perpendicular (PE) and the parallel (PA) to the longest cardiac axis. Twenty swine pericardium were opened from the base to the heart's apex and four samples were collected PE, four in PA directions,

and immediately taken for biomechanical analysis. The maximal rupture force (MRF) and rupture elongation (RE) in the PE were 18.78±5.62N and 4.89±3.45mm and in the PA were 18.94±6.19N and 3.23±0.84mm, respectively. The swine pericardial sac is less elastic in the PA direction and there was no significant difference between the MRF of the PE and PA directions.
Key words: anatomy, surgery, biological membrane, resistance.

INTRODUCTION

The pericardium is a thin, fluid-filled sac, two-layer that covers the outer surface of the heart (KÖNIG & LIEBICH, 2016). It can be used as a biological membrane in surgeries and has been applied in Brazil since 1964 (PIGOSSI, 1964) through the use of glycerin-preserved canine dura mater in reconstructive surgeries. These membranes are easy to obtain, with low cost, simple preparation, viable sterilization, simple storage, little or no tissue reaction when used, and have a long period of viability as an implant (ALVARENGA, 1992, BRUN et al., 2002).

Bovine pericardium started to be used in 1972 as an adhesive for vascular and cardiac surgeries (PIRES et al., 1997). Its patches avoid the need to remove a vein, which can lead to difficult wound healing and pain (TEXAKALIDIS et al., 2018).

Research involving biological membranes, obtained from different animal species, seeks to evaluate surgical procedures' viability. Their main functions are to provide a framework for the orientation and development of new tissues, through repair processes, which restore the structure and function of the affected organ (BATISTA et al. 1996).

Biological implants can be classified into four types according to the donor-recipient relationship: autogenous, homogenous, isogenous, and xenogenous. By autogenous, it is understood that the recipient and donor are the same. In homogenous implants, the recipient and donor are of the same species but do not share histocompatibility antigens. Cases of isogeny occur when the donor and recipient have histocompatibility antigens, whereas implants classified as xenogenous occur when the recipient and the donor belong to different species (ALVARENGA, 1992).

Among the most used biological membranes is the bovine pericardium, which has as its main characteristic almost exclusively collagen constitution (ALVARENGA, 1992). Its use as a biological membrane is due to its ease of obtaining and the amount of usable tissue, which is adaptable to the different situations in which it is submitted in surgical practice (BASTOS et al. 2005; STELMANN et al. 2010; VIDOR et al. ., 2013).

Bovine biological membranes have been used in experimental studies both as homogenous and xenogeneic implants, showing satisfactory results. As an example, we describe the use of bovine pericardium preserved in glycerin as a reinforcement in the raffia of the peritoneum of a horse in the surgical treatment of eventration (STELMANN et al. 2010) and in the manufacture of human valve bioprostheses, as it results in a low incidence of thromboembolism in the absence of anticoagulants, being, for this reason, the most used natural biological membrane for this purpose (COSTA et al. 2005). The traction force supported by the following membranes from bovines, the tendon center of the diaphragm, parietal peritoneum, and pericardium, preserved in 98% glycerin, was evaluated compared with other tissues (GUIMARÃES et al., 2007). Another research showed that the direction of a collection of bovine pericardium influences its resistance and that it can be stored for 4 months in glycerin without losing its biomechanical characteristics (SOARES et al. 2021).

Pigs are superior to other species with respect to anatomical and physiological similarities to humans, such as heart size, cardiac output and blood pressure. Pigs are also fairly easy to handle and cause minor ethical problems (LI et al., 2007).

Biomechanical tests allow comparing fresh tissues with those subjected to conservation, generating information that contributes to the improvement of surgical techniques in the search for alternative biological material for animal experimentation (CAMARGO et al., 2014).

Currently, biomechanical analysis of animal tissues have been carried out with the aim of evaluating tissue resistance during processes of preservation and conservation of formaldehyde-free cadavers. The skin of cats (FRAÇÃO et al., 2019) and dogs (ROCHA et al., 2018) fixed only with alcoholic solution, as well as veins (PELÓGIA et al., 2018) and arteries (CERQUEIRA et al., 2017) of dogs were analyzed for resistance and elasticity. Furthermore, the resistance of the duodenum, jejunum, and colon of fresh dogs was also evaluated (QUEIROZ et al., 2019).

In the bovine pericardium, the collection in the perpendicular direction (PE) presented a tissue resistance 30% greater than the collection in the parallel direction (PA) (SOARES et al. 2021) to the cardiac axis. This project aimed to describe the biomechanical analysis of *in natura* swine pericardium collected in two directions, perpendicular and parallel to the main heart axis, for tissue resistance application in surgery.

MATERIALS E METHOD

Twenty swine pericardia, obtained from Frigorífico Frimel, located in Guariba, São Paulo, Brazil, were used.

The samples were collected immediately after slaughtering healthy swine, male or female. After collecting the membrane, cleaning was done with tap water. The excess blood and fat remaining in the pericardium were removed, followed by freezing and transportation in thermal bags to the Laboratory of Surgical Anatomy at UNESP Jaboticabal, São Paulo, approximately 100 km away.

The pericardium remained frozen for a week, then thawed in tap water, and those intact and with no apparent lesion were chosen. For the tissue collection, a 1x5 cm stainless steel rectangular mold was used with a scalpel to standardize samples (ALVARENGA, 1992).

Each pericardium was opened from the base to the heart's apex to maintain the anatomical reference of the longest axis of the heart. Four samples were collected perpendicularly to this axis and four in a parallel way (Figure 1). Identified flasks containing water were used to place the collected samples and immediately taken to biomechanical analysis. The methodology was developed by Soares et al. (2021) in bovine pericardium.

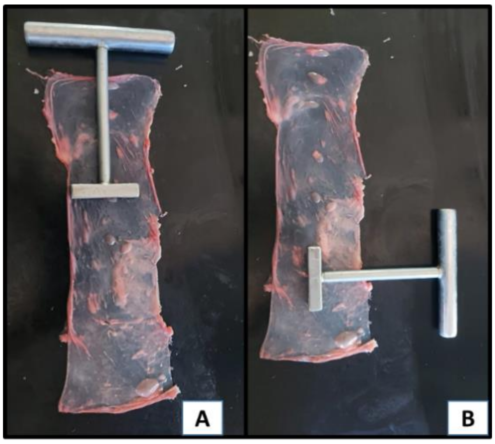

Figure 1. A- samples collect in the parallel direction and B in the perpendicular direction of the longest axis of the heart from swine pericardium.

For the biomechanical analysis an EMIC® Universal Testing Machine—model DL-2000, presented at the Surgical Anatomy Laboratory of the Department of Animal Morphology and Physiology of FCAV—UNESP—Jaboticabal was used. The load cell used was 500N; the load application speed was 100 mm/min, and the free space between the grips of the material was 20 mm.

RESULTS

The MRF and RE in the perpendicular direction (PE) were 18.78±5.62N and 4.89±3.45mm and in the parallel direction (PA) were 18.94±6.19N and 3.23±0.84mm, respectively. The Student's t-test demonstrated that the MRF did not present a significant difference ($p=0.9122$) between directions, while the RE did ($p=0.0195$). Therefore, swine pericardial tissue is less elastic in the parallel direction. Although there is no difference between PE and PA in the MRF.

DISCUSSION

Swine pericardium is a product that is simple to obtain at slaughterhouses and simple to store at laboratories or veterinary hospitals (ALVARENGA, 1992). Besides, the possible application in reconstructive surgeries is reasonable (BRUN, 2004).

The MRF and RE in the PE direction were 18.78N and 4.89mm and in the PA direction were 18.94N and 3.23mm, respectively. In bovine pericardium, the MRF and RE in the PE were 57.71N and 3.70mm, and in the parallel direction (PA) were 44N and 3.19mm (SOARES et al., 2021) may be due to collagen fibers direction.

Values were similar to the 19.98N that causes a rupture in dogs' external jugular veins (PELOGIA et al., 2018), and higher than the 25.77N in the common carotid arteries of fresh dogs (CERQUEIRA et al., 2017). They were much lower than the MRF of the cats' fresh skin (344.27N; QUEIROZ et al., 2022) or the dogs' fresh skin (125.9N; FERREIRA et al., 2021 or 75.53N; DEL PONTI et al. 2021), demonstrating a higher resistance and elasticity when comparing skin of dogs/cats and swine´s. The skin's flexibility and resistance are mainly dictated by the epidermis´ corneal layer, and the tensile strength of the skin is considered to be due to type I collagen fibers in the deeper layer of the dermis (BISMUTH et al. 2014).

In studies about biomechanics in the duodenum, jejunum, and colon of fresh dogs, the MRF and RE varied from 21.04 to 23.82N and 4.07 to 4.37, respectively (QUEIROZ et al., 2019). In the fresh duodenum of cats, values were 23.39N and 3.98mm (QUEIROZ et al., 2022). All of them were similar to the values of the analyzed pericardium, in both directions of collection.

Recent work on tissue biomechanics in animals has used frozen cadavers due to the difficulty of obtaining bodies immediately after death. This fact does not interfere with the resistance or elasticity of the samples, even when analyzed after thawing (QUEIROZ et al. 2019), 3 months (FRAÇÃO et al., 2019) or 4 months (CERQUEIRA et al., 2017; PELÓGIA et al. , 2018).

CONCLUSION

The swine pericardium sac is less elastic in the PA direction and there is no significant difference between the MRF of the PE and PA directions which infers to its appliance in reconstructive surgeries.

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