New approach to myocardial injury adaptations

A possible solution for one of the oldest problems in heart surgery

UNIVERSITÄTSMEDIZIN GÖTTINGEN UMG

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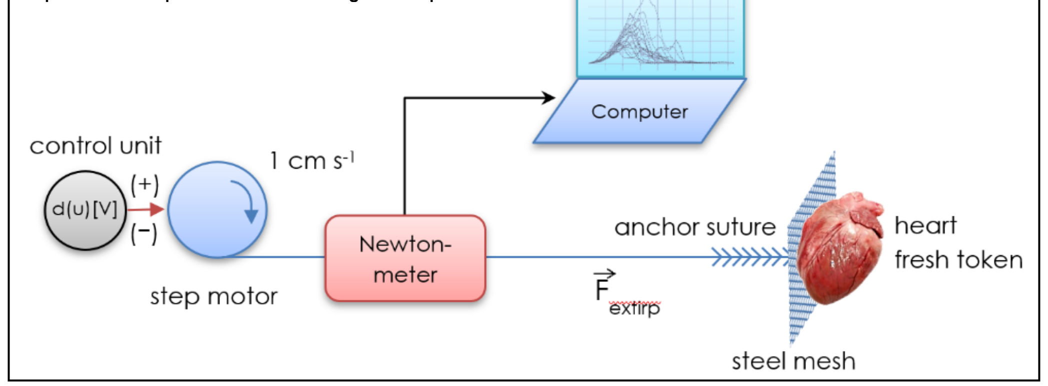
Objectives Since the beginning of cardiac surgery the issue of myocardial injury and its adaption yet remains unsolved. Myocardial lesions put the patient at severe risk. Myocardial suture can be successful – but there is a need for extracorporeal circulation support and the use of patches. Knotless anchor sutures maybe a solution. Our ambition is to establish a new suture device in cardiac surgery. Especially the preclinic worst case situations due to an injured beating heart need improvement by launching a new treatment method with a fast and safe suture system after outhouse Clamshell Thoracotomy. Therefore we created a pig heart wall tension model for bidirectional knotless anchor suturing.

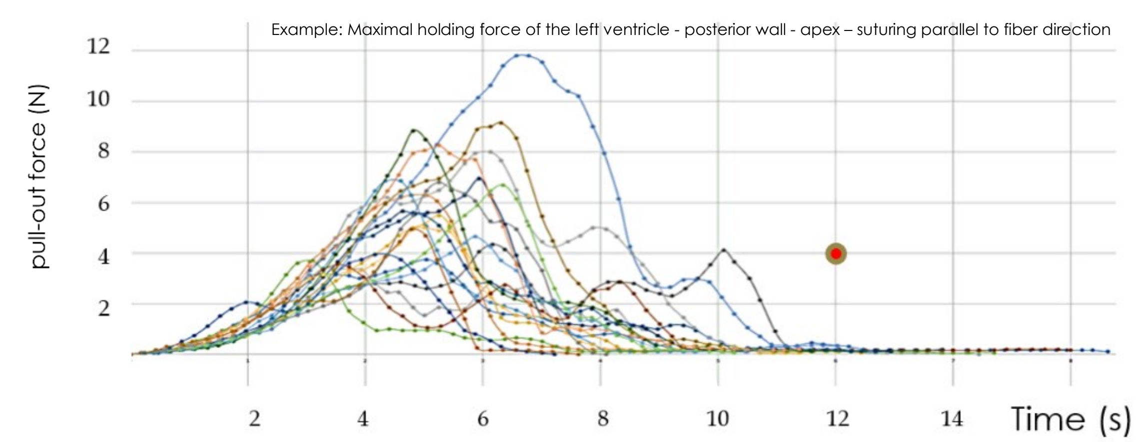
Methods - Maximal holding force The maximal holding force (N) of a commonly used knotless anchor suture (Stratafix® Johnson&Johnson, Norderstedt, D) to the myocardium (length: 3 cm) is gathered using a motor driven procedure on a high-resolution newton meter (SH100, D). 10 pig hearts were investigated for possible differences between fresh and thawed organs (up to 14 h). Different treatments groups were performed. The right (RV) and the left (LV) ventricle were individually treated. Myocardial injuries were placed in apical (A), midventricular (M) and basal (B) locations as well as in anterior and posterior heart wall. The direction of injury was parallel (FR) to the fiber direction or vertical (AFR). Additionally, the tearing strength (N) of 20 pig hearts was collected apical parallelly and vertically to the myocardial fibres right after the hearts' explantation and after the defrosting time was over. The setting was the same used for the experiments on the maximal holding force. A p-value ≤ 0.05 is set for statistical significance.

Experimental setup of the Maximal Holding Force Experiment

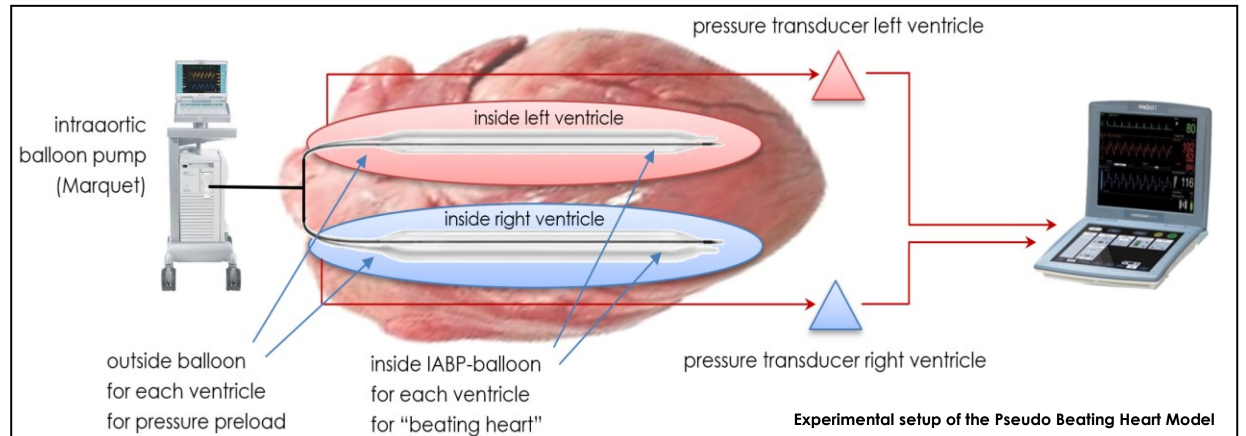


Methods - Simulation Model To simulate wall tension, heart pressure and pump effort, a "pseudo beating heart model" was developed using a double ballon model for each ventricle. Inside the outer balloon is a air driven balloon. The outer balloon adjust the preload: LV 140 ±10 mmHg, RV 60 ±10 mmHg, 80 beats per minute (BPM). 20 ex vivo defrosted pig hearts were analysed. After beating simulation of 60 minutes, myocardial injuries were placed and 4 cuts were made (length: 1 cm). The margins of the wounds were adapted using the bidirectional knotless anchor suture. For every cut, two suture systems were utilised. After that the beating simulation was continued. The compliance of the suture systems was videotaped for another 60 minutes.

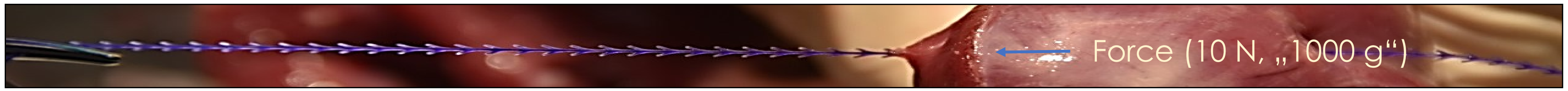
https://www.youtube.com/watch?v=nXCAi_4Bp_w&feature=youtu.be



Results
The myocardial tearing strength is significantly different for each defined myocardial tissue part. The basal area (7.16 N) reveals the highest holding force in comparison to the midventricular section (6.53 N; p = 0.03) and the heart apex area (6.38 N; p = 0.003). Further there are force varieties between the right (7.01 N) and the left (6.39 N) ventricle (p = 0.0049). There was no difference between the anterior (6.83 N) and the posterior (6.56 N) wall (p = 0.75). A precise distinction has to be made between suturing parallelly (6.9 N) or vertically (6.5 N) to the fibres (p = 0.03). With the pseudo beating heart model an easily repeatable wall tension model was established. The ventricular pressures are stable as well as the intracavitary pressures are. The constructed suture devices work partly depending on the myocardial wall thickness and the fibre directions. (Figg. 1-4)



Experimental setup of the Pseudo Beating Heart Model



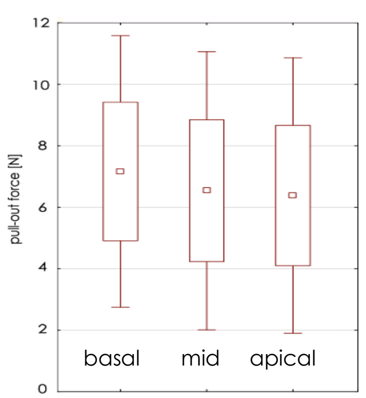


Fig. 1 Box-Whisker-Plot: maximal pullout force varieties of different myocardial sections (p > 0.05)

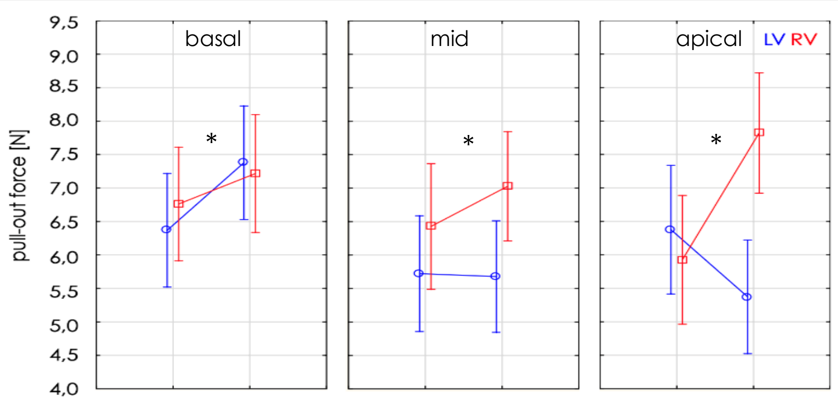


Fig. 2 Suturing vertically to myocardial fiber direction, comparing ventricle different heart locations (basal, mid, apocal); left: left ventricle - right ventricle; anterior wall - posterior wall

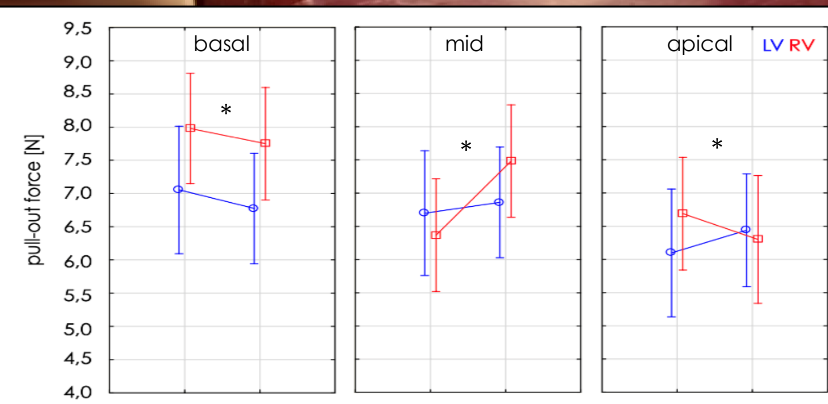


Fig. 3 Suturing parallel to myocardial fiber direction, comparing ventricle different heart locations (basal, middle, apocal); left: left ventricle - right ventricle; anterior wall - posterior wall

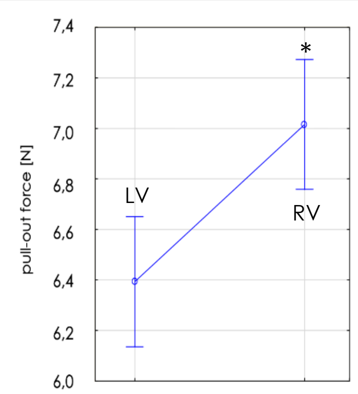
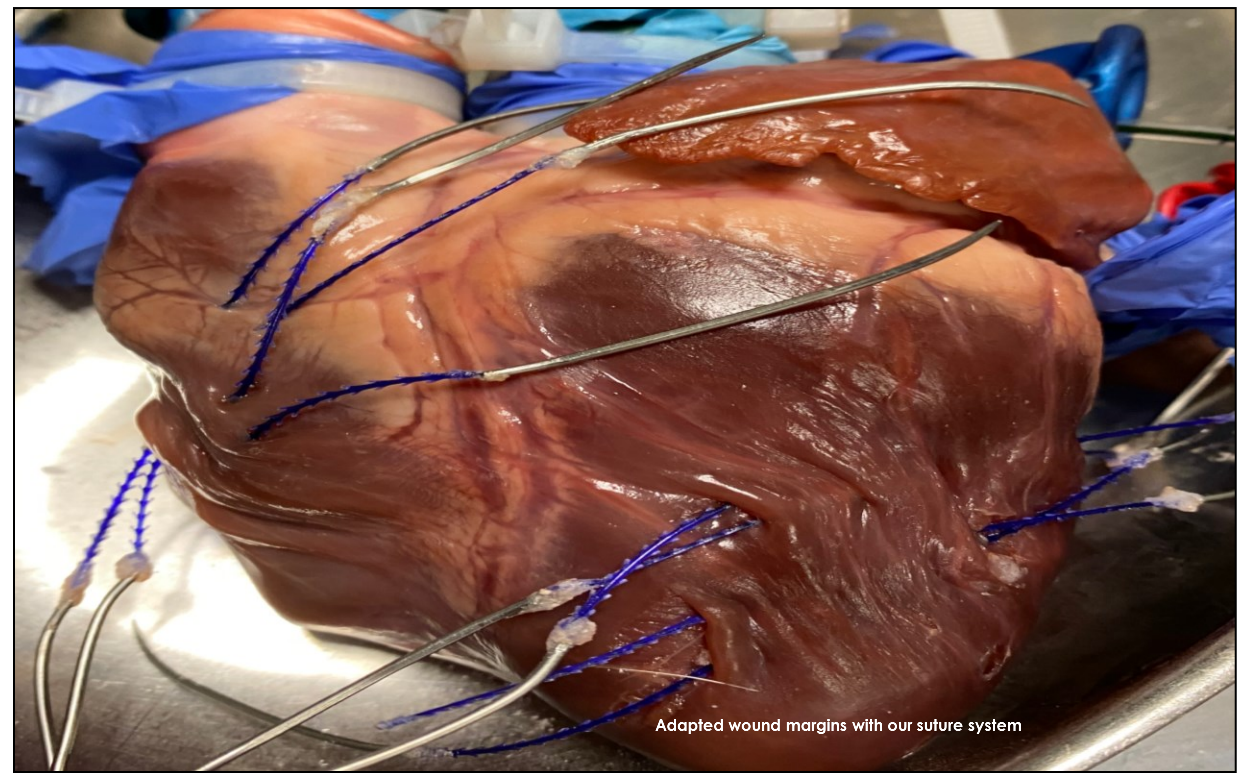


Fig. 4 Pull out force is significant different between ventricle sides (p = 0,0049).

Conclusion This suture system is effective. Regardless, certain geometric improvements concerning the anchor distribution and the anchor surface need to be made. In addition, the Pseudo Beating Heart Model proved to be a reliable and less elaborate simulation model for the heart's pressure und pump effort. For other research projects our model can be applied. In vivo pig experiments are believed to start soon after incorporating those new advancements.



Adapted wound margins with our suture system