

BACE™ in Experimental Animals

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ABSTRACT

Effective epicardial treatment of functional mitral regurgitation with BACE™ in experimental animals

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Background:

Functional mitral regurgitation (MR) is primarily due to abnormalities of the ventricular muscle in the presence of normal mitral leaflets. Present surgical treatment options address the mitral valve annulus and leaflets, and not the ventricular muscle.

Methods:

Functional mitral regurgitation was induced in seven sheep with rapid ventricular pacing over a period of 6 to 14 weeks. BACE (Basal Annuloplasty of the Cardia Externally) was performed with a customized silicone device, which was applied epicardially without the use of cardiopulmonary bypass. The device was implanted circumferentially at the level of the atrioventricular groove, while overlapping the subannular ventricular muscle. The device was then adjusted by inflating one to four chambers that subtended the mitral annulus, remotely through silicone tubing connected to subcutaneous ports: this dynamically reduced MR under echocardiographic guidance. Once MR was effectively reduced, the chest was closed and the animals recovered.

The animals were followed up clinically and echocardiographically.

Results:

All sheep developed severe MR on a combination of echocardiographic parameters after 6 to 14 weeks of pacing with a mean mitral annular diameter of 5.03 ± 0.47 cm. Epicardial application of the BACE device effectively reduced from Grade 4 to 0 (measured by a combination of jet penetration, PISA, Continuous Wave jet intensity, left atrial size) and reduced mitral annular diameter to 4.18 ± 0.46 cm ($p < 0.01$ by paired t test). This effect was sustained at one and three months post-operatively, despite ongoing pacing and a slight increase in mitral valve annular diameter to 4.48 ± 0.45 cm. Terminal studies showed no adhesion to the silicone band.

Conclusions:

Epicardial application of the BACE device along with its adjustment can be performed safely without the use of cardiopulmonary bypass with effective reduction in MR. The device does not form significant adhesions, allowing ease of explant.

OBJECTIVES

Mitral valve repair or replacement generally involves open-chest, open-heart surgery. A new, less invasive technique has been developed. The Basal Annuloplasty of the Cardia Externally (BACE™) device is simple to position around the base of the heart and eventually will be deployed through a minimally invasive procedure. Thrombus formation on an inadequately healed annuloplasty ring can be a potential source of thromboembolism, as could loose sutures and threads. However, this concern does not apply to the BACE device, as it is placed outside the heart, also eliminating the requirement for post-operative anticoagulant therapy, as well as the potential for valvular stenosis, a complication associated with annuloplasty rings.

The BACE device employs integral small silicone chambers that can be filled with saline to tailor the pressure exerted by the device to each individual patient's heart (Figure 1).

The purpose of this study was to assess whether the BACE device is effective to repair mitral valve regurgitation.

Figure 1. The Mardil BACE device



Figure 2. The BACE device implanted around the heart



METHODS

Nine animals were enrolled in the study. A pacemaker (VVI) was implanted in the right ventricle through the external jugular vein. The pacemaker was set with 180 beats per minute and the animals were followed with echocardiogram to assess whether mitral regurgitation exists. When mitral regurgitation was identified, the animal underwent BACE implantation. The device was implanted circumferentially at the level of the atrioventricular groove through left thoracotomy without cardiopulmonary bypass (Figure 2). The device was then adjusted by inflating one to four chambers that subtended the mitral annulus, remotely through silicone tubing connected to subcutaneous ports: this dynamically reduced MR under echocardiographic guidance. Once MR was effectively reduced, the chest was closed and the animals recovered. The animals were followed up for three months after the BACE implantation with continuous rapid pacing and echocardiogram was performed one, and three months after the implantation.

RESULTS

- All nine sheep developed severe MR on a combination of echocardiographic parameters after 6 to 14 weeks of pacing with a mean mitral annular diameter of 5.03 ± 0.47 cm.
- Two animals died during sedation for the BACE implantation. One animal died during recovery after the BACE implantation. One animal died 3 days after the implantation due to stomach ulcer and peritonitis. Five animals survived implants and showed no negative effects that could be attributed to the BACE implant during the entire follow-up period.
- Epicardial application of the BACE device effectively reduced from MR Grade 4 to 0 (measured by a combination of jet penetration, PISA, Continuous Wave jet intensity, left atrial size) and reduced mitral annular diameter to 4.18 ± 0.46 cm ($p < 0.01$ by paired t test).
- MR Grade 0 was sustained at one and three months post-operatively, despite ongoing pacing and a slight increase in mitral valve annular diameter to 4.48 ± 0.57 cm (Figure 3).
- Furthermore, cardiac function, EF and %FS, improved during the follow-up despite ongoing rapid pacing (Figures 4 & 5).
- Necropsy showed that the BACE device was encapsulated with thin fibrocellular tissue and did not form significant adhesions (Figure 6).

CONCLUSION

Epicardial application of the BACE device along with its adjustment can be performed safely without the use of cardiopulmonary bypass with effective reduction in MR. Furthermore, this study suggests that the BACE device has the ability to improve cardiac dysfunction, by effecting the ventricular component of MR. There was little reaction to the device at explant.

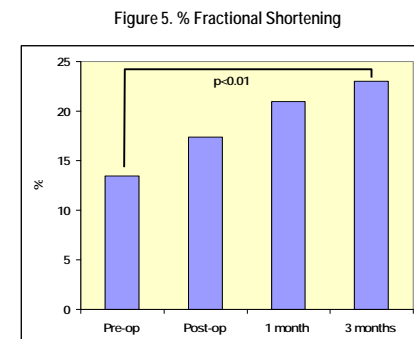
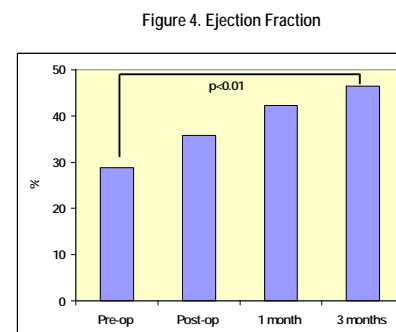
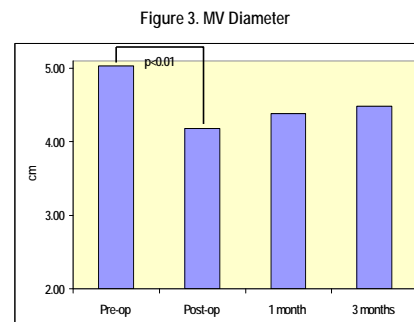


Figure 6. Necropsy Photograph

