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Prognostic impact of leaflet-to-annulus index in patients treated with transapical off-pump echo-guided mitral valve repair with neochord implantation

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*This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

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made the analysis and interpretation of data, (2) AC drafted the article, All authors revised it critically for important intellectual content, All authors approved final version to be submitted.

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Abstract

Background: The transapical echo-guided NeoChord repair is a procedure to correct mitral regurgitation (MR) without the need for concomitant annuloplasty for degenerative mitral valve (MV) disease. Lacking strict criteria to define normal annular dimensions for patients undergoing MV repair, we consequently miss to have precise selection criteria to identify patients who can benefit from a ringless procedure respect to whom would need a combined annular and leaflet repair. Aim of this study is to identify whether a new preoperative echocardiographic index may predict postoperative outcomes after Neochord repair.

Methods: All consecutive patients with posterior leaflet disease who underwent Neochord repair between November 2013 and January 2016 presenting complete postoperative echocardiographic assessment up to 1-year were included. Leaflet-to-Annulus Index (LAI) was defined as the ratio between the sum of anterior leaflet length (AML) and posterior leaflet length (PML) over antero-posterior length (AP; $AML+PML/AP$). Measurements were performed with 2Dtransesophageal echocardiography.

Results: Sixty-six patients were enrolled. At 1-year MR was absent in (24) 38% of patients, mild in (28) 44%, moderate in (10) 16% and severe in (1) 2%. Logistic regression analysis identified LAI as positive prognostic predictor of MR \leq mild for values greater of 1.35 at 3-months, 1.30 at 6-months and 1.25 at 1-year. At 30-day the LAI was not associated with the grade of residual MR.

Conclusions: The LAI is a positive postoperative predictor of MR \leq mild at 1-year follow-up and can be used to identify patients who could benefit from a ringless NeoChord repair procedure for the absence of a leaflet-to-annulus mismatch.

Introduction

Mitral valve repair (MV) is the preferred surgical treatment for severe degenerative mitral regurgitation (DMR) due to leaflet prolapse or flail. It is generally performed with the combination of leaflet repair together with ring annuloplasty. Despite its widespread use, there are new evidences showing that an annuloplasty could not be always mandatory if the degenerative MV pathology is treated an early phase of the disease when there is no annular or ventricular involvement (1).

Following this observation, recently the transapical echo guided NeoChord repair has been presented as a new, safe and effective procedure to correct MR without the need for concomitant annuloplasty (2-6).

Lacking strict criteria to define normal and dilated annular dimensions for patients undergoing MV repair surgery, we consequently miss to have precise selections criteria to identify patients who can benefit from a ringless procedure respect to whom would need an additional annuloplasty ring implantation together with leaflet repair. The aim of this study is to identify whether a new preoperative echocardiographic index may predict postoperative outcomes after Neochord repair.

Methods

All consecutive patients with posterior leaflet disease mainly affecting the central P2 segment of the MV who underwent Neochord repair between November 2013 and November 2015 presenting complete postoperative echocardiographic assessment up to 12 months were included. Leaflet-to-Annulus Index (LAI) was defined as the ratio between the sum of anterior leaflet length (AML) and posterior leaflet length (PML) over antero-posterior length (AP; $AML+PML/AP$). Measurements were performed on 2D transesophageal echocardiography images always after having recognized an appropriate A2 and P2 segments using the simultaneous 3D MV reconstruction performed with a dedicated software (4D MV-Assessment TomTec Imaging Systems GmbH, Munich, Germany) (9). The preprocedural echocardiographic analysis were performed by a blinded investigator using anonymized images.

The AL, PL and AP measurements were performed based on TEE images in mid-systole (mid-esophageal at 135° view) for more precise identifications of MV margins respect to a mid-diastole phase. The AL, PL and AP measurements of the MV were performed point-by-point using 2D images (Figure 1).

MR severity was graded as absent/trace, mild, moderate, or severe based on a combination of semiquantitative and quantitative parameters (11) by an independent Core Lab.

The primary endpoint was defined as the LAI's association to MR grade \leq mild (absent and mild) at each follow-up (30 days, 1 month, 3 months, 6 months and 1 year). Patients were enrolled in the single center experience TACT Registry (ClinicalTrial.gov number NCT01777815). Informed consent was obtained from each patient and the study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected by the institution's human research committee approval.

Descriptive statistics for baseline patient characteristics, pre-operative and post-operative echocardiographic data have been produced using median (I-III quartile) for continuous variables and percentage for categorical variables. The effects of pre-operative echocardiographic data on grade of MR at 1-year follow-up were evaluated using logistic regressions and introducing, when it was possible, opportune propensity scoring covariate including left ventricle end diastolic volume [iLVEDV], left ventricle ejection fraction [LVEF], left atrial volume indexed [iLAV] and systolic pulmonary artery pressure [sPAP] and age variables as confounders. The analyses were performed using the RMS and CBPS libraries (12, 13) and the R System (14). The thresholds on LAI index were identified selecting values corresponding to an estimated Inverse Odds Ratio (IOR) greater or equal to 2, because it has been considered to indicate a causal relationship between variables and outcome as reported by Des Jardins et al (15).

Results

Sixty-seven patients were studied. Median age was 71 years (59-78), median EuroSCORE II was 1.51% (0.69-2.5%) and median STS-PROM was 1.11% (0.52-1.96%). All patients presented PML disease and the majority of patients were in NYHA functional class III or IV (64%). Transapical Neochord procedure was concluded

successfully in all patients. We did not observe intraoperative deaths or conversion to traditional surgery. Two patients with very high surgical risk score died within 30 days. No additional deaths were observed. Two other patients required MV replacement for recurrence of severe MR, at three months. At discharge, no MR was present in 22 patients (34%), mild MR in 38 patients (58%) and moderate MR in 5 patients (8%). At 30 postoperative days, no MR was observed in 33 patients (51%), mild MR in 25 patients (38%), moderate MR in 5 patients (8%) and severe MR in 2 patients (3%). Sixty-three patients reached 3 postoperative months, of those 33 patients (52%) presented no MR, 23 patients (37%) presented mild MR, 7 patients (11%) presented moderate MR. At 6 postoperative months, no MR was present in 27 (43%) patients, mild in 26 (41%) and moderate in 10 (16%). At 1 year FU no MR was observed in 24 (38%) patients, mild in 28 (44%) patients, moderate in 10 (16%) patients and severe in one patient (2%). No patients presented NYHA functional class III or IV at each FU.

Analysis of the association between LAI levels as a prognostic factor and MR (\leq mild vs $>$ mild) as outcome was positive with an IOR greater of 1.35 at 3-months, 1.30 at 6-months and 1.25 at 1-year. At 30-day the LAI was not associated with the grade of residual MR (Figure 2).

Discussion

The result of this study shows that the LAI is a positive postoperative predictor of MR \leq mild at 1-year follow-up with a cut-off value of 1.25. The LAI identifies the quantity of overlapping leaflet tissue that will represent the potential coaptation surface after the correction. When LAI is \geq 1.25 the sum of the leaflet length is 25% longer than the AP dimension. This excess of leaflet tissue will constitute the potential coaptation surface after an effective restoration of the posterior leaflet movement using the Neochord repair procedure.

The result of the present study suggests that concomitant annuloplasty might not always be mandatory in MVR. In conventional open MVR using artificial chordae implantation, annuloplasty is added as an adjunctive “parachute maneuver” in order to reduce leaflet strain, increase leaflet coaptation surface, and counteract

unfavorable changes of the leaflet height due to ventricular dilatation over a long-term period. (12, 13). However, annuloplasty disrupts the ventriculo-annular continuity 3D dynamics (16). Therefore, patients who receive treatment which restores physiological leaflet motion without the use of annuloplasty, may benefit from the preservation of this dynamic structure. Under such considerations, some surgeons elected to avoid implanting a ring whenever possible in order to preserve the dynamic complexity of the mitral valve (1, 17, 18). Nevertheless, when the concept of annuloplasty was first developed by Carpentier with the so called “French Correction” (19) leaflet prolapse was treated by quadrangular resection and plication of the annulus. Without a stabilizing annuloplasty ring, the area of annular plication would eventually dehisce. Furthermore, patients were referred at a later stage of the disease, with dilated LV and consequently dilated annuli. Nowadays, early referral, as suggested by Suri et al. (18), allows to treat patients with only leaflet disease and preserved LV volumes and not dilated annulus questioning the need for a ring and confirming the rationale behind the Neochord repair procedure.

The LAI shifts the paradigm of annular dilatation as an absolute number to a more patient-specific definition. The LAI also overcome to limitations of previously described indexes (1) measuring anatomical structures in mid-diastole because all the measurements are now performed in mid-systole when both the leaflets and annulus can be easily identified and also during the cardiac cycle phase in which it will occur leaflet coaptation. Moreover, the measurements were performed using the 2D-TEE visualization that represent the most diffuse and reproducible imaging modality available worldwide. Interestingly, we observed that the LAI cut-off for an effective repair reduced progressively over time. A possible explanation is the reverse left ventricular and annular remodeling observed postoperatively that reduces the amount of excess tissue required to have an appropriate leaflet coaptation. The LAI is not correlating with MR at 30-postoperative days because for the present study we considered also patients who experienced an early recurrence of MR due to technical failure such in case of chordal detachment from the leaflet.

Conclusion

The present result confirms that the calculation of the LAI may be a useful tool to identify patients who could benefit from a ringless NeoChord repair procedure because of the absence of an annular-to-leaflet mismatch.

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Figure 1. Example of leaflet-to annulus index measurements with 2D and 3D transesophageal echocardiography. PML (Posterior mitral leaflet), AML (Anterior mitral leaflet), Antero-posterior diameter (AP).

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Figure 2. Correlation between Leaflet-to-annular index and the degree of mitral regurgitation (MR) \leq Mild at 1-year follow-up.

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