Aortic annular enlargement with aortic valve replacement

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Procedures which enable a larger valve prosthesis implantation into the small annulus with the preservation of the native annulus is called the aortic root enlargement. Nicks procedure has been described as a potential surgical option to prevent an imminent patient prosthesis mismatch. Seventeen patients with a small aortic annulus and severe aortic stenosis underwent an aortic valve replacement with an aortic root enlargement according to Nicks. Our primary endpoints in this study were to determine the safety of Nicks procedure and to compare the echocardiographic parameters of the valve prosthesis and left ventricle preoperatively and during the follow-up. The secondary aim was to confirm the benefits of annular enlargement procedures in patients with a small aortic annulus. There were one in-hospital mortality (5.8%) due to stroke and two mortalities during the follow-up period of 22.93±17.75 months due to non-valve–related reasons. We observed regression of the left ventricular mass from 246±47.61 to 240±43, but it was not statistically significant. The mean pressure gradients after the NP decreased from 37.06±16 preoperatively to 9.86±3.84 postoperatively (p<0.0005). Nicks procedure appears as a simple and safe surgical technique of aortic root enlargement. Based on our work, its justification seems to be an optimal surgical option for patients with a small aortic annulus indicated to the aortic valve replacement.

Key words: aortic valve replacement, aortic annulus enlargement, Nicks procedure, patient prosthesis mismatch

Zväčšenie aortálneho prstenca pri náhrade aortálnej chlopne

Zväčšenie aortálneho prstenca je chirurgická procedúra dovoľujúca implantáciu protézy do malého aortálneho prstenca. Procedúra bola do praxe zavedená za účelom eliminácie nezhody pacient-protéza. Do práce bolo zaradených 17 pacientov, ktorí podstúpili zväčšenie aortálneho prstenca podľa Nicksa. Sledované boli echokardiografické parametre ľavej komory srdca a tlakových parametrov na aortálnej chlopni a protéze predoperačne a pooperačne. Cieľom štúdie je vyhodnotiť vplyv chirurgickej procedúry podľa Nicksa na echokardiografické parametre ľavej komory srdca. Hospitalizačná mortalita bola 5,8 % (náhla cievna mozgová príhoda). Sledovanie pacientov bolo 22,93 ± 17,75 mesiaca, počas ktorých bola zaznamenaná smrť ďalších dvoch pacientov. Pri sledovaní echokardiografických parametrov bola zaznamenaná štatisticky nesignifikantná regresia hmotnosti ľavej komory (246 ± 47,61 g predoperačne a 240 ± 43g pri sledovaní) a štatisticky signifikantný (p < 0,0005) pokles tlakového gradientu aortálnej chlopne (37,06 ± 16 mmHg predoperačne a 9,86 ± 3,84 mmHg pri sledovaní). Z prezentovaných výsledkov vyplýva, že procedúra podľa Nicksa je jednoduchá a bezpečná procedúra zväčšenia aortálneho prstenca a je optimálnym chirurgickým riešením u pacientov so stenózou aortálnej chlopne a malým aortálnym prstencom.

Kľúčové slová: náhrada aortálnej chlopne, zväčšenie aortálneho prstenca, procedúra podľa Nicksa, nezhoda pacient-protéza

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Introduction

Aortic annular enlargement (ARE) has been endorsed for the patients with a small aortic annulus. On the other hand, its benefit is still unproven to minimize the number of patients with a patient-prosthesis mismatch who undergo an aortic valve replacement. In order to bring more light into this controversy issue, we have accomplished a small pilot study comprising of 17 patients with a small annulus who underwent an aortic valve replacement combined with a posterior annular enlargement.

A serious finding in the aortic valve replacement (AVR) is a small aortic annulus and a large patient´s body surface area. In this situation a special phenomenon may emerge – a patient prosthesis mismatch (PPM), which is a disparity between the effective orifice area (EOA) and body surface area (BSA). Procedures that enable a larger valve prosthesis implantation into the small annulus with the preservation of the native annulus are called the aortic root enlargement (ARE). There are four common techniques for the aortic root enlargement: Nicks, Manougian, a modified Bental operation and aorto-ventricular plasty. The usual materials for these procedures are either Dacron or various types of pericardium (bovine, autologous, equinus).

The primary endpoints of this study were to determine the in-hospital morbidity and mortality in patients undergoing AVR combined with ARE in patients with a small aortic annulus, regression of the LV mass, decrease in the NYHA group and other echocardiographic parameters described in table 1. The secondary endpoint was to confirm the clinical benefit of annular enlargement procedures in patients with the small aortic annulus.

Material and Method

Our study has a retrospective, observing character, we present clinical and echocardiographic follow-up data. During the period between February 2009 and December 2015, seventeen patients un-

derwent the AVR and Nicks procedure (NP) for ARE. These patients had a calculated indexed effective orifice area (iEOA) less than 0.85 cm^2/m^2 for an intended aortic prosthesis implantation without aortic root enlargement. The surgical procedure started with a transverse aortotomy which was extended in the caudal direction towards the middle portion of the non-coronary sinus of Valsalva and after the aortic annulus crossing it expanded to the anterior cusp of the mitral valve without cutting it. We enlarged the orifice with a diamond-shaped patch of bovine or autologous pericardium fixed in glutaraldehyde in a standard fashion. The enlargement allowed implantation of the prosthesis more than one size bigger at least. In the study, we analyzed perioperative complications (dialysis, stroke, heart block, reduced cardiac output, reoperation for bleeding, pneumonia, stroke), the postoperative regression of the left ventricle muscle mass and other echocardiographic parameters. The follow-up data and echocardiographic findings were collected retrospectively, the mean follow-up was 22.93±17.75 months. An isolated AVR including NP was performed in seven patients, AVR-NP combined with a coronary bypass in five patients and AVR-NP combined with Mitral valve repair (MVP) in five patients. Biological prosthesis was implanted in six patients, mechanical replacements with an average size of 20.4±1.8 were used in eleven cases. Autologous pericardium was used in ten patients, in seven patients we used bovine paricardium. Calculated EUROSCORE II was 2.89±1.68. Statistical analysis was done by paired two samples for means (Student T- TEST) and by the Mann-Whitney U test. A value of $p<0.05$ was considered statistically significant.

Table 1. Patient characteristics

Number of Patients	17
Men/Women	4/13
Age Min/Max	66 years 41/79
Duration of Follow-up Min/Max	22.93±17.75 months 5/70
AVR-NP	7
AVR-NP and MVP	5
AVR-NP and CABG	5
Mechanical AVR-NP	11
Biological AVR-NP	6

Table 2. Perioperative and postoperative complications

Postoperative complications	n (%)
30-day in-hospital mortality	1 (5.8)
Mortality after discharge (non valve-related)	2 (11.7)
Reoperation for bleeding	2 (11.7)
AV block	3 (17.6)
Low cardiac output	0
Dialysis	5 (29.4)
Stroke	1 (5.8)
Pneumonia	0

Table 3. Echocardiographic data (LVIVS: left ventricular–intraventricular septum, LVPWT: left ventricular posterior wall thickness, LV mass: left ventricular mass, EOA: effective orifice area, EF: ejection fraction, LVEDD: left ventricular end-diastolic diameter)

	Preop	Follow-up	*p*
LVIVS	14.6±3.73	12.75±1.80	no different
LVPWT	14.38±3.23	11.15±2.19	p<0.05
LV Mass (g)	246±47.61	240±43	no different
Peak gradient	71.69±26.78	19.54±7.13	p<0.001
Mean gradient	37.06±16	9.86±3.84	p<0.0005
EOA	0.78±0.25	1.50±0.41	p<0.05
EF	57±6.65	67±6	p<0.01
LVEDD	47.88±5.11	40.46±7.17	p<0.0005
NYHA III-IV	2.69	1.54	p<0.001

Results

Patients' baseline characteristics are shown in table 1. There were 17 patients (4 men) enrolled between February 2009 and December 2015. All the patients had severe stenosis of the aortic valve, while five patients had concomitant mitral regurgitation and another five patients had concomitant coronary artery disease. The mean age was 66±10 and the mean BSA was 1.85±0.13. The average follow-up was 22.93±17.75 months (table 1). All the complications are shown in table 2. We have encountered two re-explorations for bleeding, three atrioventricular blocks with a necessity of pacemaker implantation. None of the patients exposed low cardiac output syndrome of pneumonia. We have registered temporary dialysis in five patients. The extracorporeal circulation lasted 135±39 minutes, an average X-clamp time was 114±31 minutes. One patient died (5.8%) due to stroke on the 8th postoperative day. Two more patients died from not valve-related complications after hospital discharge. We observed a regression of the left ventricular mass but it was not statistically significant (table 3). The mean valvular gradients declined from 37.06±16 to 9.86±3.84 postoperatively (follow-up), p<0.0005 respectively. An average left ventricular end-diastolic diameter decreased from 47.88±5.11 to 40.46±7.17 pre- and postoperatively, (p<0.001) respectively. An average preoperative grade of NYHA Class was 2.69, with a statistically significant postoperative decline to 1.54 (p<0.01), (table 3). All other parameters are listed in table 3.

Discussion

Although experimental studies on the cadavers hearts referred Nicks procedure as a procedure with the smallest benefit for the enlargement of aortic annulus (2), its simplicity favors this procedure in case of an immediate necessity for root expansion.

Prevalence of the aortic annular enlargement combined with AVR due to aortic stenosis in the literature is reported as one of 14 cases. Other authors describe the prevalence of 6.8%-18% (1, 7). Nicks procedure is roughly 10 to 13 minutes longer than the isolated AVR. Kulik et al., in the group of 172 patients, had the cross-clamp time 94 minutes and cardiopulmonary bypass duration 137 minutes, the numbers correspondent with our outcomes (6). The recent study has revealed that the procedure does not increase mortality compared with patients who underwent an isolated AVR. The mortality range varies between 3-7% (1, 4, 7).

Our study achieved a statistically significant improvement in observed echocardiographic parameters (decrease in mean and peak gradients, increase

of EOA and EF) without a LV mass regression, where we have observed no statistically significant difference so far. It may be associated with a shorter follow-up period.

Rammos et al., show in their study statistically significant improvements in the left ventricle–intraventricular septum thickness (LVIVS), in the left ventricular posterior wall thickness (LVPWT), in the left ventricular mass (415±33 vs 388±41, p<0.01) and in the peak/mean gradient. The effective aortic valve orifice after Nicks procedure was 1.4±0.5 cm^2. On the other side the left ventricular end-diastolic pressure (LVEDP) and especially ejection fraction (EF) remained unchanged (4). These differences between our and authors' series could be explained by a shorter follow-up period (60 vs 22.93 months) and rate of patients with concomitant coronary artery disease (2/15 vs 5/17) (4). In the early postoperative period compensatory supernormal EF may persist and in patients with a low EF preoperatively, an improvement in LV contractility following the AVR can be generally expected (5).

Reported specific complications consist of mitral regurgitation, left atrial-aortic fistula, haemolysis secondary due to Dacron material, pseudoaneurysm secondary to patch dilation or rupture. We have not encountered any of these complications. The result of comparative studies has documented that there is no difference in perioperative complications between an isolated AVR and AVR combined with an annular enlargement. Stroke is reported in 0.6% to 2%, pacemaker implantation in 5% to 7.8%, reoperation for bleeding in 10%, acute renal failure require dialysis in 10.6% (6, 7, 8). Our unusually high occurrence of dialysis (29.4%) and AV block (17.6%) can be explained by the advanced age and frequent concomitant procedures as CABG or mitral valve repair. The learning curve and proportion of ARE on overall AVR also play a considerable role. Coutinho et al. performed ARE in 15% from total AVR procedures (8).

The German study by Beckmann suggests a save alternative to the conventional valve replacement and ARE, which is the sutureless valve implantation (3). In their study, the postoperative outcome was similar in both groups (AVR+ARE versus sutureless valve implantation) in terms of the re-sternotomy rate, the mean stay on the intensive care unit and the 30-day mortality rate. Conditions for sutureless valve implantations were the age over 75 years, incidence of NYHA classes III and IV and expectance for more concomitant surgical procedures (3).

Excellent hemodynamics outcomes also favor Bentall procedure with an oversizing valve by a modified, self-assembled composite graft. This was confirmed by another German study from Bad Neustadt. The above mentioned procedure was done in the group of 29 patients with a small aortic annulus. They recommended not to hesitate with the decision to extent the procedure, especially in cases when the risk of injury is particularly susceptible (small annulus or pathologically changed aortic root) (9).

Conclusion

NP appears as a simple and safe surgical technique of ARE for patients with a small aortic annulus indicated to the aortic valve replacement. Improved echocardiographic parameters suggest that NP is a reasonable option for preventing PPM. On the other hand, a longer follow-up including higher numbers of patients are needed.

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