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The Wheat Operation: Role of 5 mm in Postoperative Aortic Dilatation

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Abstract

Aim: The Aortic Root (AR) dilatation after Wheat Operation (WO) is an important issue to consider in the long-term Follow-Up (FU). This study aims to identify possible predictor factors involved in this late complication.

Material and Method: We retrospectively analyzed a 216 consecutive patients (150 males and 66 females) cohort who underwent WO from June 2009 to April 2018 in the Cardiac Surgery of the Policlinico Campus Bio -Medico of Rome, Italy, and in the Cardiac Center of the Brighton and Sussex University Hospital of Brighton, United Kingdom. The mean echocardiographic (TTE) FU was 44.9 ± 22.2 months. The increase of 10% in the size of the aortic root compared to the pre-operative baseline was the outcome variable. Statistical analysis used 1) the Student's t - test or chi - square test for the comparisons between variables, 2) Kaplan – Meier's analysis for the survival curves, and 3) the Cox's regression models, via methodology backward stepwise after evaluation of the exploratory variables, for the assessment of the predictive value of the variables over the time. A p-value less than 0.05 was significant.

Result: No significant differences among patients underwent aortic valve repair and patients underwent aortic valve replacement (log rank = 0.917). In the group of patients underwent valve replacement, the dilation of the AR it was associated to the difference between the diameter of the prosthetic valve and the diameter of the straight vascular prosthesis (OR 0.87, P = 0.024). Based on the difference in diameter between vascular and valve prosthesis we have organized two groups. The small group (S) (n = 52), if the difference was ≤ 5 mm, and the large group (L) (n = 34) if the difference was > 5 mm. Using this grouping variable, a significant dilatation of the AR was observed in 30.8 % of the S and in the 14.7 % of the L (log rank = 0.026). A difference of more than 5 mm between the aortic valve prosthesis and the vascular prosthesis was protective for the AR enlargement in the long-term FU (OR 12:31, P = 0.033), even after adjustment for age and sex (OR 00:32, P = 0.043).

Conclusion: In our series, the difference between the size of the aortic valve prosthesis and the vascular prosthesis less than or equal to 5 mm appears to be the only factor associated with increased risk in AR dilatation after WO in the long-term FU.

Keywords: Wheat operation; Aortic root; Ascending aorta aneurysm; Ascending aorta replacement; Aortic valve replacement; Aortic valve repair

Introduction

The treatment of the Ascending Aorta Aneurysms (AAA) associated with concomitant aortic valve disease includes different surgical options. In case of anatomical preservation of the Sino-Tubular Junction (STJ), a straight vascular prosthesis replaces the aneurysmal portion of the ascending aorta, leaving unaltered the Aortic Root (AR) and the Coronary Ostia (CO), while the aortic valve undergoes repair or replacement. This surgical option is the Wheat Operation (WO) [1]. Although the WO arrests the progression of the AAA and the deterioration of the valve with concomitant benefit on cardiac function. The dilation of the AR is an important issue to consider in the long-term follow-up (FU) after WO. This further enlargement can indeed lead to 1) the AR rupture, 2) the narrowing of the CO due to the traction, and/or 3) the functional anomalies of the native aortic valve or of the aortic prosthetic valve [2]. This analysis aims to identify possible predictor factors involved in the AR dilatation after the WO.

Material and Methods

We retrospectively analyzed a 216 consecutive patients (66 females and 150 males) cohort who underwent WO from June 2009 to April 2018 in the Cardiac Surgery of the Policlinico Campus Bio -Medico of Rome. The mean echocardiographic (TTE) FU was 44.9 ± 22.2 months. Table 1 summarizes the patients' demographic data. The increase of 10% in the size of the aortic root compared to the pre-operative baseline was the outcome variable we evaluated [3]. Statistical analysis used 1) the Student's t - test or chi - square test for the comparisons between variables, 2) Kaplan – Meier's analysis for the survival curves, and 3) the

Cox's regression models, via methodology backward stepwise after evaluation of the exploratory variables, for the assessment of the predictive value of the variables over the time. A p-value less than 0.05 was significant. The replacement of the aortic valve has been the treatment of choice in 172 patients, in 24 patients a commissuroplasty was performed, and in 8 patients pericardial patch valve plasty was used [4-6]. In 80% of the replacement a biological prosthetic valve have been used, in consideration of the patients age. In 6 patients it was performed coronary artery bypass grafting of one or more vessels, and one patient underwent concomitant mitral valve replacement. One patient underwent cardiac reoperation after 7 years after the first procedure for subsequent aortic valve stenosis (Table 2).

Table 1: Summarizes the patients' demographic data.

	n.	%
Female	33	31
Male	75	69
Hypertension	75	69
Dyslipidemia	57	53
Diabetes	48	44
COPD	34	31
Psychiatric disorders	17	16
Bicuspid aortic valve	18	17
Aortic stenosis	76	70
FU Mortality	0	0
Mean FU (months)	44.9 +/- 22.2	
Age (year)	67.8 +/- 9.3	
EuroScore II	3.1 +/- 0.9	
Ejection Fraction (%)	55.1 +/- 4.7	
Aortic root diameter (mm)	40.4 +/- 5.2	
Sino – tubular junction TJ diameter (mm)	32.9 +/- 5.3	

Table 2: Summarizes the operative data.

Aortic vascular prosthesis size	n.	Aortic valve prosthesis size	n.
22 mm	1	19 mm	4
24 mm	4	21 mm	22
26 mm	6	23 mm	54
28 mm	26	25 mm	74
30 mm	32	27 mm	16
32 mm	22	29 mm	2
34 mm	17	-----	-----
CPB time (min)	74.1+/- 10.7	Biologic Aortic valve prosthesis (n.)	138
X clamp time (min)	52.4 +/- 8.4	Mechanic Aortic valve prosthesis (n.)	34
Other surgical procedures	7	Aortic valve repair (n.)	44
associated (n.)			

Results

No significant differences among patients underwent aortic valve plasty and patients underwent aortic valve replacement (log rank = 0.917) were found (Figure 1). Dilation of the AR occurred in 16 of 44 patients in the AVP group (36.3%) and in 42 of 172 patients in AVR group (24.4 %). Cox's regression analysis confirmed the no significance of this difference, since AVR showed an odds ratio 1.04 (95% CI 12:46 to 2:37) with P = 0.920.

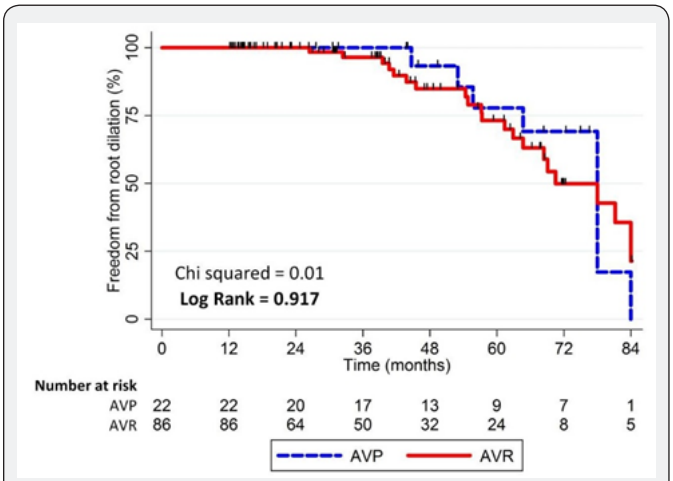

Figure 1: Kaplan Meier curve on the absence of dilatation of the AR in patients underwent AVP or AVR.

In the group of patients underwent valve replacement, the AR dilatation was associated with the difference between the diameter of the prosthetic valve and the diameter of the straight vascular prosthesis (OR 0.87, P = 0.024) [7-10]. The mean difference between the prosthetic valve and vascular graft is 6.0 ± 2.4 mm. According to the difference in diameter between vascular and valve prosthesis we have organized two groups compared on the average value of this difference between prosthetic valve and vascular graft sizes [11]. The small group (S) (n. = 104 pts.), if the difference was ≤ 5 mm, and the large group (L) (n. = 68 pts.), if the difference was > 5 mm. At the end of the FU, a variation of the AR > 10 % compared to the preoperative size was observed in 58 patients (27 %) (Table 3).

Table 3: Reports the diameters of the AR and the STJ at the FU with the changes compared with the preoperative value.

AR post (mm)	46.4 +/- 5.6
STJ post (mm)	40.1 +/- 5.4
AR variation (mm)	9.9 +/- 11.9
STJ variation (mm)	3.2 +/- 4.8
AR variation > 10% (n.)	29

Using this grouping variable, a significant dilatation of the AR was observed in 30.8 % of the S and in the 14.7 % of the L (log rank = 0.026) as the Figure 2 shows. Cox's regression quantified the predictive validity of this observation. This analysis showed that a difference of more than 5 mm between the aortic valve prosthesis and the vascular prosthesis is associated with a lower

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risk of residual AR enlargement in the long-term FU (OR 12:31, P = 0.033), even after adjustment for age and sex (OR 00:32, P = 0.043) [12-15]. The assumption of the proportional hazards was quantified using the Schoenfeld residuals test, showing a Chi square = 1.93 with 3 degrees of freedom, and it is associated with a P < 0.05. Graphics tests confirmed the validity of this analysis. These evaluations include the log-log plot as the Figure 3 shows, and the overlap between predicted and observed survival functions as the Figure 4 reports.

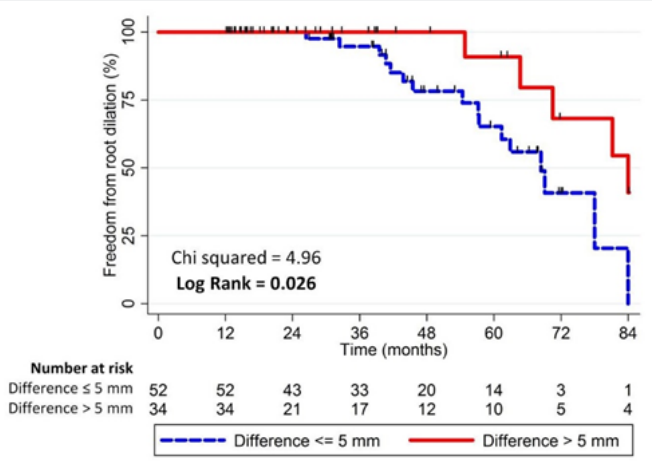

Figure 2: Kaplan Meier shows the significant dilatation of the AR in S and L groups (log rank = 0.026).

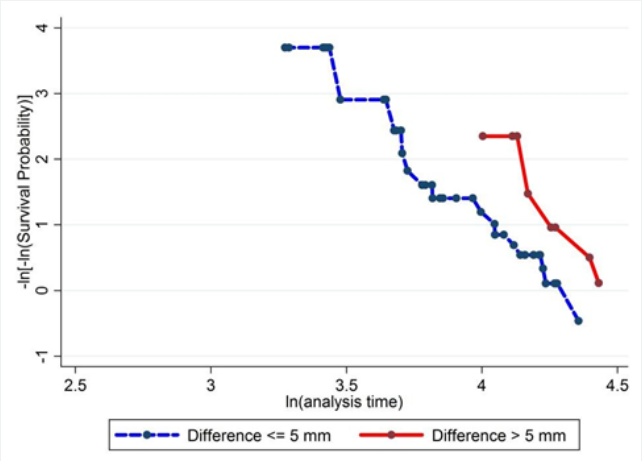

Figure 3: Log-log plot evaluation.

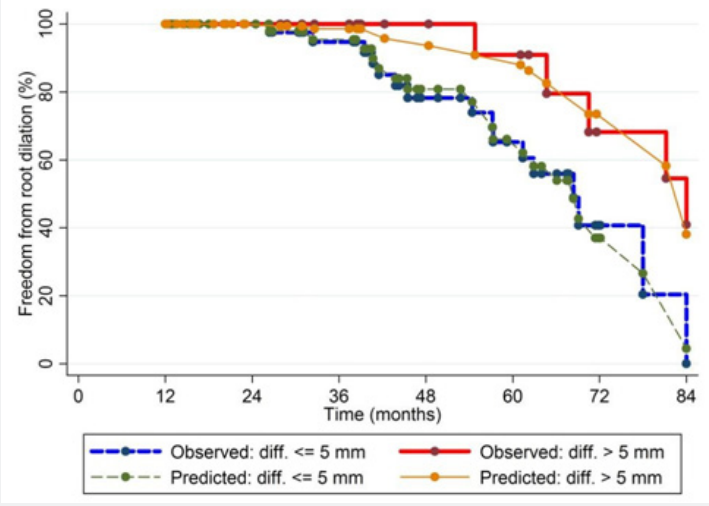

Figure 4: Kaplan Meier versus survival probability plot.

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Discussion

The synthetic vascular grafts, including Dacron® or PTFE®, used as substitutes of the aortic wall in the WO, are widespread for many years for their ease of use, but do not reflect the biomechanical characteristics of the native vascular wall [16-20]. The compliance of the vascular prosthesis, defined as the increase in volume for increase of pressure units, is four times lower than the native aorta, and this concept of compliance mismatch between the graft and the native aorta generates blood flow anomalies with important clinical implications in the long-term period. The loss of elastic properties after replacement with vascular prostheses can cause retrograde effects, with involvement of the aortic root, the aortic valve (or prosthetic aortic valve), and the left ventricular [21].

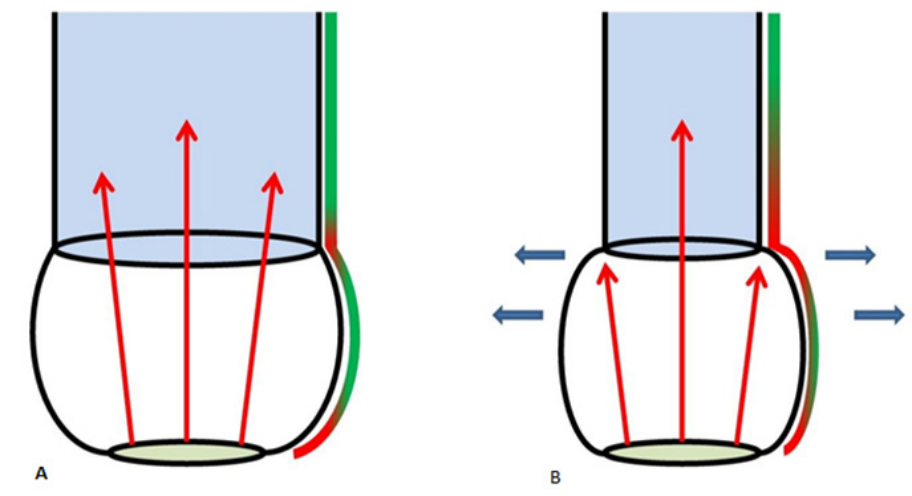

Figure 5: Schematic representation of the WO in S group (A) and L group (B). The red arrows indicate the blood flow. The color scale indicates a lower (green) or major (red) shear stress in the AR and in the vascular graft. Based on our results, the difference between the valve prosthesis and the vascular prosthesis size appears the key factor in the aortic root enlargement after wheat operation. According to this evidence, the best choice appear the attempt to implant the aortic valve prosthesis as big as possible. In case of small aortic annulus surgeon can use sutureless aortic prosthesis because they allow the use of one size more than stented aortic prosthesis.

Among the retrograde effects, the insertion of a vascular graft and the compliance mismatch determine significant changes in mechanical properties of the AR [22-25]. In the WO the aortic valve is replaced with a prosthesis which optimally responds to the fluid dynamic changes resulting from the replacement of the ascending aorta. Therefore, all retrograde shear stress loads on the AR, which is the only not prosthetic portion. In our single center experience, we observed that by using a difference of 5mm or more between the prosthetic valve and aortic vascular graft there is a smaller difference in diameter between the vascular graft and the AR [26]. This geometry determines a reduction in the dilatation of the AR in the long-term FU. On the contrary, in case between the valve and the graft there is a difference < 5 mm, the Valsalva sinus shows a more accentuated barrier effects [27]. The turbulent flow due to this barrier effects are the most plausible causes involved in the greater dilation of the AR, as the Figure 5 explains.

Conclusion

In our series, the difference between the size of the aortic valve prosthesis and the vascular prosthesis less than or equal to 5 mm appears to be the only factor associated with increased risk in AR dilatation after WO in the long-term FU. Further research, are needed to provide a more detailed explanation of this phenomena.

Disclosure

No conflict of interest declared.

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