Does the type of suture technique affect the fluid-dynamic performance of bioprostheses implanted in small aortic roots? Results from an in vitro study

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Background: The in vivo hemodynamic performance of a bioprosthesis implanted in an aortic position is affected by the characteristics of the prosthesis and the sizing strategy adopted. Recently, it has been hypothesized that the type of suture used to implant the prosthesis might influence hemodynamics.

Methods: Bioprostheses with labeled sizes of 19 mm and 21 mm were implanted in 2 groups of 5 porcine aortic roots, with native annuli of 19 mm and 21 mm, by means of 2 different suture techniques: simple interrupted and noneverting mattress with pledgets. The aortic roots were tested in an in vitro mock loop. The stroke volume imposed by the mock loop was set at 40 mL, and was increased by steps of 15 mL until a stroke volume of 100 mL was attained. Main fluid-dynamic parameters were analyzed.

Results: At each level of stroke volume, ie, 40 mL, 55 mL, 70 mL, 85 mL, and 100 mL, the mean and peak pressure drops were significantly greater with the noneverting mattress suture with pledgets than with the simple interrupted suture. The effective orifice area behaved accordingly, being significantly smaller in the former case.

Conclusions: Our data show that the type of suture technique can influence bioprosthesis performance and that it is reasonable to assume that this is especially true in small annuli ($\leq$21 mm). Thus, to optimize prosthesis performance and reduce the incidence of patient-prosthesis mismatch, the role of the suture technique should not be disregarded. (J Thorac Cardiovasc Surg 2015;149:912-8)

See related commentary on pages 918-9.

The in vivo hemodynamic performance of a bioprosthesis implanted in the aortic position is affected by the characteristics of the prosthesis, such as stent design, type and position of the leaflets, sewing-ring size, and the sizing strategy adopted.[1,2] In addition, the type of suture technique used to implant the prosthesis has been hypothesized to influence hemodynamics,[3,4] modifying the left ventricular outflow tract (LVOT) morphology near the sewing cuff. In this regard, 2 recent studies[4,5] involving small bioprostheses, ie, with labeled sizes of 19 mm and 21 mm, came to different conclusions. Tabata and colleagues[4] reported that the use of a noneverting mattress suture technique with pledgets, on the ventricular side, reduced prosthesis performance, as manifested by the reduction in the effective orifice area (EOA). By contrast, Ugur and colleagues[5] found no such difference, and they did not discern a relationship between the suture technique adopted and the EOA. These studies were retrospective and nonrandomized, and therefore open to possible bias.

Aortic valve implantation may be performed by means of several types of suture: simple interrupted suture (SIS), semicontinuous suture, and mattress suture with pledgets (MSP), in either everting or noneverting fashion. The way in which the suture might influence performance has to do with changes in the LVOT, the housing of the prosthesis, and the attitude of the surgeon in sizing. In any case, even if a bioprosthesis is effectively designed, the fluid-dynamic characteristics may be spoiled when the valve is implanted in a true aortic root. This possibility may be of paramount importance in patients with a small aortic annulus, in whom the risk of developing high gradients,[6,7] and of patient-prosthesis mismatch (PPM), is higher, and may have negative repercussions.[8-11] The aim of the current experimental study was to find out whether the suture technique used in aortic valve replacement may influence the hemodynamic performance of a bioprosthesis.

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Abbreviations and Acronyms

ARU = aortic root unit
Δpm = mean systolic pressure drop
EOA = effective orifice area
LVOT = left ventricular outflow tract
MSP = mattress suture with pledgets
P_{ao} = pressure measured at the aorta
PPM = patient-prosthesis mismatch
P_{ven} = pressure measured at the ventricle
Q_{rms} = mean square root of the systolic flow rate
SD = standard deviation
SIS = simple interrupted suture
SV = stroke volume

MATERIALS AND METHODS

FoRcardioLab Pulsatile Mock Loop

Figure 1, *A* shows a schematic representation of the mock loop used,[12-14] which consisted of a computer-controlled volumetric pump able to replicate left ventricular flow waveforms, a sample test section designed to house a whole aortic root unit (ARU), and an adjustable hydraulic afterload mimicking the hydraulic input impedance of the systemic circulation. In this experimental campaign, the mock loop was instrumented with a transit-time flow-meter (HT100R; Transonic System Inc, Ithaca, NY), the 1-inch probe of which was placed downstream of the ARU sample; and with 3 pressure transducers (PC140 series; Honeywell Inc, Morristown, NJ), one immediately upstream and one immediately downstream of the sample (P_{ven} and P_{ao}, respectively, in Figure 1, *A*), and the third at the inlet section of the hydraulic afterload. A high-speed digital camera (Phantom Miro2; Visionresearch, Morristown, NJ) was placed downstream of the sample so as to acquire an aortic view of the working prostheses. In our tests, we used saline solution (0.9% w/v NaCl). Data were acquired at 200 Hz, via an analog/digital board (USB 6210; National Instrument, Austin, Tex).

Sample Preparation and Prosthesis Sizing

We selected 10 fresh whole swine hearts with native aortic annuli of 19 mm (5 hearts) and 21 mm (5 hearts) measured by a metric probe. To replicate the operating-room scenario, we used the probes and the valve replica provided by the manufacturer to choose the prosthesis size that could be comfortably implanted, with a maximum of only slight forcing. This approach was adopted because the porcine ascending aorta was extremely elastic, a feature that might have introduced a bias into prosthesis size selection. Indeed, oversizing was theoretically possible in the case of all valves, owing to the extreme elasticity of the ARU; in real life, however, the stiffness of the aorta would have made this difficult, if not impossible.

The ARU samples were then harvested by 2 experienced surgeons. The samples included 1.5 cm of the left ventricular outflow tract, which was rendered cylindrical by closing the mitral valve commissures by means of a running suture to the adjacent muscular septum. The ascending aorta was transected 0.5 cm above the sinotubular junction, and the coronary ostia were ligated to prevent fluid loss. Circular Dacron meshes were sutured to the inflow and outflow of the aortic root sample, in order to fix it into the housing section of the mock loop, as described elsewhere.[12-14]

Experimental Design

Tests simulating physiologic conditions in patients at rest were conducted on the mock loop. The stroke volume (SV) imposed by the pulsatile pump was set at 40 mL, and was increased by steps of 15 mL until an SV of 100 mL was attained. The systolic ejection time was set at one third of the entire cardiac cycle, and the heart rate was set at 70 bpm, with a mean simulated arterial pressure of 80-104 mm Hg. After being excised and housed in the test section holder of the mock loop, the native leaflets were removed, and the prostheses were implanted by an experienced surgeon and tested in each sample.

A Trifecta n. 19 prosthesis (St. Jude Medical Inc, St. Paul, Minn) was implanted in each aortic root with an aortic annulus size of 19 mm. This procedure was performed twice, first with one type of suture technique and then with the other, using 9-10 sutures with the MSP, and 16-17 with the simple interrupted suture (SIS) technique. In exactly the same way, a Trifecta n. 21 prosthesis was implanted twice in each aortic root with an aortic annulus size of 21 mm, using 12-14 sutures with MSP, and 18-20 for SIS. The bioprostheses were implanted by means of an SIS technique, whereby all stitches (Ethibond 2/0) were placed radially in the aortic annulus and then in the sewing ring of the prosthesis.

The second technique adopted was a noneverting MSP (Ethibond 2/0) on the ventricular side. The sequence of type of suture used in each aortic root was randomized. After implantation, and prior to testing in the mock loop, each prosthesis was visually inspected via the digital video, to qualitatively assess its integrity and proper functioning. No prosthesis had to be discarded during the entire experiment. For each point, experimental data were evaluated over 5 consecutive simulated heart cycles.

The flow rate, the pressures upstream and downstream of the aortic root, and the pressure in the afterload were acquired via the analog/digital acquisition board. Postprocessing of the raw data was performed to calculate the following quantities:

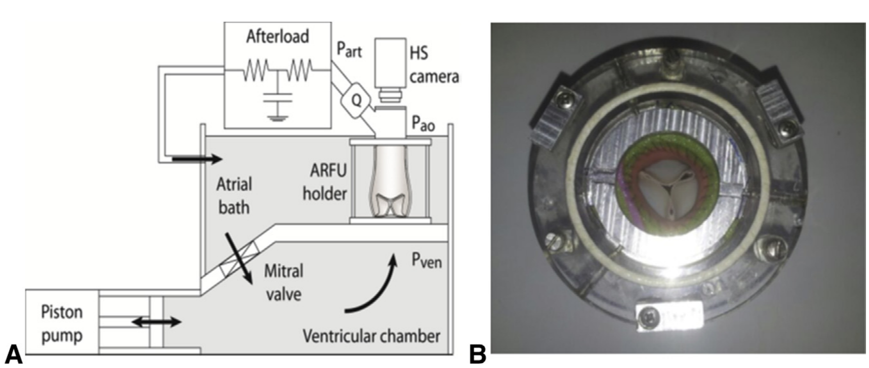

FIGURE 1. A, The mock loop scheme; (B) a prosthesis implanted in the ARU housed in the holder. P_{art}, Arterial pressure; *HS*, high-speed; *ARFU*, aortic root functional unit; P_{ven}, pressure measured at the ventricle; P_{ao}, pressure measured at the aortic valve.

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- The mean systolic pressure drop (⊿pm, mm Hg) across the ARU, as the difference between pressures measured at the ventricle (p_{ven}) and the aorta (p_{ao}) (Figure 1, *A*), averaged over the systolic interval;
- The maximum systolic pressure drop (⊿pM, mm Hg);
- The EOA in cm^2.

The EOA was calculated from the following formula:

$$EOA = \frac{Q_{rms}}{k\sqrt{\varDelta P_{mean}}},$$

where Q_{rms} (L/min) is the mean square root of the systolic flow rate; ⊿pm (mm Hg) is the mean systolic pressure drop across the sample; and k is a conversion factor (k = 3.1 to yield the EOA in cm^2).

Statistical Analysis

Continuous variables were expressed as mean values ± standard deviation (SD); the mean and peak pressure drops and EOA were analyzed by means of a paired *t* test with Bonferroni's correction; *P* values <.05 were considered significant.

RESULTS

In 9 of the 10 aortic roots tested, the MSP technique was associated with a higher gradient and smaller EOA than the SIS technique. The 1 aortic root tested in which the bioprosthesis implanted with the MSP technique performed better than that implanted with the SIS technique had a 21-mm native aortic annulus and showed a negligible difference in mean pressure drop: −0.77 mm Hg, +0.08 mm Hg, −0.26 mm Hg, −1.17 mm Hg, and −1.15 mm Hg at 40 mL, 55 mL, 70 mL, 85 mL, and 100 mL, respectively. For the EOA, the differences were +0.91 cm^2, −0.11 cm^2, +0.02 cm^2, +0.06 cm^2, and +0.01 cm^2 at 40 mL, 55 mL, 70 mL, 85 mL, and 100 mL, respectively.

In the whole sample, the mean and peak pressure drops were higher when the MSP technique was used than when SIS was used (see Table 1 and Figure 2), the differences being statistically significant at each level of SV, except for the peak pressure drop at 70 mL (*P* = .10) (Table 1). The EOA behaved accordingly, being lower at all SV levels in bioprostheses implanted with the MSP technique; the difference was statistically significant at all SV levels except 40 mL (*P* = .9) (Table 1).

Analysis of the 2 subgroups, ie, aortic annulus size of 19 mm and 21 mm, showed a clear trend toward higher mean and peak pressure drops for MSP than SIS in both groups; this difference increased as SV rose (Figure 3). In the 19 mm group, the difference in mean pressure drop was +3.0 ± 1.5 mm Hg, +3.0 ± 2.0 mm Hg, +4.2 ± 2.0 mm Hg,

TABLE 1. Experimental study results

Group studied	Type of suture	SV 40	SV 55	SV 70	SV 85	SV 100
Entire population						
Mean pressure drop (mm Hg)	SIS	2.93 ± 1.4	6.11 ± 2.8	9.7 ± 4.2	13.9 ± 5.5	19.0 ± 7.1
	MSP	4.60 ± 2.4	8.25 ± 3.9	13.0 ± 5.6	18.8 ± 7.6	24.4 ± 9.3
P value		.036	.06	.01	.008	.007
Peak pressure drop (mm Hg)	SIS	12.6 ± 2.2	18.8 ± 4.4	25.8 ± 6.2	35.6 ± 9.9	46.3 ± 13.1
	MSP	15.3 ± 3.4	22.6 ± 5.5	31.6 ± 9.8	43.9 ± 14.3	56.2 ± 16.8
P value		.05	.04	.10	.017	.01
EOA (cm^2)	SIS	2.04 ± 0.61	1.95 ± 0.54	1.91 ± 0.39	1.90 ± 0.35	1.88 ± 0.35
	MSP	1.83 ± 0.85	1.68 ± 0.44	1.65 ± 0.38	1.65 ± 0.37	1.65 ± 0.32
P value		.9	.016	.006	.022	.021
Size 19 mm						
Mean pressure drop (mm Hg)	SIS	4.0 ± 1.0	8.1 ± 2.2	12.9 ± 3.2	17.9 ± 4.6	24.3 ± 5.4
	MSP	6.4 ± 1.3	11.0 ± 3.4	17.1 ± 4.4	24.3 ± 5.8	31.0 ± 6.8
P value		.007	.48	.17	.05	.028
Peak pressure drop (mm Hg)	SIS	14.5 ± 0.9	23.3 ± 2.7	30.1 ± 3.5	43.0 ± 7.8	56.2 ± 8.6
	MSP	17.5 ± 2.8	26.3 ± 4.5	38.2 ± 8.7	53.8 ± 12.5	67.5 ± 14.4
P value		.63	.51	.72	.32	.24
EOA (cm^2)	SIS	1.59 ± 0.27	1.61 ± 0.17	1.59 ± 0.14	1.64 ± 0.17	1.62 ± 0.13
	MSP	1.28 ± 0.16	1.36 ± 0.16	1.36 ± 0.15	1.38 ± 0.13	1.41 ± 0.15
P value		.27	.20	.11	.14	.07
Size 21 mm						
Mean pressure drop (mm Hg)	SIS	1.90 ± 0.76	4.13 ± 1.7	6.54 ± 1.9	9.9 ± 2.5	13.8 ± 4.0
	MSP	2.84 ± 1.8	5.47 ± 2.15	8.96 ± 3.2	13.3 ± 4.6	17.8 ± 6.5
P value		.98	.33	.58	.69	.76
Peak pressure drop (mm Hg)	SIS	10.68 ± 1.0	15.3 ± 2.5	20.7 ± 3.2	28.3 ± 5.3	36.4 ± 8.5
	MSP	13.0 ± 2.3	18.8 ± 3.4	25.0 ± 5.7	34.0 ± 7.6	44.9 ± 10.3
P value		.64	.21	.44	.21	.54
EOA (cm^2)	SIS	2.50 ± 0.5	2.28 ± 0.5	2.22 ± 0.3	2.16 ± 0.3	2.14 ± 0.3
	MSP	2.38 ± 0.9	2.0 ± 0.4	1.94 ± 0.3	1.92 ± 0.3	1.90 ± 0.3
P value		.99	.63	.43	.80	.75

SV, Stroke volume; *SIS*, simple interrupted suture; *MSP*, mattress suture with pledgets; *EOA*, effective orifice area.

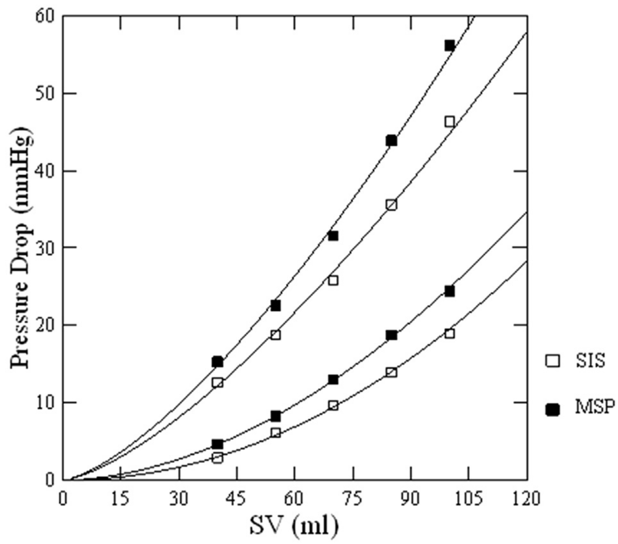

FIGURE 2. Mean (*lower curves*) and peak (*upper curves*) pressure drop at each level of SV. *SIS*, Simple interrupted suture; *MSP*, (noneverting) mattress suture with pledgets; *SV*, stroke volume.

+6.4 ± 2.1 mm Hg, and +6.8 ± 1.9 mm Hg at SV values of 40 mL, 55 mL, 70 mL, 85 mL, and 100 mL, respectively, in valves implanted with the MPS technique in comparison with those implanted with the SIS technique. These differences in mean pressure drop were either statistically significant or close to significance at SV levels of 40 mL, 85 mL, and 100 mL (Table 1). The EOA behaved accordingly, the difference being close to statistical significance ($P = .07$) at an SV level of 100 mL.

In the 21 mm group, a clear trend toward higher gradients emerged among valves implanted with the MSP technique (Table 1 and Figure 3). Both mean and peak pressure drops were greater, with a difference in mean pressure drop of +0.9 ± 1.3 mm Hg, +1.3 ± 0.8 mm Hg, +2.5 ± 1.8 mm Hg, +3.5 ± 2.8 mm Hg, and +3.9 ± 3.5 mm Hg at SV levels of 40 mL, 55 mL, 70 mL, 85 mL, and 100 mL, respectively. Although appreciable, these differences did not reach statistical significance. Again, the EOA behaved accordingly (Table 1).

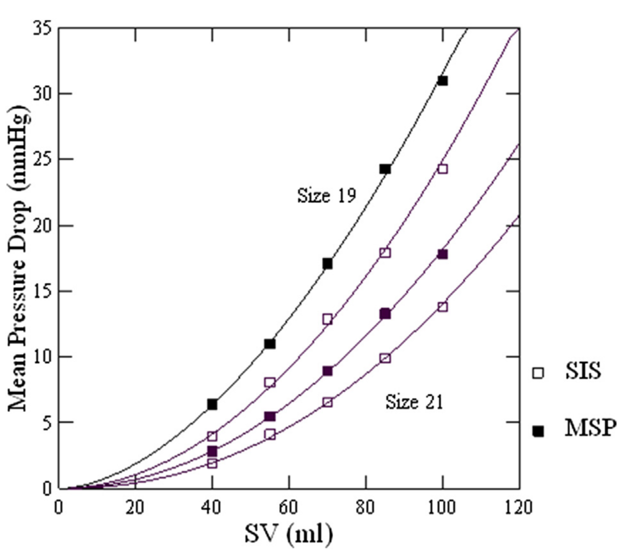

FIGURE 3. Mean pressure drops according to prosthesis size (19 mm and 21 mm) and type of suture adopted. *SIS*, Simple interrupted suture; *MSP*, (noneverting) mattress suture with pledgets; *SV*, stroke volume.

DISCUSSION

The fluid-dynamic performance of a bioprosthesis depends on stent design, type of leaflets (ie, porcine and pericardial), and the position of the leaflets themselves (ie, mounted inside or outside the stent).[15,16] In vitro studies are the ‘‘gold standard’’ for investigating and quantifying fluid-dynamic characteristics in detail. However, these characteristics tend to change when the bioprosthesis is surgically implanted. Indeed, the in vivo scenario is very complex, and in this context, the performance of the prosthesis may be influenced by many factors, not least sizing strategy.[2] Consequently, implanting a prosthesis that meets the patient’s cardiac output requirement requires experience with and knowledge of the true dimensions of the bioprosthesis—its internal and external diameters—and of tissue annulus diameters.

The results of our study show that the MSP technique causes higher pressure drops than the SIS technique when adopted in aortic valve replacement with bioprostheses in small annuli. Hypothesized effects of the implantation technique on bioprostheses[3] have never been studied in a randomized trial. It has recently been suggested that the type of suture technique adopted for the implantation of a bioprosthesis in an aortic position might affect its performance.[4] The logical consequence is that, in small aortic annuli, which are at risk of high residual gradients, the use of the right suture technique might optimize the performance of the bioprosthesis, thereby helping to reduce the incidence and severity of PPM and its clinical consequences.[8-11] Tabata and colleagues[4] found that, in small annuli, the use of a simple interrupted suture technique, rather than a noneverting MSP, seemed to yield better hemodynamic results. On the other hand, Ugur and colleagues[5] did not find any differences between the 2 types of suture technique in a similar patient group. The MSP technique is the most adopted type of suture in aortic valve replacement because it is considered a solid suture with a low incidence of perivalvular leaks, which is one of the reasons some manufacturers typically recommend MPS.

Experimental Study Results and Interpretation

We found that the type of suture technique tested (ie, SIS and MSP) influenced the fluid-dynamic performance of the bioprosthesis in a range of SV values from 40 mL to 100 mL. In 9 of 10 experimental comparisons,

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we observed a greater pressure drop and a smaller EOA in the MSP group than in the SIS group. As reported in Table 1, the mean pressure drop was significantly greater at each SV level when the MSP technique was used (Table 1). The EOA behaved accordingly and was smaller for the MSP technique at each SV level; these differences were statistically significant, except at an SV of 40 mL. It is likely that the EOA, calculated by the Gorlin formula, is the effective area of the LVOT and not of the prosthesis itself. Doppler gradient across the prosthesis is mainly dependent on both SV and EOA, whereas left ventricular ejection time plays a minor role, at least at physiologic heart rate.[17] The EOA is related to the geometric orifice area, which is in turn related to the internal diameter of the prosthesis. Thus, for a given size of prosthesis, a high gradient may be found when there is a mismatch between EOA and SV.

This mismatch is typically present either when the SV increases, such as during physical activity, or when the SV at rest is too high for the implant size, ie, as in PPM. However, as expected, the differences we found between the 2 groups were small, at least at those SV values that corresponded either to the rest condition or were consistent with mild PPM, ie, $\leq$70 mL, for the sizes used in this experiment. Thus, it is likely that, in the clinical scenario, the difference would be negligible in most cases. Indeed, a clinical effect, such as on hypertrophy regression, may be seen when the difference in mean gradient is $\geq$4 mm Hg.[18,19] Nevertheless, when the SV increases, as during physical activity or in the case of moderate PPM, the difference might be clinically relevant.

Differences Among Annulus Sizes

Our study suggests that the type of suture technique may be relevant in small annuli, especially those $\leq$21 mm. Indeed, as can be seen in Table 1, in the 19 mm group, the mean pressure drop was markedly greater in valves implanted with the MSP technique than in those implanted with the SIS technique: +3.0 $\pm$ 1.5 mm Hg, +3.0 $\pm$ 2.0 mm Hg, +4.2 $\pm$ 2.0 mm Hg, +6.4 $\pm$ 2.1 mm Hg, and +6.8 $\pm$ 1.9 mm Hg at SV levels of 40 mL, 55 mL, 70 mL, 85 mL, and 100 mL, respectively. However, when the aortic annulus size was 21 mm, the difference in pressure drop was smaller and not statistically significant. Nevertheless, there was still a clear trend toward a greater pressure drop among valves implanted with the MSP technique: +0.9 $\pm$ 1.3 mm Hg, +1.3 $\pm$ 0.8 mm Hg, +2.5 $\pm$ 1.8 mm Hg, +3.5 $\pm$ 2.8 mm Hg, and +3.9 $\pm$ 3.5 mm Hg at SV levels of 40 mL, 55 mL, 70 mL, 85 mL, and 100 mL, respectively.

It is reasonable to assume that the encumbrance resulting from the pledgets and the tissue is the same, regardless of the internal diameter of the prosthesis. Therefore, the smaller the internal diameter, the greater the percentage reduction in the geometric orifice area due to protrusion of the pledgeted tissue into the area available for the flow, leading to more significant effects on pressure drops in smaller annuli. Thus, in the case of small annuli, the safety margin on which the surgeon can rely, to avoid performing a potentially obstructive suture, is lower. So, we may hypothesize that in vivo as well, in small annuli, the simple suture may help optimize the hemodynamics of a bioprosthesis, thereby reducing the incidence, or the degree, of PPM.

Potential Mechanisms of Flow Obstruction in the MSP Technique

When a noneverting MSP is used, the main mechanism involved in reducing prosthesis performance appears to be that of LVOT shrinkage, as tissue is gathered underneath the prosthesis (Figure 4). However, flow may also be obstructed when the bioprosthesis is implanted in a tilted position, owing to the reduction in the annulus diameter caused by this type of suture. Another, but less apparent, mechanism concerns the size chosen by the surgeon (ie, ineffective sizing). Indeed, being aware of the annulus

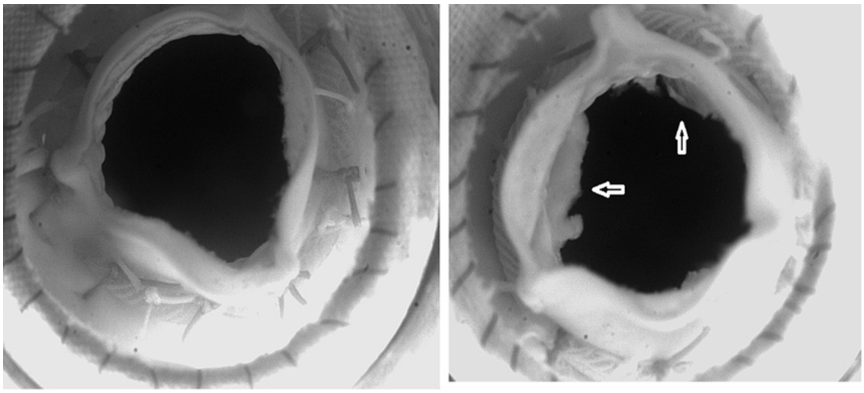

FIGURE 4. *Left*: A 21-mm size prosthesis implanted with SIS. *Right*: The same prosthesis implanted with MSP. *Arrows* point to the tissue gathered underneath the valve.

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shrinkage due to the suture, the surgeon may be prompted to choose a smaller size, to house the prosthesis inside the aortic root safely and without tilting it.

This mechanism may partly explain the results of the retrospective study by Tabata and colleagues,[4] in which the MSP group displayed a smaller EOA and a higher incidence of PPM. Indeed, the MSP group had a larger aortic annulus and a lower prosthesis-annulus size ratio, revealing the propensity of the surgeon to implant a larger valve when using a simple interrupted suture than when using the noneverting MSP. With a lower prosthesis-annulus size ratio, it is possible that more tissue is gathered underneath the prosthesis, obstructing the LVOT flow. In this regard, the EOA calculated by the continuity equation is the effective area of the LVOT that has become smaller than the prosthesis inner diameter, owing to the type of suture. For this reason, the incidence of PPM in patients with a valve implanted with an MSP might be slightly higher than that in patients with a prosthesis implanted with an SIS.

In our study, the same prosthesis was implanted by means of both types of suture technique in the same aortic root anatomy. Furthermore, several variables were kept constant: the surgeon, the afterload, and the SV increment. These conditions are almost impossible to obtain in clinical studies, especially nonrandomized ones, so investigating the effect of suture technique on bioprosthesis performance is very difficult. For these reasons, comparison of our in vitro study with a clinical study is very difficult. However, Ugur and colleagues[5] recently reported that, in a study of the echocardiographic data collected at 1 year, neither a significant difference nor a differential trend was found, using the same prostheses we used. An explanation of the discrepancy with our results might be found in the fact that the patients in the study were not randomized; in addition, the initial tissue gathered underneath the valve may reshape itself over time, decreasing the initial obstruction. The data from Tabata and colleagues[4] indicated a trend in this direction.

We believe that the SIS is an effective technique that contributes to optimizing hemodynamic results. The current results corroborate our previous clinical report[20] on patients with small aortic annuli (average native aortic annulus of 21 mm), in whom the Trifecta bioprosthesis was implanted using the SIS technique. In that randomized study, a very low mean gradient of 5.5 mm Hg and a PPM incidence of only 15% were found on discharge.

Limitations

As this study was conducted in vitro, the prostheses were implanted in an aortic root that was not diseased, might have influenced the results. Another bioprosthesis with a larger sewing cuff might not show the same trends; therefore, the results may not be generalizable to other valves. However, even with a similar prosthesis, the results depend on how close the stiches are to the posts and leaflets.

CONCLUSIONS

Our data show that the type of suture technique can influence bioprosthesis performance and that it is reasonable to assume that this is especially true in small annuli (≤21 mm). Thus, to optimize prosthesis performance in a small annulus and reduce the incidence of patient-prosthesis mismatch, the role of the suture technique should not be disregarded.

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EDITORIAL COMMENTARY

Little things matter

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See related article on pages 912-8.

In the crowded world of the small aortic root, nuances of prosthesis design and surgical technique can have significant consequences. Incomplete relief of outflow tract obstruction, manifest as high transvalvar gradients and patient–prosthesis mismatch, can lead to higher operative mortality, less symptomatic relief, decreased late survival, impaired left ventricular remodeling and mass regression, and diminished durability of the bioprosthesis. The commercial valve wars have focused us on the role of prosthetic valve design, and master surgeons have debated the relative merits of root replacement, root enlargement, and more recently catheter-based stent valve delivery, but relatively little attention has been paid to the simple matter of suture technique. All of us who have implanted small aortic bioprostheses and then looked through the valve orifice to see tissue and pledgets encroaching on the real estate know that these considerations are important too.

Earlier this year in this *Journal*, Tabata and colleagues[1] reported a provocative retrospective clinical study showing that, in their hands, small supra-annular bioprostheses (19- and 21-mm Carpentier Edwards [Irvine, Calif] pericardial valves) had higher gradients if implanted using noneverting pledgeted mattress sutures rather than simple plain interrupted sutures (Figure 1). These elevated gradients translated into a higher incidence of patient–prosthesis mismatch, but without clinical sequelae. Conversely, simple interrupted sutures had lower gradients; of note, this was achieved without the expense of more periprosthetic leaks. Also in the *Journal*, Ugur and colleagues[2] followed with an analysis of the early multi-institutional St Jude Medical Inc (St Paul, Minn) Trifecta pericardial bioprosthesis experience and compared suture techniques, but they found no significant difference between simple interrupted and noneverting pledgeted mattress groups. In the current study, Tasca and colleagues[3] went to the laboratory to evaluate the small (19 and 21 mm) Trifecta bioprostheses in a mock circulation loop using pig hearts, standardized implant techniques, and sophisticated analyses of valve performance. Their study showed statistically significant lower transvalvar gradients with simple interrupted sutures across a broad range of flows and stroke volumes. It appeared that in the interrupted mattress group, tissue and pledgets impinged on the orifice and reduced the effective orifice area, but

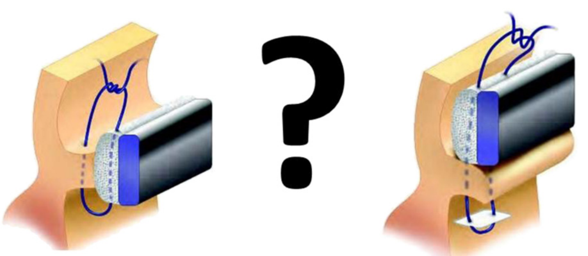

FIGURE 1. Simple interrupted (*left*) versus noneverting pledgetted mattress (*right*) suture techniques. Aadapted from www.cthsurgery.com.

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