

Hemodynamic Performance Following the Ross Operation: Comparison of Two Different Techniques

Jürgen O. Böhm¹, Cornelius A. Botha¹, Wolfgang Hemmer¹, Claudia Schmidtke², J. F. Matthias Bechtel², Ulrich Stierle², Joachim-Gerd Rein¹, Hans H. Sievers²

¹Sana Herzchirurgische Klinik Stuttgart, Stuttgart, Germany, ²Department of Cardiac Surgery, Medical University of Schleswig-Holstein, Luebeck Campus, Germany

Background and aim of the study: The Ross operation as aortic valve replacement has undergone technical evolution. Originally described as a subcoronary implant, the full-root replacement technique is now more common worldwide. It remains unclear which of the two techniques has the better results. Hence, the hemodynamic performances of the two implantation methods, as applied by two experienced centers, were compared as part of the German Ross Registry. **Methods:** In total, 132 (Group 1, root replacement, mean age 40 ± 14 years) and 249 (Group 2, subcoronary implant, mean age 48 ± 14 years) consecutively operated patients were compared clinically and echocardiographically. Data were analyzed focusing on pulmonary autograft and homograft function at mid-term (2.78 ± 1.89 versus 2.26 ± 2.11 years).

Results: Echocardiography revealed autograft peak systolic gradients of 5.0 ± 2.7 mmHg for Group 1 and 6.7 ± 3.7 mmHg for Group 2 ($p < 0.05$), and an indexed effective orifice area (EOA) of 1.98 ± 0.57 cm²/m² and 1.64 ± 0.43 cm²/m² ($p < 0.05$), respectively. Homograft peak systolic gradients were 15.6 ± 9.0 mmHg and 11.7 ± 6.8 mmHg for Groups 1 and 2 ($p < 0.05$) respec-

tively, and the indexed EOA with regard to the homograft was 1.08 ± 0.49 cm²/m² and 1.26 ± 0.50 cm²/m² ($p < 0.05$). Autograft insufficiency grade >I was present in 1.5% (2/132) of Group 1 and 2.8% (7/249) of Group 2 patients. Pulmonary insufficiency grade >I was 17.4% (23/132) for Group 1 and 4.8% (12/249) for Group 2 ($p < 0.05$).

Conclusion: Although both groups enjoyed excellent hemodynamics in the mid-term, the root replacement technique had the advantage of larger annulus diameters and greater aortic EOA. Clinically relevant autograft regurgitation in both groups was gratifyingly rare, and seemed to be independent of surgical technique. Long-term durability of the more demanding subcoronary technique versus the problems of larger dimensions of the sinus of Valsalva and sinotubular junction in the free-root technique, remains to be proven. Apparent differences in pulmonary homograft hemodynamics can most likely be explained by surgical differences, younger patients in Group 1, and by homograft variation.

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The pulmonary autograft or so-called Ross operation as aortic valve replacement was originally introduced as a subcoronary intra-aortic implant (1). The full root replacement technique which subsequently followed was not only surgically less demanding, but also had consistently reproducible results (2). The result has been an increased acceptance and a broader application for this operation using the latter method. Continuous technical evolution has made the full root replacement the most practiced and favored technique worldwide (3).

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Address for correspondence:
Dr. Jürgen O. Böhm, Sana Herzchirurgische Klinik Stuttgart, Herdweg 2, 70174 Stuttgart, Germany
e-mail: joboehm@z.zgs.de

Despite convincing functional results, recent studies have reported autograft dilatation with the root replacement technique (4,5), especially in patients with a native bicuspid aortic valve or other congenital aortic valve disease - conditions which are considered to be more prone to aortic annulus and ascending aortic dilatation (6). Other authors have not been able to corroborate these findings however (7). Due to this discrepancy, possible advantages of the subcoronary technique have come to be reconsidered. Few comparative data are available concerning the hemodynamic properties of the pulmonary autograft when used in the two techniques (6,8), notably with regard to the calculated effective orifice area (EOA) achieved by each method.

Which of the two techniques will provide better results, or whether either technique better suits or is

contraindicated in a particular subgroup of patients, is uncertain. The aim of the present study was to compare the hemodynamic performance, patient outcome and complications of the two implantation techniques as respectively applied by two experienced centers within the German Ross Registry.

Clinical material and methods

Patient selection

Between February 1995 and June 2002, a total of 289 Ross operations was performed at the Sana Cardiac Clinic in Stuttgart, all as root replacements. All data required to calculate the EOA were available for a subgroup of 132 patients, and these were included in the present study (Group 1).

Between February 1990 and June 2002, among 271 patients who received a Ross operation at the Department of Cardiac Surgery, Medical University of Schleswig-Holstein, Luebeck Campus, a subgroup of 249 patients, all with only subcoronary implant of their

autograft and with data available for EOA calculation, were included as Group 2.

All patients were evaluated clinically and echocardiographically at regular intervals by each institution. The underlying patient characteristics, surgical diagnosis and operative data are listed in Table I.

Surgical technique

All operations were performed using standard cardiopulmonary bypass (CPB) with membrane oxygenators and mild hypothermia with either near-continuous cold antegrade and retrograde blood cardioplegia (Group 1) or cold crystalloid cardioplegia (Group 2).

Autograft

In all cases of Group 1 the autograft was implanted as a freestanding root. Dissection of the autograft proximally was in a scalloped fashion, following the natural valve cusp rim with 2-4 mm right ventricular muscle rim. In order to guarantee optimal cusp appo-

Table I: Patient demographics, surgical diagnosis and operative data.

| Parameter | Group 1 | Group 2 |
|---|-------------------|--------------------|
| No. of patients | 132 | 249 |
| Gender ratio (M:F) | 105:27 | 192:57 |
| Age (years)* | 40 ± 14 | 48 ± 14 |
| Bodyweight (kg)* | 74 ± 18 (12-115) | 78 ± 14 (46-122) |
| Height (cm)* | 171 ± 15 (86-188) | 174 ± 14 (145-198) |
| BSA (m ²)* | 1.93 ± 0.3 | 1.94 ± 0.2 |
| NYHA class preoperatively | | |
| I + II | 108 (82) | 194 (78) |
| III + IV | 24 (18) | 55 (22) |
| Bicuspid aortic valve | 45 (34) | 137 (55) |
| Aortic stenosis | 44 (33.3) | 51 (34.5) |
| Aortic regurgitation | 42 (31.8) | 86 (20.5) |
| Combined disease | 44 (33.3) | 110 (44.2) |
| Not classified | 2 (1.5) | 2 (0.8) |
| Active endocarditis | 2 (1.5) | 24 (9.6) |
| Previous cardiac/aortic operation | 14 (11) | 27 (10.8) |
| CPB time (min)* | 152 ± 32 | 211 ± 31 |
| Cross-clamp time (min)* | 124 ± 26 | 165 ± 27 |
| No. of combined procedures | 43 (32.5) | 81 (32.5) |
| CABG | 7 (5.3) | 8 (3.2) |
| Ascending aorta replacement | 18 (13.6) | 12 (4.8) |
| Ascending aorta remodeling/reconstruction | 12 (9) | 50 (20) |
| Mitral valve repair | 1 (0.8) | 4 (1.6) |
| Modified Maze procedure | 2 (1.5) | 1 (0.4) |
| Myectomy | 1 (0.8) | 6 (2.4) |
| PAPVC correction | 1 (0.8) | 0 |
| VSD closure | 1 (0.8) | 0 |

*Values are mean ± SD (range).

Values in parentheses are percentages.

BSA: Body surface area; CABG: Coronary artery bypass grafting; CPB: Cardiopulmonary bypass; PAPVC: Partial anomalous pulmonary vein connection; VSD: Ventricular septal defect.

sition, the aortic annulus had to be equal or even smaller in diameter than the pulmonary autograft inflow, and was conscientiously plicated at one or more commissures if necessary.

The proximal anastomoses were performed with the pulmonary autograft inverted into the left ventricle with three running 3-0 Prolene sutures starting equidistantly at the actual center or imagined center in the case of a bicuspid annulus of each sinus. From 1998 onwards, all patients received an external Dacron strip as a fixed support of the aortic annulus to autograft anastomoses to prevent annular dilatation. The distal aorta was tailored to fit the distal pulmonary autograft diameter at the sinotubular junction, and any dilated aorta was generously replaced with a prosthetic tube to permanently fix the dimension of the sinotubular junction. Excess autograft tissue above the sinotubular junction was excised. Details of the technique have been described previously (9,10).

All Group 2 patients received their autograft-implanted subcoronary via a J-shaped aortic incision through the non-coronary sinus down to the annulus, as described in detail elsewhere (11). The proximal autograft to annulus anastomosis was performed with single interrupted 4-0 Prolene sutures with the non-coronary autograft sinus left intact. If necessary, an annuloplasty was performed to reduce the annulus diameter using a piece of Dacron graft (12). The sinotubular junction of the aortic root was always matched to the diameter of the autograft. In Group 2, no patient received fabric or other reinforcement of either the annulus or the sinotubular junction.

Homograft

Right ventricular outflow tract reconstruction was performed in all patients with the use of a cryopreserved pulmonary homograft, and all anastomoses were completed with the heart arrested, using a continuous uninterrupted 5-0 Prolene suture for distal and 4-0 for proximal anastomoses. The homografts were matched as far as possible to the recipient's body surface area (BSA), age and blood group.

Echocardiography

Transthoracic echocardiography was performed using 2.5 MHz ultrasound transducers (Hewlett-Packard Sonos 2500/5500 system; Hewlett-Packard, Andover, MA, USA, or GE Vingmed Ultrasound Vivid FiVe system; Horten, Norway) during routine follow up and recorded either on VHS videotape or digitally on a magnetic optical disc.

Two-dimensional echocardiography

Left ventricular outflow tract (LVOT) and aortic annulus dimensions, diameters of the sinus of Valsalva

and sinotubular junction were measured from parasternal long-axis views of the aortic root, using the inner wall distances during early systole from three to five consecutive cardiac cycles (13).

Continuous-wave, pulsed-flow and color-flow Doppler imaging

Doppler measurements consisted of assessment of the transvalvular flow velocity for the aortic valve using continuous-wave Doppler and for the LVOT velocity with use of pulsed-wave Doppler, both obtained from apical standard views. From the left parasternal short-axis view, the velocity across the pulmonary homograft valve was measured again with use of continuous-wave Doppler.

To assess autograft regurgitation, pulsed-wave Doppler and color-flow Doppler imaging were used for mapping the LVOT. The deceleration slope and pressure-half-time of the regurgitant jet were estimated using continuous-spectral Doppler imaging. Autograft regurgitation was then graded using the method of Perry et al. (14) in which the ratio of the width of the regurgitant jet to the diameter of the LVOT, at the level of the annulus was determined. Regurgitation that was not sufficiently severe to be classified according to these criteria was considered trivial.

Whenever possible, regurgitation of the pulmonary homograft was estimated with the grading of Chan et al. (15).

Calculations

Peak systolic pressure gradients across the valves where calculated using the modified Bernoulli equation. The EOAs of the valves were determined with the standard continuity equation, with use of the LVOT stroke volume for the calculation of both the aortic and pulmonary valve areas.

Data analysis

Categorical data were reported as total numbers and relative frequencies. Continuous data were presented as mean \pm SD. Different groups were compared using the unpaired *t*-test, Mann-Whitney *U*-test or Fisher's exact test when appropriate. All tests were two-tailed, and a *p*-value <0.05 was considered to be statistically significant. The analysis was performed with statistics software (SPSS® Version 9.0, SPSS Inc., Chicago, IL, USA).

Results

The mean follow up periods for Groups 1 and 2 were 2.78 ± 1.89 and 2.26 ± 2.11 years, respectively. Cumulative follow up for these groups were 364 patient-years (pt-yr) and 559 pt-yr. There was no oper-

ative mortality in either group, but two in-hospital deaths occurred in Group 2; one death was due to arrhythmia which was resistant to treatment, and the other was due to coronary embolism with lethal myocardial infarction. No further patients died due to cardiac-related causes during follow up. All relevant complications are listed in Table II. At the latest follow up, 88% and 92% of Groups 1 and 2 respectively were in NYHA functional class I.

Autograft reoperation was necessary in two patients of Group 1. In one case, autograft dilatation with additional cusp prolapse occurred 20 months after the Ross operation and was treated by replacing the failed autograft with an aortic homograft. The second patient who had poorly controlled systemic hypertension developed progressive autograft insufficiency. At reoperation 29 months after the first operation, the left coronary cusp of the autograft had prolapsed and, as the patient was 66 years old at that time, he received a stented bioprosthesis.

In Group 2, three patients underwent autograft reoperation. One patient developed infective endocarditis with severe aortic regurgitation and required surgery. In another patient, technical failure of the autograft implantation at surgery caused progressive incompetence, while the third patient experienced autograft cusp prolapse. All three received bileaflet mechanical prostheses.

Homograft reoperation was necessary twice for one young male patient (aged 8 years) of Group 1. This patient had received an aortic homograft for aortic valve replacement prior to the Ross procedure. Post-operatively, he soon developed a rapidly progressive

homograft stenosis, and eight months after the Ross operation a patch widening of the homograft was performed without loss of valve competence. After a further 47 months the homograft was seen to be stenotic and was replaced with an acellular pulmonary homograft (SynerGraft®; CryoLife Inc., Kennesaw, GA, USA), in an attempt to minimize possible immune reactivity.

In Group 2, four patients underwent replacement of their homograft. Two of these patients developed moderate-to-severe regurgitation due to prolapsing leaflets, and the remaining two showed progressive conduit stenosis. In three cases a replacement was performed with a standard cryopreserved homograft, and in one patient a decellularized pulmonary homograft (SynerGraft®) was implanted.

In addition to the single patient with autograft infective endocarditis of Group 2 who received a mechanical valve for cardiac failure due to autograft regurgitation, one patient from Group 1 was diagnosed with culture-negative early endocarditis. This was suspected on echocardiography and responded to an appropriate antibiotic regimen for two months.

The calculated EOA for Group 1 and Group 2 each were standardized to the patients' BSA and expressed as the number of standard deviations from the mean value of a normal population (z-value, normal deviation; Human Heart Valve Chart, CryoLife Inc., Kennesaw, Georgia, 1999). A z-value of -0.2 ± 1.7 for Group 1 patients indicated that they possessed a similar EOA to that of a normal population of the same age and BSA. The z-value of -1.3 ± 1.4 in Group 2 reflected a slightly lower EOA compared to a corresponding

Table II: Complications.

| Complication | Group 1 (n = 132) | | Group 2 (n = 249) | |
|----------------------------|-------------------|------|-------------------|------|
| | n (%) | LER | n (%) | LER |
| Operative death | 0 | | 0 | |
| Early death | 0 | | 2 (0.8) | |
| Reentry for bleeding | 1 (0.8) | | 1 (0.4) | |
| Pacemaker implantation | 3 (2.3) | | 5 (2.0) | |
| Follow up (years)* | 2.78 ± 1.89 | | 2.26 ± 2.11 | |
| Cardiac-related late death | 0 | | 0 | |
| Thromboembolic events | 0 | | 2 (0.8) | 0.36 |
| Hemorrhagic events | 0 | | 2 (0.8) | 0.36 |
| Reoperation | | | | |
| Autograft | 2 (1.5) | 0.55 | 3 (1.2) | 0.54 |
| Homograft | 1 (0.8) | 0.27 | 4 (1.6) | 0.72 |
| Endocarditis | 1 (0.8) | 0.27 | 1 (0.4) | 0.18 |

*Mean ± SD.

LER: Linearized event rate.

normal population.

All data relating to echocardiographic examinations are listed in Table III.

Discussion

In both patient groups, the perioperative morbidity and complications during follow up were gratifyingly low, and in the mid-term all patients enjoyed excellent hemodynamics due to physiological gradients across the pulmonary autograft valves. Patients who underwent the free-standing root technique (Group 1) were subjected to significantly shorter CPB and cross-clamp times, which supports the theoretical advantage of simplicity over the subcoronary implantation group (Group 2). Clinically relevant autograft regurgitation in both groups was also rare, and in the mid-term period of follow up of the present study it appeared to be independent of surgical technique. This occurred despite earlier publications which reported a higher incidence of autograft regurgitation and thus a higher incidence of autograft-related reoperation in patients treated with the subcoronary technique (2). No statistically significant difference was found between both groups with regard to the development of clinically relevant autograft regurgitation, nor was any higher incidence seen of autograft-related reoperation. The

subcoronary technique has theoretical disadvantages; marked autograft to annulus mismatch presents a technical challenge with the technique, and the maintenance of autograft root geometry in a scalloped subcoronary insertion technique is often imprecise, particularly when applied to a distorted bicuspid aortic annulus, or a previous aortic valve prosthesis recipient. The free-standing root technique on the contrary is more reproducible and easily implanted without distortion. When distended, normal geometry is virtually always achieved. The long-term effects of uneven strain or stress on possibly imprecisely aligned autograft cusp apposition, measured against the deleterious effects of possible dilatation of an unsupported free root autograft with subsequent loss of cuspal coaptation and subsequent prolapse, remain to be identified. In the original series conducted by Donald Ross, 107 patients underwent a subcoronary implantation technique. In the long term, 27 of these patients (6.4%) had an autograft reoperation for regurgitation (16). Other composite graft inclusive technique series have reported on the possibility of wall hematomas and perivalvular leakage with the subcoronary technique (17). In the present series, the free-root group enjoyed lower gradients, which was most likely due to the greater bulk of tissue in the outflow tract resulting from the subcoronary implantation technique.

Table III: Echocardiographic data.

| Parameter | Group 1 (n = 132) | Group 2 (n = 249) | p-value |
|---|----------------------|----------------------|---------|
| NYHA class I (at latest follow up) | 116 (88) | 228 (92) | |
| Diameter of aortic annulus (mm)* | 24.2 ± 2.9 | 21.3 ± 3.4 | <0.05 |
| Diameter of sinus of Valsalva (mm)* | 36.7 ± 5.4 | 28.9 ± 4.1 | <0.05 |
| Autograft | | | |
| Peak systolic gradient (mmHg)* | 5.0 ± 2.7 | 6.7 ± 3.7 | <0.05 |
| Mean systolic gradient (mmHg)* | 2.9 ± 1.3 | 3.7 ± 1.8 | <0.05 |
| AI grade >I | 2 (1.5) | 7 (2.8) | |
| EOA (cm ²)* | 3.84 ± 1.26 | 3.19 ± 0.89 | <0.05 |
| Indexed EOA (cm ² /m ²)* | 1.98 ± 0.57 | 1.64 ± 0.43 | <0.05 |
| z-value of EOA* | -0.2 ± 1.7 | -1.3 ± 1.4 | |
| Homograft | | | |
| Peak systolic gradient (mmHg)* | 15.6 ± 9.0 | 11.7 ± 6.8 | <0.05 |
| Mean systolic gradient (mmHg)* | 9.2 ± 6.2 | 6.1 ± 3.7 | <0.05 |
| Peak systolic gradient >30 mmHg | 7 (5.2) | 5 (2.0) | |
| PI grade >I | 23 (17.4) | 12 (4.8) | <0.05 |
| EOA (cm ²)* | 2.10 ± 1.01 | 2.45 ± 0.97 | <0.05 |
| Indexed EOA (cm ² /m ²)* | 1.08 ± 0.49 | 1.26 ± 0.50 | <0.05 |
| z-value of EOA* | -4.5 ± 1.7 | -3.8 ± 1.6 | |

*Mean ± SD.

Values in parentheses are percentages.

AI: Autograft insufficiency; EOA: Effective orifice area; PI: Pulmonary homograft insufficiency.

However, this difference was of no noticeable clinical relevance for the duration of the present study.

The subcoronary technique is expected to offer protection against autograft dilatation, and indeed, in Group 2 patients no autograft enlargement was observed (8). To date, several reports have been made of autograft reoperation due to autograft regurgitation or aneurysmatic transformation of the autograft, and particularly for the sinus of Valsalva, when the root replacement technique is used (2,4,6). In the present study, autograft dilatation with the free-root technique was also clearly documented (18).

Others have also noted that patients with a larger aortic annulus are more prone to autograft failure with the Ross operation (2,6,8-9). Patients therefore with presumed greater susceptibility to tissue dilatation and aneurysm formation such as those with bicuspid or other congenitally malformed aortic valves might profit from a subcoronary implant of their autograft. On the other hand, in the subgroup of patients with an excessively large aortic annulus, a substantial autograft to aortic annulus mismatch often exists (10), partially in combination with an asymmetric deformed annulus in bicuspid aortic valve disease (19). It is unclear how often such mismatch or concomitant coronary artery anomalies preclude a Ross operation in the subcoronary implantation group, but certainly with the free-root technique the operation is always technically feasible.

In the mid-term, Group 1 patients showed no significantly higher incidence of autograft reoperation than patients in Group 2, while 34% versus 55% of patients had a bicuspid valve at the Ross procedure. In agreement with other publications (2,9), the present authors found that meticulous annulus reduction and fixation also at the sinotubular junction, improved mid-term results and reduced autograft dilatation in the root replacement technique.

The larger annulus diameters in the root replacement technique have the advantage of greater left-sided EOA dimensions and, according to their z-value of EOA, they approximate the mean value of a normal population. The indexed EOA dimensions are largely greater than $0.85 \text{ cm}^2/\text{m}^2$ in both groups - a value proposed and validated recently as a criterion to exclude prosthesis-patient mismatch (20). In fact, this might explain the clinically good results for both groups and the excellent exercise capability of patients after the Ross procedure (21,22). The long-term durability of the demanding subcoronary technique versus the larger sinus of Valsalva and sinotubular junction diameters of the free-root technique is the focus of both of the present groups during future follow up.

In the mid-term, the measured and calculated right-sided homograft parameters reflected satisfying

results, allowing an excellent clinical outcome and a low incidence of homograft-related reoperation in both groups. A detailed analysis did however reveal higher gradients across the valves and a higher incidence of homograft regurgitation when compared to the autograft. This confirmed the pulmonary homograft as being the major disadvantage of the Ross procedure.

Apparent differences in right-sided homograft hemodynamics between both groups were interestingly of statistical significance, with lower gradients and greater indexed EOA in Group 2 patients, as well as a lower incidence of more than grade 1 homograft regurgitation in Group 2. Clinically, these measured differences seemed to be negligible and most likely could be explained by surgical or homograft variation as well as patient age in the two groups.

In Group 1 patients, the inserted homografts were often excessively short due to their origin being mostly from heart-transplanted donors. Despite meticulous non-obstructive suture techniques, a short homograft conduit might be stretched and caused to flatten, with possible reduction of its cross-section or deformation of its geometry. It has been speculated that tension may lead to direct structural tissue damage, or even to the release of tissue factors, leading to an excessive mediastinal fibrotic reaction (23). Right-sided homograft performance and its durability is not yet ideal.

In conclusion, for the mid-term of this study the overall excellent results with a low morbidity and few reoperations independent of technique justified the use of both methods. Where the subcoronary implantation and the root replacement technique do differ in major respect is with regard to the more stable autograft dimensions in the subcoronary group and larger EOA dimensions in the root replacement technique, though in the mid-term no clear clinically relevant difference is apparent. Long-term follow up and greater patient numbers may alter this conclusion, however. The cryopreserved homograft does not yet offer the ideal pulmonary valve replacement.

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Meeting discussion

DR. J.J.M. TAKKENBERG (Rotterdam, Netherlands): Could you provide some more detail on the autografts that were reoperated on. What happened to them?

DR. JÜRGEN O. BÖHM (Stuttgart, Germany): There was only one autograft reoperation for Group 1, but I can tell you full series results. Until now, we have performed 40 Ross operations and have had seven patients with autograft failure. Five of those patients were operated on early in the series. All of them had a type of annular dilatation with subsequent cusp prolapse - that is why we introduced annulus support with a Dacron strip.

DR. TAKKENBERG: What about neo-aortic root dilatation?

DR. BÖHM: One patient had endocarditis and needed reoperation, one patient had a surgical/technical problem, and a third patient had leaflet prolapse.

DR. HANS-HINRICH SIEVERS (Luebeck, Germany): But the question was, do you find some patients with dilatation of the root, the sinus area of the root replacement?

DR. BÖHM: Yes. But none needed reoperation for this reason.

DR. SIEVERS: We saw your dimensions - it was 36 mm in the sinus of Valsalva area. Were there other dilatations at the sinotubular junction?

DR. BÖHM: Dilatation occurs mainly at the site of the sinus of Valsalva.

DR. SIEVERS: But the sinotubular junction size is constant?

DR. BÖHM: Yes, very stable.

SIR MAGDI M. YACOUB (London, UK): Did you look sequentially at sinus diameters, annular sinus and sinotubular, year by year, in both groups?

DR. BÖHM: Yes. The patients had a yearly follow up at each institution, and annual echocardiographic examinations were performed. We have some patients

with continuous dilatation - that's the reason we changed our technique.

DR. SIEVERS: I think one of the important points here is that we compared two groups and two surgeons. We found that there was a lower effective orifice area in the subcoronary technique. Why it occurs, I do not know, so we have to check that. The other point is that there was a difference in the homograft between both groups - so we have to look for a reason for that, to improve the results.

MR. YACOUB: Are these results from the German Registry, or one surgeon-type results? I ask because it is relevant in terms of the techniques used. As we have just said, technical factors can play a major role both in the upper and lower suture lines. If there are multicenter-type statistics, that's welcome, but for that to happen we must control assiduously all the technical factors, otherwise we will be no wiser.

DR. SIEVERS: You are totally correct. These are the first results of the Registry, from two centers, and comparing mainly two surgeons and two surgical techniques. But now we have integrated more than six

centers, and are completing the results. So what you said is becoming increasingly important.

DR. CORNELIUS A. BOTHA (Stuttgart, Germany): It is gratifying that the full root technique has followed a general pattern. Everybody seems to have the same conclusions - fix the bottom and fix the top, the sinotubular junction and the annulus. But very often, with annuloectasia, you have large roots to reduce. This report is interesting because maybe we should look at subgroups - if the subcoronary procedure can be reproduced and revived, then it's those patients where you have reduced the annulus that also often have a larger pulmonary autograft - the two go together. If the aorta is large, the autograft is also large, generally. These groups should then probably be put into the aorta as a subcoronary implant. The aim should be to identify subgroups best suited for either technique.

DR. SIEVERS: Thank you - I think you are totally correct. As Sir Magdi Yacoub has just said, we have to look at subgroups and different surgical techniques, and compare the results.