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Wall motion score index predicts mortality and functional result after surgical ventricular restoration for advanced ischemic heart failure☆

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Abstract

Objective: Advanced ischemic heart failure can be treated with surgical ventricular restoration (SVR). While numerous risk factors for mortality and recurrent heart failure have been identified, no plain predictor for identifying SVR patients with left ventricular damage beyond recovery is yet available. We tested echocardiographic wall motion score index (WMSI) as a predictor for mortality or poor functional result. **Methods:** One hundred and one patients electively operated between April 2002 and April 2007 were included for analysis. All patients had advanced ischemic heart failure (NYHA-class $\geq$ III and LVEF $\leq$ 35%). Mean logistic EuroSCORE was 10 $\pm$ 8. All patients were evaluated at 1-year follow-up. Risk factors for poor outcome, defined as mortality or poor functional result (NYHA class $\geq$ III) at 1-year follow-up were identified by univariable logistic regression analysis. Preoperatively, a 16-segment echocardiographic WMSI was calculated and receiver operating characteristic curve analysis was used to identify cut-off values for WMSI in predicting poor outcome. **Results:** Early mortality was 9.9%, late mortality 6.6%. NYHA class improved from 3.2 $\pm$ 0.4 to 1.5 $\pm$ 0.7. At 1-year follow-up, 10 patients (12%) were in NYHA class III and the remaining patients were in NYHA class I or II (75 patients, 88%). WMSI was found to be the only statistically significant predictor for poor outcome (odds ratio 139, 95% confidence interval (CI) 17—1116, $p < 0.0001$). The optimal cut-off value for WMSI in predicting mortality or poor functional result was 2.19 with a sensitivity and specificity of 82% (95% CI 81.5—82.5% and 81.4—82.6%). The area under the curve was 0.94 (95% CI 0.90—0.99). Positive and negative predictive values were 67% and 92% respectively (95% CI 66.4—67.6% and 91.4—92.6%). **Conclusions:** Sufficient residual remote myocardium is necessary to recover from a SVR procedure and to translate the surgically induced morphological changes into a functional improvement. Preoperative WMSI is a surrogate measure of residual remote myocardial function and is a promising tool for better patient selection to improve results after SVR procedures for advanced ischemic heart failure.
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Keywords: Surgical ventricular restoration (SVR); Left ventricular reconstruction surgery; Dor procedure; Ischemic heart disease; Heart failure; Wall motion score index (WMSI); Risk stratification; Risk factors

1. Introduction

Surgical ventricular restoration (SVR) has established its position in the treatment of patients with post-infarction ventricular dilatation and a wide range of symptoms [1—3]. This procedure is also increasingly performed in patients with severely depressed left ventricular function and heart failure [5,6]. SVR encompasses ventricular remodeling surgery combined with complete coronary revascularization and mitral valve plasty or replacement when moderate or severe mitral regurgitation is present. The ventricular remodeling as described by Dor et al. excludes asynergetic areas, restores the normally elliptical left ventricular shape and reduces the left ventricular volume within the normal range. This results in reduced left ventricular wall stress with decreased oxygen consumption and reorients the myocardial fibers to a more efficient orientation to improve systolic performance [4].

While numerous studies have identified risk factors for mortality and limited survival after SVR in patients with heart failure, including renal insufficiency, severe mitral regurgitation, concomitant mitral valve surgery, and progressive left ventricular dilatation, no plain risk variable is yet available to identify patients who have a poor outcome [10,11,16]. Better patient selection and preoperative risk stratification will reduce mortality and improve outcome after SVR procedures. In this study, the echocardiographic wall motion score index (WMSI) was evaluated as a predictor

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Table 1
Preoperative patient characteristics (n = 101).

Age (years) (mean ± SD)	61 ± 10
Gender, male/female (n)	81/20
Median interval after infarction (months, range)	48 (0—360)
<3 months (n, %)	7 (6.9%)
>3 months (n, %)	94 (93.1%)
Previous cardiac surgery (n, %)	8 (7.9%)
Renal insufficiency (n, %)	5 (5.0%)
Severe pulmonary hypertension (n, %)	13 (12.9%)
Logistic EuroSCORE (mean ± SD)	10 ± 8
NYHA class (mean ± SD)	3.2 ± 0.4
III (n, %)	81 (80.2%)
IV (n, %)	20 (19.8%)
Concomitant angina (n, %)	18 (17.81%)
CCS class (mean ± SD)	2.7 ± 0.6
VO2max (mean ± SD)	17 ± 5
Spontaneous VT (n, %)	21 (20.8%)
Preoperative ICD implantation (n, %)	23 (22.8%)

NYHA: New York Heart Association; VT: ventricular tachyarrhythmia; ICD, implantable cardioverter-defibrillator.

for mortality or poor functional result in patients with advanced ischemic heart failure undergoing SVR.

2. Materials and methods

2.1. Patient characteristics

Between April 2002 and April 2007, 101 patients were electively operated and included for analysis. There were 80 men and the mean age was 61 ± 10 years. All patients had advanced ischemic heart failure (NYHA class ≥ III and LVEF ≤ 35%), 81 patients were in NYHA class III and 20 patients in NYHA class IV. Patients were considered eligible for surgery, whenever at least three of the four segments of the remote myocardium, i.e. the basal pyramid of the left ventricle (septum, anterior, lateral and inferior regions) showed systolic thickening. If only two segments showed thickening, the potential for functional recovery of at least one additional basal segment was actively sought for. For this purpose, viability studies including dobutamine-stress echocardiography, and/or contrast-enhanced MRI were used. Severe renal insufficiency (serum creatinine ≥ 200 μmol/l) was present in five patients. Thirteen patients had severe pulmonary hypertension (systolic pulmonary artery pressure ≥ 60 mmHg). Logistic EuroSCORE averaged 10 ± 8. Concomitant angina was present in 18 patients. The median time interval after myocardial infarction was 48 months (range 0—360) and seven patients were operated within 3 months after infarction. Eight patients had previous cardiac surgery. Patients with coexisting aortic valve disease necessitating aortic valve replacement or previous aortic valve surgery were excluded. A summary of the patient characteristics is provided in Table 1.

The mean LVEF was 25 ± 7%, mean left ventricular end-diastolic volume index (LVEDVI) and left ventricular end-systolic volume index (LVESVI) were 116 ± 46 ml/m^2 BSA and 87 ± 42 ml/m^2 BSA respectively. Moderate to severe mitral regurgitation was present in 49 patients. The preoperative echocardiographic data are shown in Table 2.

2.2. Operative technique

All operations were performed using normothermic cardiopulmonary bypass, aortic cross-clamping and intermittent antegrade warm-blood cardioplegia. SVR was carried out according to Dor using a shaping Fontan stitch at the transitional zone between viable and scarred myocardium and sizing the residual ventricle using a saline-filled balloon or commercially available shaper (TRISVR, Chase Medical, Richardson, TX, USA) at 55 ml/m^2 BSA. An endoventricular oval Dacron patch was used to close the residual opening left after tightening the Fontan stitch around the balloon. To facilitate the creation of a neo-apex in 13 patients, one or two U stitches where placed in the inferior wall [24]. Concomitant myocardial revascularization was performed in 60 patients. The mean number of distal anastomoses was 2.3 ± 1.2. Restrictive mitral annuloplasty (RMA) with stringent down-sizing (two sizes) using a semi-rigid ring (Carpentier Edwards Physioring, Edwards Lifesciences, Irvine, CA, USA) was performed in 53 patients in whom pre- or intra-operative echocardiography demonstrated at least moderate mitral regurgitation. In 19 patients a concomitant tricuspid annuloplasty was performed using the MC3-ring (Edwards Lifesciences, Irvine, CA, USA) because the tricuspid annular diameter exceeded 40 mm (our threshold for tricuspid annuloplasty). If patients had spontaneous ventricular arrhythmias preoperatively, a cryo-ablation at the border zone between scar tissue and viable myocardium was performed; this procedure was performed in 11 patients. Since 2006 implantation of an epicardial LV-lead formed a routine part of the procedure. A summary of the surgical data is provided in Table 3.

2.3. Pre- and postoperative echocardiography

A transthoracic echocardiogram (TTE) was performed within 3 days before surgery. Patients were imaged in the left lateral decubitus position using a commercially available

Table 2
Transthoracic echocardiographic data.

	Baseline	Early postop.	p value early vs baseline	1-year FU	p value 1-year FU vs early postop.
EF (%)	25 ± 7	36 ± 9	<.01	36 ± 11	.76
LVESVI (ml/m^2 BSA)	87 ± 42	48 ± 18	<.01	53 ± 25	.50
LVEDVI (mL/m^2 BSA)	116 ± 46	73 ± 21	<.01	79 ± 26	.33
LVESD (cm)	5.1 ± 1.1	4.8 ± 1.0	0.06	4.8 ± 1.0	.75
LVEDD (cm)	6.5 ± 1.0	6.0 ± 1.0	<.01	6.1 ± 0.8	.39

EF: left ventricular ejection fraction; LVEDVI: left ventricular end-diastolic volume index; LVESVI: left ventricular end-systolic volume index; BSA: body surface area; LVEDD: left ventricular end-diastolic diameter; LVESD: left ventricular end-systolic diameter; postop.: postoperative; FU: follow-up; SD: standard deviation.

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Table 3
Surgical data (n = 101).

SVR with patch (n, %)	98 (97.0%)
Patch size (cm^2) (mean ± SD)	13 ± 8
Inferior wall plication (n, %)	13 (12.9%)
Balloon/shaper size (ml) (mean ± SD)	109 ± 12
Mitral valve annuloplasty (n, %)	53 (52.5%)
median ring size (range)	26 (24—30)
Tricuspid valve annuloplasty (n, %)	19 (18.8%)
median ring size (range)	30 (26—34)
CABG (n, %)	60 (59.4%)
No. of distal anastomosis/patient (mean ± SD)	2.3 ± 1.2
Cryo-ablation (n, %)	11 (10.9%)
Epicardial LV-lead (n, %)	26 (25.7%)
IABP (n, %)	20 (19.8%)

SVR: surgical ventricular restoration; IABP: intra-aortic balloon pump.

system (Vingmed Vivid Seven, General Electric-Vingmed, Milwaukee, Wisconsin, USA). Images were obtained using a 3.5 MHz transducer at a depth of 16 cm in the parasternal and apical views (standard long-axis, 2- and 4-chamber images). The left ventricular dimensions (end-systolic and end-diastolic) were determined from parasternal M-mode acquisitions. The left ventricular volumes and LVEF were calculated from the conventional apical 2- and 4-chamber images, using the biplane Simpson's technique. Serial TTEs were performed after surgery as part of a structured heart failure program, with the first postoperative TTE performed before hospital discharge. From the TTEs performed at discharge and at 1-year follow-up, LVEF, left ventricular dimensions, left ventricular volumes and left ventricular shape were derived. Two cardiologists, blinded from the clinical data and the timing of the echocardiogram, analyzed all TTEs in random order.

2.4. Echocardiographic wall motion score index

Preoperative regional left ventricular function was evaluated by the echocardiographic derived WMSI. As recommended by the American Society for Echocardiography a 16-segment model was used for left ventricular segmentation [23]. This model consists of six segments at both the basal and mid-ventricular levels and four segments at the apex. The attachment of the right ventricular wall to the left ventricle defines the septum, which is divided at basal and mid-left ventricular levels into anteroseptum and inferoseptum. Continuing counterclockwise, the remaining segments at both basal and mid-ventricular levels are labeled as inferior, inferolateral, anterolateral and anterior. The apex includes septal, inferior, lateral and anterior segments. Each segment was analyzed individually and scored on the basis of its motion and systolic thickening. Each segment's function was confirmed in multiple views. Segments were scored are as: normal or hyperkinesis = 1, hypokinesis = 2, akinesis = 3 and dyskinesis (or aneurysmatic) = 4. WMSI was derived as the sum of all scores divided by the number of segments visualized.

2.5. Clinical follow-up

Patients were maintained on optimal medical treatment for heart failure after surgery, i.e. whenever possible ACE-inhibitors, spironolactone, diuretics and β-blockers were prescribed. Functional status was assessed using the NYHA classification for heart failure symptoms. The symptoms were evaluated within 1 week before surgery and at serial follow-up visits at the outpatient clinic as part of the structured heart failure program. For all surviving patients, NYHA class at 1 year was assessed.

2.6. Statistical analysis

Statistical analysis was performed using SPSS 16.0 statistical software (SPSS Inc, Chicago, IL, USA). Categorical variables are described as frequencies and percentages and compared using the chi-square test with Yates' correction. Continuous data are expressed as mean ± standard deviation (SD) or median with ranges and compared using Student's t-test for paired data. Risk factors for poor outcome, defined as mortality or poor functional result (NYHA-class ≥ III) at 1-year follow-up, were identified by logistic regression analysis. The optimal cut-off value for WMSI to predict poor outcome was determined by receiver operating characteristics (ROC) curve analysis. The optimal cut-off value was defined as that providing maximal accuracy to distinguish between patients with a good outcome (NYHA class I or II) and patients with a poor outcome. A p value <0.05 was considered significant.

3. Results

3.1. Clinical results

Early mortality (in-hospital or <30 days mortality) was 9.9% (10 patients). Causes of early mortality are shown in Table 4. Mean postoperative stay in the intensive care unit was 7 ± 9 days. Mean postoperative stay in the hospital was 19 ± 15 days. In 36 patients (39.6%) an internal cardioverter-defibrillator (ICD) was implanted postoperatively for primary or secondary prevention (an additional 23 patients already had an ICD preoperatively).

All patients were evaluated at 1-year follow-up. Late mortality was 6.6% (six patients). Causes of late mortality are shown in Table 4. At follow-up, a significant functional improvement was observed: mean NYHA class improved from 3.2 ± 0.4 preoperatively to 1.5 ± 0.7 ($p < 0.001$) at 1-year follow-up. Of the surviving patients, 88.2% (75 patients) were in NYHA class I or II and 11.8% (10 patients) had recurrent heart failure (NYHA class ≥ III). No patients needed reoperation during the follow-up period. Endocarditis or thromboembolic events were not observed.

3.2. Risk factors for mortality or poor functional result

Preoperative WMSI was found to be a highly significant predictor at univariable analysis for poor outcome at 1 year (odds ratio (OR) 139, 95% confidence interval (CI) 17—1116, $p < 0.0001$) (Table 5). Other preoperative risk factors, including age, renal insufficiency (serum creatinine ≥ 200 μmol/l), severe pulmonary hypertension (systolic pulmonary artery pressure ≥ 60 mmHg), moderate to severe mitral regurgitation, LVEF, LVESVI, and LVEDVI were not

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Table 4
Causes of early and late mortality .

Cause of early mortality	No. of patients	Cause of late mortality	No. of patients
Cardiac early mortality	7	Cardiac late mortality	3
HF/LCO	6	HF/LCO	2
AMI	1	SCD	1
Non-cardiac early mortality	3	Unknown	3
Sepsis	2		
Pump lung	1		
Total early mortality	10	Total late mortality	6

HF/LCO: heart failure or low cardiac output; AMI: acute myocardial infarction; SCD: sudden cardiac death.

Table 5
Logistic regression analysis.

Preoperative variables	Univariable analysis		
	OR	95% CI	*p*
Age	1.004	0.961—1.049	0.866
Renal dysfunction	2.116	0.333—13.451	0.427
Pulmonary hypertension	2.125	0.625—7.223	0.227
Moderate—severe mitral regurgitation	1.853	0.739—4.645	0.188
EF	0.99	0.926—1.059	0.771
LVESVI	0.995	0.983—1.007	0.42
LVEDVI	0.997	0.986—1.007	0.529
WMSI	139	17—1116	<0.0001

EF: left ventricular ejection fraction; LVESVI: left ventricular end-systolic volume index; LVEDVI: left ventricular end-diastolic volume index; WMSI: wall motion score index; CI: confidence interval.

statistically significant (Table 5). Since only one statistically significant predictor was found at univariable analysis, a multivariable analysis would be redundant.

3.3. Echocardiography and WMSI

LVEF, left ventricular dimensions and volumes (indexed) as measured by TTE preoperatively, early postoperatively (at discharge) and at 1-year follow-up are provided in Table 2. A significant improvement in LVEF occurred early postoperatively, with a reduction in left ventricular volumes. At 1-year follow-up these changes were maintained.

The preoperative WMSI could range from 1 to 4. ROC curve analysis revealed that the optimal cut-off value for WMSI to predict mortality or poor functional result was 2.19; application of this cut-off value yielded a sensitivity and specificity of 82% (95% CI 81.5—82.5% and 81.4—82.6%). The ROC curve is shown in Fig. 1. The area under the curve for this cut-off value was 0.94 (95% CI 0.90—0.99) (Fig. 2). Positive and negative predictive values were 67% and 92% respectively (95% CI 66.4—67.6% and 91.4—92.6%). Calculating 95% sensitivity and specificity yielded a WMSI of 2.3 and 2.1 respectively. The scatter-plot of WMSI versus outcome is shown in Fig. 3. It is noteworthy that below a WMSI of 2.0 no mortality or poor outcome was observed. Conversely, above a WMSI of 2.5, outcome was always poor.

4. Discussion

We found that the echocardiographically derived WMSI has a good ability to predict outcome after SVR surgery. This was the single statistically significant predictor for poor outcome at 1-year follow-up. Other preoperative variables including age, renal insufficiency, severe pulmonary hypertension, and moderate to severe mitral regurgitation proved not to be significant predictors of outcome. While numerous studies did identify renal insufficiency, posterior infarction, concomitant mitral valve surgery, age and diabetes as risk factors for mortality and limited survival after SVR in patients with

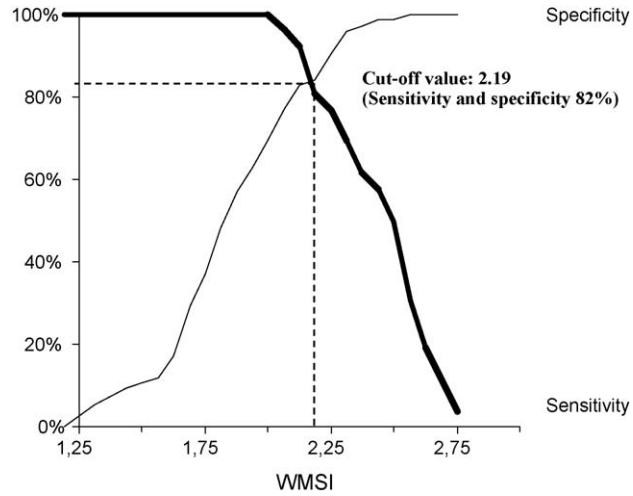

Fig. 1. ROC curve analysis shows an optimal cut-off value for WMSI in predicting mortality or poor functional result of 2.19 (sensitivity and specificity 82%). WMSI: wall motion score index.

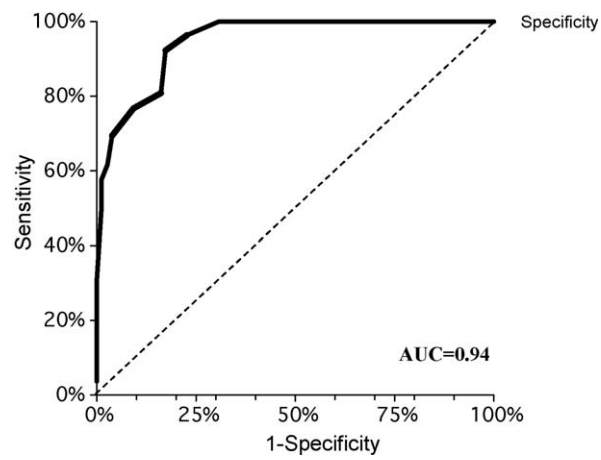

Fig. 2. ROC curve analysis shows an area under the curve (AUC) of 0.94 (95% CI 0.90—0.99).

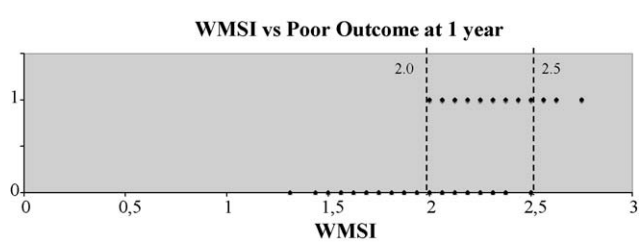

Fig. 3. Scatter-plot. The dotted lines indicate a WMSI of 2.0, below which the outcome was always favorable and a WMSI of 2.5, above which the outcome was consistently poor. WMSI: wall motion score index.

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heart failure, they are not useful as a screening tool for SVR [10,11]. Besides comorbidity and concomitant procedures a depressed LVEF has been reported to be a predictor of increased early and late mortality [12—14]. However, White et al. described that left ventricular dilatation after myocardial infarction was more closely related to outcome then a decreased LVEF [15]. Di Donato and Dor confirmed that in ventricular restoration procedures, relatively irrespective of LVEF, the mortality increased in parallel to preoperative left ventricular volumes [16]. However, heterogeneity in the capacity for functional recovery of the residual remote myocardium might influence operative risk in patients with equally increased left ventricular volumes. Indeed, the post-infarction remodeled left ventricle consists of heterogeneous tissue: scar (with varying degrees of transmurality), and residual myocardium with varying contractility. Volume derived indices, such as LVEDV or LVEF are incapable of predicting outcome since these parameters depend on global ventricular measurements. It was indeed observed that preoperative LVEF, LVESVI and LVEDVI were not statistically significant in predicting for poor outcome after SVR surgery. A potential screening tool needs to take into account the variability in function of various areas of the ventricle and WMSI appears to reflect this information.

Why is screening for SVR so important? SVR is increasingly performed in patients with heart failure and severely depressed left ventricular function [5,6]. Although improved outcome have been reported, its widespread use is still hampered by a considerable early mortality and uncertainty about late outcome [8]. We recently performed a structured literature review (including 14 studies with 4135 patients) and noted an early mortality of 11.0% with a late mortality at 3 years of 15.2% in patients operated for heart failure [7]. However, the results need to be interpreted with caution, since significant heterogeneity of the underlying type and extent of dysfunction (localized dyskinesis or true aneurysms vs global hypokinesis). Menicanti et al. reported an early mortality of 6.6% in a homogenous series of patients that underwent SVR for ischemic cardiomyopathy [8]. In these patients a global increase of systolic function with a sustained reduction in left ventricular volumes was demonstrated. It is of interest that the 'real-world' application of SVR, is associated with higher operative risks as reported by Hernandez et al. as compared to the results reported by experienced tertiary referral centers [9].

In the current series of patients with advanced ischemic heart failure (NYHA class $\geq$ III and LVEF $\leq$ 35%) we observed an early mortality of 9.9% with a late mortality of 6.6% at 1-year follow-up. In addition, a significant improvement in systolic function with a reduction in left ventricular volumes was noted, which was maintained at 1-year follow-up. Given this significant improvement in both ventricular function and functional status, it therefore appears that patient selection forms the dominant problem evaluated at 1 year after the operation. Although continuous improvement in early surgical outcome has been demonstrated by various groups around the world, patient selection remains a difficult issue. Apparently, the systolic function of the remote myocardium is important for residual left ventricular systolic function after SVR and subsequent long-term outcome. In an attempt to quantify systolic left ventricular function, WMSI has been used since this parameter reflects a summation of the entire systolic function of the left ventricle. Our initial strategy to use the function of the basal pyramid to select patients eligible for SVR surgery, proved to be insufficient: about one-quarter of the patients did not benefit from the procedure (26 out of 101 patients: mortality 15 patients, NYHA class $\geq$ III 10 patients). Indeed using the function of the basal pyramid takes into account only part of the left ventricle and does not differentiate between normo- and hypokinesia. WMSI considers the entire left ventricle and uses quantitative segmental function.

Indeed, application of WMSI to select patients appeared useful since this parameter could predict outcome with 95% sensitivity and specificity if the WMSI was above 2.3 or below 2.1 respectively. Moreover, if WMSI was below 2.0, outcome was always favorable and if WMSI was above 2.5 a poor outcome was obtained. Accordingly, patients with a WMSI $<$2.0 have a high likelihood of good outcome after SVR, whereas patients with a WMSI $>$2.5 have a high likelihood of poor outcome and should not be referred for SVR. Patients with a WMSI between 2.0 and 2.5, results may vary in outcome, and in these patients additional information may be needed to decide on SVR or not. Apparently, some patients with this score do well and others do not. This might be caused by reserve contractile properties of the left ventricle, related to ischemia (hibernation) or remodeling. The potential to reverse those factors will most likely determine the final outcome. The capability of the remaining left ventricle to improve its function after a SVR procedure is difficult to predict. Obviously, when large areas of (reversible) ischemia are present, even patients with very bad contractility will recover.

Future studies are needed in this patient category to further define additional parameters to optimize prediction of outcome after SVR. Possibly, more information on the presence and the extent of scar tissue and viable myocardium is needed, and for this, more sophisticated imaging techniques are needed such as metabolic imaging with positron emission tomography or contrast-enhanced MRI [17,18]. Hibernating myocardial segments or myocardial segments with partial scar tissue and high wall stress could improve contractility after coronary revascularization and SVR respectively [19]. Echocardiography and WMSI have the disadvantage of not being able to distinguish viable or hibernating myocardium from scar tissue among segments of not contracting myocardium compared to, for example contrast-enhanced MRI [20]. On the other hand, echocardiography can be performed in all patients, irrespective of the presence of devices like (biventricular) pacemakers or ICDs. Progressive use of device-therapy in patients with heart failure in forthcoming years renders an imaging technique with few contraindications of particular use [21,22]. Moreover, echocardiography is widely available and easy to perform. These are important advantages over MRI if used as a screening tool.

5. Limitations

Although a fairly large sample size is included, more patients need to be studied to confirm the current results.

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Also, longer follow-up data are needed. Finally, future studies need to focus on patients with WMSI between 2.0 and 2.5 to evaluate what additional information (provided by which techniques) is needed to further optimize prediction of outcome after SVR.

6. Conclusions

In conclusion, sufficient residual remote myocardium is necessary to recover from a SVR procedure and to translate the surgically induced morphological changes into a functional improvement. Preoperative WMSI is a surrogate measure of residual remote myocardial function and is a promising tool for improved patient selection. Implementation of echocardiographic WMSI will help to improve results after SVR procedures for advanced ischemic heart failure.

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Appendix A. Conference discussion

Dr H. Suma (*Tokyo, Japan*): I thank you for showing us a good way to select the patient in the surgical treatment for ischemic heart failure by using echo study, which is routinely available in our practice. In fact, we still don't have a reliable method to predict an outcome following surgical ventricular restoration, particularly in case of dilated left ventricle. As we know, there are heterogeneous extents of myocardial viability, and it is hard to detect its reversibility by using ordinary examination in those groups of patients. I have two questions.

Number one, as you said, all of those patients who have a wall motion score index more than 2.5 went bad after surgery. Was it because the remaining myocardium was too bad or you made the ventricle too small, because those bad ventricles often have low compliance and high stiffness. The second question is, because wall motion score index between 2.0 and 2.5 is a gray zone, do you think dobutamine echo or some other method is valuable to find a good candidate for surgery?

Dr Klein: We recognize your vast experience in left ventricular restoration procedures for both ischemic and non-ischemic cardiomyopathy. To answer your first question about diastolic failure in some patients: we size the residual

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left ventricular volume using an intracavitary balloon or a commercially available shaper device to 50 to 60 ml/m^2 of body surface area. This avoids creating a residual ventricle that is too small, which would lead to diastolic failure. All of these patients were sized according to this technique. So the failure outcome, predominantly heart failure or recurrent heart failure, which constitutes the majority of the mortality, about two thirds, can be ascribed to systolic failure and not to diastolic failure.

To answer your second question about the intermediate group, we used advanced imaging techniques like dobutamine-stress echocardiography, late enhancement MRI, and viability testing by nuclear imaging to find evidence of contractility or viability in these patients. A further study is being conducted to analyze this subgroup between a wall motion score index of 2.0 and 2.5 to find what tests may predict contractility or viability.

Dr P. Pinho (*Porto, Portugal*): I have a couple of questions. If I well remember, we focused initially on when you do the Doppler series, mostly on the extension and the type of infarcted area. I don't know if your numbers include mostly patients with akinetic or dyskinetic areas. Do you think with this score, the score is valid for both types of dysfunctional myocardium that you are supposed to reconstruct?

Dr Klein: The patients in our study have mainly akinetic segments; only 20% have clear dyskinesia. So 80% have extended akinesia. Wall motion score actually assigns a 3 for akinetic segments and a 4 for dyskinetic segments, which would make dyskinesia more severe than akinesia. Maybe this is correct, because in akinetic segments, part of the infarction may be not completely transmural, let's say less than 50 or 40%, and has the potential to increase contractility if wall stress is less, if there is revascularization. So contractility might improve in these segments. I think wall motion index adequately assigns a lower score to akinesia.

Dr M. Zembala (*Zabrze, Poland*): My question is, can you share just this experience from wall motion score to something more practical, like Di Donato classification, which for us is very practical and covered the echo findings, angio and magnetic resonance together, and including one territory versus multi-territory as well? That is one question.

The comments. Again, thank you for inspiration for this very important issue, but let's wait for the published outcomes of STICH data which will allow us to get to know better this significant and difficult problem.

Dr Klein: Of course, the STICH trial is also eagerly awaited in our center, which will render very interesting results for this group of patients. We are still studying the combination of wall motion score index and other risk stratifying and predictors of outcome in this patient group. So we will correlate different predictors and different imaging techniques to wall motion score index in order to come up with the best predictors and the best risk stratifying sequence.

Dr Zembala: Especially when it is practically quite easy.

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