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Renal Function after Port Access and Median Sternotomy Mitral Valve Surgery

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ABSTRACT

Background. Acute renal injury is an important postoperative complication of mitral valve surgery. We tested the hypothesis that minimally invasive port access (PA) surgery is linked to a smaller postoperative renal injury compared to the standard median sternotomy (MS) technique.

Methods. Ninety-six patients in the PA group and 102 patients in the MS group were compared regarding postoperative renal dysfunction. Preoperative and maximal postoperative serum creatinine levels were used to calculate creatinine clearance which was implemented for the renal function assessment. Additionally, the new RIFLE classification for acute renal injury was used for the comparison of the postoperative kidney function. This classification is divided into 3 levels and in addition to the glomerular filtration rate, it is also based on urine output.

Results. The analysis of preoperative renal function did not demonstrate any significant differences between the two groups in any of the creatinine-based renal function markers. However, the comparison of the minimal postoperative creatinine clearance showed significantly lower values in the median sternotomy group. The conventional MS approach was confirmed as an independent renal risk factor in the multivariate analysis. The postoperative RIFLE classification comparison also showed higher postoperative renal impairment in the MS group.

Conclusion. With the limitations of a retrospective study, our results suggest that for mitral valve surgery the minimally invasive PA approach might be associated with lower postoperative renal injury compared to the conventional surgical technique.

INTRODUCTION

Acute postoperative renal failure (ARF) remains an important cause of increased mortality, morbidity, and cost in cardiac surgery. Renal failure requiring renal replacement therapy develops in 1% to 2% of patients after cardiac surgery and is linked to especially high mortality rates, reaching over 60% [Chertow 1997; Bove 2004]. Recent reports state that even minor postoperative reductions in renal function, where renal replacement therapy is not necessary and creatinine values increase only mildly or remain within normal ranges, influence the outcome of cardiac surgery [Mangano 2000; Stafford-Smith 2001; Lassnigg 2004]. The incidence of ARF depends on definitions employed. Because over 35 definitions of ARF have been so far used in the literature, new consensus recommendations have been outlined by The Acute Dialysis Quality Initiative Workgroup [Bellomo 2004]. This new Risk, Injury, Failure, Loss and End-Stage (RIFLE) classification, divides ARF into 3 levels according to either creatinine level or urine output (UO). It has already been proposed as a robust and valuable method for the evaluation of ARF in critically ill patients [Hoste 2006], including patients after cardiac surgery [Kuitunen 2006].

Port access (PA) was introduced to perform minimally invasive video-assisted valvular operations using minithoracotomy instead of median sternotomy. Many aspects of PA surgery have been evaluated and compared to classical median sternotomy, but according to our knowledge there has been only one study specifically comparing postoperative acute renal injury after PA and median sternotomy (MS) mitral valve surgery [McCreath 2003]. McCreath's study is based on creatinine-derived renal function markers. Our investigation also includes UO as a renal function indicator and represents the first comparative report of renal dysfunction between PA and MS mitral valve surgery concerning the severity of the RIFLE classification.

MATERIALS AND METHODS

Patient Selection and Data Collection

Prospectively collected data on adult patients who underwent mitral valve surgery between January 2001 and December 2004 at our institution were obtained from medical records and retrospectively analyzed. The study was approved by the National Medical Ethics Committee.

Emergency operations, simultaneous myocardial revascularizations, aortic valve and atrial reduction procedures were

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Table 1. Demographics*

	Port Access	Median Sternotomy	*P*
Age, y	62.0 (10.3)	60.8 (11.6)	.435
Weight, kg	74.6 (13.9)	74.5 (16.8)	.963
Height, cm	168.7 (11.3)	167.7 (8.8)	.478
Body mass index, kg/m^2	26.2 (4.4)	26.4 (5.0)	.749
Female, %	51.0	59.8	.215
Mitral regurgitation, %	74.0	74.5	.929
Mitral stenosis, %	12.5	15.7	.520
Combined stenosis and regurgitation, %	12.5	9.8	.546
Mitral valve replacement, %	82.3	78.4	.495
Mitral valve repair, %	17.7	21.6	.495
Concomitant tricuspid valve repair, %	38.5	46.1	.284
Additive EuroSCORE index	4.77 (2.07)	5.33 (2.02)	.054
Logistic EuroSCORE index, %	4.52 (3.56)	5.37 (4.11)	.126
Previous cardiac surgery, %	3.1	11.8	.022
Chronic obstructive lung disease, %	1.04	4.90	.113
Pulmonary hypertension >60 mmHg, %	20.8	22.6	.770
Diabetes mellitus, %	6.3	5.9	.914
Arterial hypertension, %	29.2	31.4	.736
Left ventricular ejection fraction <50%, %	23.2	31.4	.197
Preoperative use of ACEI, %	69.2	68.3	.900
Preoperative use of diuretics, %	43.6	56.4	.074
Cardiopulmonary bypass time, min	151.4 (45.6)	100.5 (34.0)	<.001
Aortic occlusion time, min	88.3 (27.9)	64.5 (22.4)	<.001
Aprotinine use, %	100.0	59.6	<.001

*Univariate analysis. Mean values or percentage, values in the brackets represent standard deviation. ACEI indicates angiotensin converting enzyme inhibitors.

excluded. We also excluded patients with preoperative acute or chronic renal failure requiring renal replacement therapy. Tricuspid valve repair was not an exclusion criterion. As defined by the EuroSCORE system, an emergency operation was any surgery carried out before the beginning of the next working day [Roques 1999]. There were 3 conversions from PA to MS. All conversions were marked as PA patients on the basis of "intention-to-treat" analysis. One patient was cardiopulmonary resuscitated immediately prior to surgery. Since it was not possible to determine the isolated effect of surgical intervention on renal function in this case, the patient was excluded as well. Demographic data collection (Table 1) based on previously described renal failure risk factors in cardiac surgery [Chertow 1997; Mangano 1998; Bove 2004]. Besides the renal function markers (Table 2), the postoperative data collection includes the postoperative intubation time, intensive care unit (ICU) stay, hospitalization time, transfusion needs, drainage volumes, inotropic and intra-aortic balloon pump support and also antibiotic, diuretic, and aprotinine use (Table 3).

Renal Function Markers

Preoperative creatinine (Cr.Pre) levels were obtained from routine blood tests as part of the Department's preoperative protocol. Postoperative creatinine levels were measured once or twice daily during the ICU stay and later at regular intervals, depending on the clinical situation. The highest postoperative creatinine concentration (Cr.Max) during the hospitalization was identified and time from surgery recorded. Creatinine clearance was calculated from Cr.Pre (Cl.Pre) and Cr.Max (Cl.Min) using the Cockroft-Gault equation [Cockroft 1976]. The glomerular filtration rate (GFR) was calculated using the Modification of Diet in Renal Disease equation: estimated GFR = 186 × (plasma creatinine level [mg/dL])$^{-1.154}$ × (age [years])$^{-0.203}$, multiplied by 0.742 if the patient was female [National Kidney Foundation 2002]. In the ICU, the UO was measured every hour. The patients were classified in an appropriate RIFLE classification level regarding UO and GFR. The RIFLE classification system includes separate criteria for creatinine and UO (Table 4). The criteria that lead to the worst possible classification should be used. The F component of RIFLE is present even if the increase in serum creatinine is under 3-fold as long as the new serum creatinine is higher than 350 μmol/L in the setting of an acute increase of at least 44 μmol/L [Bellomo 2004]. Patients with good renal function not fulfilling any of the RIFLE category were marked as RIFLE-0.

Surgical Technique

Classical MS surgery was performed with a complete median sternotomy, central arterial and double venous cannulation, external clamping of the aorta and antegrade and retrograde cold blood cardioplegia. The approach to the mitral valve was either through the interatrial septum or direct left atrial incision.

In PA surgery, a double-lumen endobronchial tube was used to enable single-lung ventilation. Venous cannulation was performed percutaneously through the right internal jugular and right femoral vein for superior and inferior vena cava, respectively. The arterial cannulation site was the right femoral artery. The endoaortic balloon (endoclamp) was

Table 2. Renal Function Assessment*

	Port Access	Median Sternotomy	*P*
Preoperative assessment			
Cr.Pre, μmol/L	85.8 (17.4)	87.1 (27.5)	.690
Cl.Pre, mL/min	82.3 (28.0)	83.0 (33.2)	.877
GFR.Pre, mL/min	74.7 (17.5)	74.8 (23.6)	.970
Postoperative assessment			
Cr.Max, μmol/L	116.6 (73.7)	136.7 (80.4)	.068
Cl.Min, mL/min	67.8 (27.1)	58.5 (26.6)	.016
GFR.Min, mL/min	62.1 (23.0)	51.1 (21.8)	.001
Cr.Max onset time, h	24.9 (41.5)	29.8 (42.5)	.420
Postoperative dialysis, %	1.1	1.0	.953

*Univariate analysis. Mean values or percentage, values in the brackets represent standard deviation. Cr.Pre indicates preoperative creatinine concentration; Cl.Pre, preoperative creatinine clearance; GFR.Pre, preoperative glomerular filtration rate; Cr.Max, maximal postoperative creatinine concentration; Cl.Min, minimal postoperative creatinine clearance; GFR.Min, minimal postoperative glomerular filtration rate.

Table 3. Postoperative Course*

	Port Access	Median Sternotomy	*P*
Mechanical ventilation time, h	10.2 (31.6)	38.2 (140.6)	.061
(Patients who died were excluded)	6.3 (21.6)	35.6 (139.1)	.048
Intensive care unit stay, h	64.6 (82.8)	127.8 (214.8)	.008
(Patients who died were excluded)	61.5 (81.1)	126.9 (216.6)	.007
Hospitalization time, d	6.3 (4.16)	11.0 (8.5)	<.001
(Patients who died were excluded)	6.3 (4.18)	11.2 (8.6)	<.001
Concentrated erythrocyte transfusion, units	1.38 (2.88)	4.30 (5.08)	<.001
Fresh frozen plasma transfusion, units	1.17 (3.34)	4.72 (4.89)	<.001
Concentrated platelet transfusion, units	0.46 (1.91)	0.63 (2.13)	<.555
Drainage volume, mL	610 (774)	1334 (1213)	<.001
Antibiotic use: cephasoline, %	91.5	84.0	.113
Antibiotic use: vancomycine, %	11.6	18.0	.208
Antibiotic use: aminoglycosides, %	0.0	3.0	.091
Antibiotic use: other, %	2.13	18.0	<.001
Postoperative diuretics, %	98.9	97.0	.348
Inotropic support, %	54.7	83.2	<.001
Intra-aortic balloon pump support, %	1.1	0.0	.299

*Univariate analysis. Mean values or percentage, values in the brackets represent standard deviation.

introduced through the femoral artery into the ascending aorta. After inflating the endoclamp balloon, antegrade cardioplegia was delivered. Then mitral (and tricuspid, if indicated) valve replacement or repair was undertaken. The incisions for the PA operation included a 2.5- to 3-cm working port and a few small 2- to 5-mm holes for ports and holders on the right thorax, a 1.5-cm groin incision at the cannulation site, and the pericardial and atrial cut to access the valve.

In both groups, the composition of the cardiopulmonary bypass (CPB) priming solution was 2000 mL of crystalloid (Ringer) solution, 250 mL of 20% mannitol and 1 g of methylprednisolone. A nonpulsatile flow between 2.2 and 2.4 liters per square meter of body surface was maintained by a roller pump using Sarns 8000 or 9000 machines (Ann Arbor, MI, USA) equipped with a Trillium Affinity NT Hollow Fiber Oxygenator (Medtronic, Minneapolis, MN, USA).

Statistical Analysis

Independent samples *t* test for continuous and chi-square test for categorical variables were used to compare the demographic, CPB, renal function, and postoperative course data (Tables 1 and 2).

The analyses of intubation time, ICU stay, and hospitalization were also made separately with the exclusion of patients who died in the course of treatment. These patients have either never been extubated or were early reintubated. In contrast to patients with a favorable outcome, here a shorter time of mechanical ventilation or ICU stay meant earlier death and therefore a worse outcome.

Although some authors used plasma creatinine concentrations as renal injury indicators after cardiac surgery [McCreath 2003; Lassnigg 2004], we based the outcome variables on estimated creatinine clearance and GFR, as many studies indicate that these markers are better for an adequate renal function assessment [Duncan 2001; Swedko 2003].

In order to adjust for confounders, a multivariate linear regression model was constructed to test the surgical technique as an independent renal risk factor. Cl.Min was selected as the primary outcome variable as it has been shown to be a reliable indicator of acute renal injury [Mangano 2000; Stafford-Smith 2001]. Other predictors included in the model are listed in Table 5. An additional regression model with the same outcome variable was constructed in order to analyze the effect of postoperative mechanical ventilation time and ICU stay. Postoperative mechanical ventilation time and ICU stay were added to the independent variables of the previous model. In this model, the patients who died in the course of treatment were excluded due to the abovementioned reasons.

For the RIFLE classification analysis, first a chi-square test was used for the identification of differences in the classification levels between the groups. Then the patients of both study groups were divided into two subgroups: in the first there were patients without any acute renal injury (RIFLE-0) and in the second all others (RIFLE R, I, and F). A logistic regression model with the same predictors as in the previous linear regression model was created to identify independent risk factors for postoperative renal injury according to the RIFLE classification. Again, an additional model was constructed with the exclusion of the patients who died; mechanical ventilation time and ICU stay were added to the independent variables.

A *P* value less than .05 was considered statistically significant. Statistical analyses were performed using Statistical Product and Service Solution software (SPSS, Chicago, IL, USA).

Table 4. The RIFLE Classification Scheme for Acute Renal Failure

	GFR Criteria	Urine Output Criteria
Risk	Increased plasma creatinine × 1.5 or GFR decrease > 25%	UO < 0.5 mL/kg/h × 6 hours
Injury	Increased plasma creatinine × 2 or GFR decrease > 50%	UO < 0.5 mL/kg/h × 12 hours
Failure	Increased creatinine × 3 or GFR decrease > 75% or acute plasma creatinine > 350 µmol/L or acute plasma creatinine rise > 44 µmol/L	UO < 0.3 mL/kg/h × 24 hours or anuria × 12 hours
Loss	Persistent acute renal failure = complete loss of renal function > 4 weeks	
ESKD	End-stage renal disease (>3 months)	

*GFR indicates glomerular filtration rate; UO, urine output.

Table 5. Linear Multivariate Regression*

Outcome Variable: Cl.Min	β All	β Dead Excluded	P All	P Dead Excluded
Median sternotomy	−7.656	−9.039	.043	.018
Previous cardiac surgery	−5.656	−5.935	.448	.361
Female sex	−1.287	−1.609	.640	.552
Age	0.602	−0.560	<.001	<.001
Diabetes mellitus	−5.358	−5.414	.338	.320
Preoperative use of diuretics	1.190	0.201	.673	.943
Left ventricular ejection fraction >50%	4.530	2.173	.147	.488
Logistic EuroSCORE	0.072	−0.292	.880	.556
Cardiopulmonary bypass time	0.004	0.040	.949	.467
Aortic occlusion time	−0.120	−0.166	.144	.043
Preoperative creatinine clearance	0.466	0.488	<.001	<.001
Use of other† antibiotics	−11.008	−10.434	.021	.041
Postoperative inotropic support	−9.726	−8.958	.001	.001
Blood transfusion	0.481	−0.535	.224	.290
Drainage volume	0.000	0.000	.815	.787
Aprotinine use	−0.546	−0.625	.877	.858
Mechanical ventilation time		0.005		.874
Intensive care unit stay		0.021		.626

*Cl.Min indicates minimal postoperative creatinine clearance.
†Antibiotics other than cephasoline, vancomycine, or aminoglycosides.

Results

One hundred ninety-eight patients met the criteria, with 96 patients in the PA group and 102 patients in the MS group.

Regarding demographics, the PA and MS group were broadly comparable in most variables. However, there were more redos in the MS group (P = .022). A longer CPB time (P < .001) and aortic occlusion time (P < .001) was noted in the PA group. The use of antibiotics other than cephasoline, vancomycine, and aminoglycosides was higher in the MS group (P > .001) (Table 3). Because of a small number of patients receiving other antibiotics, they were statistically analyzed together in one group. Nearly all the patients in both groups (PA 98.9%, MS 97.0%; P = .348) received furosemide diuretic perioperatively.

The analysis of preoperative renal function did not demonstrate any differences between the groups in any of the creatinine-based markers. However, concerning the postoperative renal function, significant differences between PA and MS group were detected in Cl.Min (67.8 ± 27.1 versus 58.5 ± 26.6 mL/min; P = .016) and GFR.Min (62.12 ± 23.0 versus 51.1 ± 21.8 mL/min; P = .001). Cr.Max (116.6 ± 73.7 versus 136.7 ± 80.4 µmol/L) was higher in the MS group, however, with only a marginally significant P value of .068. The groups did not significantly differ in the Cr.Max onset time after surgery (PA 24.9 hours versus MS 29.8 hours; P = .420) (Table 2).

Linear multivariable regression demonstrated a significant association between the MS technique and Cl.Min (Table 5). Age, preoperative creatinine clearance, the need for inotropic support, and the use of "other" antibiotics were also identified as independent renal risk factors. Previous cardiac surgery could not be identified as a significant independent risk factor for Cl.Min.

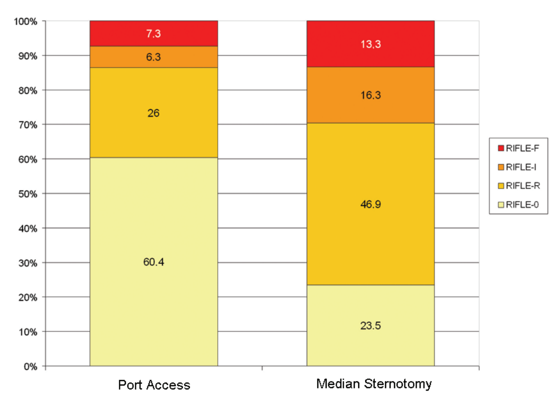
There was a significant difference (P < .001) in the distribution of patients according to the RIFLE classification (Figure). Sixty percent of the patients in the PA group and only 23.5% of the patients in the MS group were classified as RIFLE-0, while 46.9% of the MS patients and 26.0% of the PA patients were categorized as RIFLE-R. Similarly, the percentage of patients in the RIFLE-I and RIFLE-F was approximately twice as high in the MS as in the PA group (16.3% versus 6.3% for I and 13.3% versus 7.3% for F). In the logistic regression model, MS technique was also identified as an independent renal risk factor. Age, aortic occlusion time, preoperative creatinine clearance, and the need for inotropic support were identified as significant predictors as well (Table 6).

In the additional regression models (patients who died were excluded), no significant correlation between the outcome variables and mechanical ventilation or ICU stay could be identified. However, the same independent renal injury risk factors with similar β coefficients, including the MS surgical technique, have been identified (Tables 5 and 6).

One patient in each study group required dialysis. Both of these two patients restored normal renal function. Three patients in each group died.

DISCUSSION

Our findings suggest that in mitral valve surgery, the PA technique is related to lower renal injury compared to conventional surgery. Univariate analyses of all selected renal function



Comparison of the RIFLE classification. Chi-square test, P < .001.

Table 6. Logistic Multivariate Regression

Outcome Variable: RIFLE Renal Injury	β All	β Dead Excluded	*P* All	*P* Dead Excluded
Median sternotomy	1.854	1.688	.002	.007
Previous cardiac surgery	−0.318	−0.507	.769	.653
Female sex	0.676	0.609	.112	.159
Age	0.082	0.074	.002	.006
Diabetes mellitus	0.699	0.693	.425	.432
Preoperative use of diuretics	−0.139	−0.183	.745	.679
Left ventricular ejection fraction >50%	−0.236	−0.134	.618	.785
Logistic EuroSCORE	0.018	0.040	.811	.604
Cardiopulmonary bypass time	−0.009	−0.009	.306	.333
Aortic occlusion time	0.031	0.029	.022	.038
Preoperative creatinine clearance	0.040	0.039	<.001	<.001
Use of other* antibiotics	1.192	0.768	.199	.420
Postoperative inotropic support	1.327	1.213	.001	.004
Blood transfusion	0.088	0.032	.323	.761
Drainage volume	0.000	0.000	.760	.817
Aprotinine use	0.462	0.542	.401	.331
Mechanical ventilation time		.031		.202
Intensive care unit stay		.004		.446

*Antibiotics other than cephasoline, vancomycine, or aminoglycosides.

markers indicated reduced renal risk in the PA group. Multivariate models confirmed the results, each of them revealing the MS approach as an independent renal risk factor. Some of the previously known renal risk factors have been confirmed (Table 5). Serum creatinine typically peaks on the second day after cardiac surgery [Stafford-Smith 2003]. With the mean Cr.Max onset time between the 24th and 30th postoperative hour in both groups, our results correspond well to these findings.

The pathophysiology of renal injury during and after cardiac surgery is multifactorial. PA was compared to MS and associated with lower postoperative renal injury in the study by McCreath et al as well. They attributed the results to different aortic occlusion techniques. Aortic manipulation and external clamping in the MS group was supposed to cause greater atheroembolic injury of the kidneys, while endovascular balloon occlusion was presumed to cause less aortic wall distortion [McCreath 2003].

The analysis of demographics and preoperative renal function showed that the patients of both study groups were well comparable in all the observed characteristics with the exception of more redo procedures in the MS group. However, previous cardiac surgery could not be identified as an independent renal risk factor in any of our regression models.

Both, CPB and aortic occlusion duration were longer in the PA group. Many endogenous hormones and inflammatory mediators alter intrarenal hemodynamics, which may be important in the development of perioperative renal injury [Myles 1993]. In most patients, however, the extent of the inflammatory response to CPB increases significantly as the perfusion time extends beyond 3 hours [Verrier 2004]. The relationship between safety and duration of the total CPB is estimated to be close to 3 hours [Kouchoukos 2003]. We therefore think that the CPB duration in the PA group (151.4 ± 45.6 minutes) was still within safe limits. It is likely that within these limits, the harmful renal effect of the CPB is manifested relatively mildly.

A patient undergoing classical cardiac surgery is exposed to all the stress and trauma of major surgery. Minor tissue injury occurring during minimally invasive surgery can lessen the organism's stress response, ensuring greater circulatory stability during and after the operation [Glower 1998]. There is evidence that PA surgery is associated with lower postoperative bleeding, drainage volumes, blood transfusion needs, postoperative pain, and ICU stay [Gersak 2004; Sostarsic 2005]. Although the postoperative mechanical ventilation duration and ICU stay could not be proven as predictors for renal injury, PA surgery was significantly associated with lower needs for postoperative inotropic support, indicating better circulatory stability. The need for inotropic support was identified as a strong independent predictor of renal impairment in all regression models. The PA group was also linked to lower postoperative drainage volumes and fewer blood transfusions, both contributing to better hemodynamic stability. Greater circulatory stability and less postoperative pain results in earlier mobilization and enhanced convalescence [Gersak 2004; Sostarsic 2005]. Postoperative pain with classic heart surgeries is alleviated by large doses of opioid analgetics, which cause respiratory depression, vomiting, and proneness to fainting [Sostarsic 2005], all interfering with early mobilization and rehabilitation.

Various exotoxins also influence kidney function. Of the potential nephrotoxic agents, we analyzed the perioperative use of antibiotics and diuretics. Concerning anesthetics, all patients were subject to the same anesthesia induction and maintenance regardless of surgical technique. Cephasoline was the antibiotic of choice in the perioperative infection prevention. When contraindicated, eg, due to allergic reaction risk, vancomycine was used. There were no significant statistical differences between the PA and MS group regarding the use of cephasoline, vancomycine, or any of the amynoglicoside antibiotics. The use of other antibiotics was higher in the MS group. They were included in the regression analyses and significantly associated with Cl.Min ($P = .041$), but not to renal injury according to the RIFLE classification ($P = .420$). Despite the significant association with Cl.Min, the MS technique still proved to be a significant independent predictor ($P = .043$) of renal injury according to the RIFLE classification.

Although the selected creatinine-derived variables have been shown to be good renal function markers, more sensitive and earlier biochemical markers of renal dysfunction exist, including tubular enzymes, urinary proteins, and others [Trof 2006]. However, there is no evidence that perioperative increase of these markers is associated with postoperative morbidity or mortality [Baines 1994]. UO is a rarely studied variable concerning ARF after cardiac surgery, although it is more sensitive to changes in renal function than biochemical markers [Lin 2004]. Changes in UO often occur long before biochemical markers are apparent [Kuitunen 2006]. However, it is far less specific except when heavily decreased or absent. The new RIFLE classification for ARF is based on both creatinine excretion and UO. In our study, 60.4% of the patients in the PA group and only 23.5% in the MS group did not develop any renal injury according to the RIFLE criteria. In each of the 3 ARF levels, the percentage of patients was roughly twice as high in the MS group compared to the PA group (RIFLE-R 46.9% versus 26.0%, RIFLE-I 16.3% versus 6.3%, and RIFLE-F 13.3% versus 7.3%) (Figure). In both groups, the incidence of renal impairment was high compared to the reports of Kuitunen et al (813 patients after cardiac surgery: RIFLE-R 10.9%, RIFLE-I 3.5%, RIFLE-F 5.0%). They discovered significant differences in the 90-day mortality between different RIFLE categories: 0.9% in the RIFLE-0, 8.0% in the RIFLE-R, 21.4% in the RIFLE-I, and 32.5% in the RIFLE-F. However, our study included only patients after mitral valve surgery, who are particularly susceptible to kidney damage [Chertow 1997], whereas Kuitunen's population were all cardiac surgery patients and only 15% of them underwent valvular surgery.

Although we think the findings of our study are important, we are aware of all the limitations of a retrospective study. Although multivariate analyses were implemented to reduce the bias due to potential differences in the study groups, this is not an equivalent substitute for a controlled randomized trial. However, all data were gathered prospectively as part of routine clinical, perfusion, and anesthesia protocols.

In conclusion, we have demonstrated that PA mitral valve surgery might be associated with lower postoperative renal injury compared to the conventional surgery. It appears that especially greater postoperative circulatory stability, but also lower perioperative stress, earlier mobilization and recovery compensate for a somewhat longer CPB duration. Lower microemboli formation due to endovascular aortic occlusion might also contribute to the results [McCreath 2003]. Patients at high perioperative renal risk may therefore benefit from PA surgery. Our results are in concordance with the results of the only previous study in this field. We present the first combined GFR and UO based comparison of postoperative acute renal injury between PA and MS mitral valve surgery.

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