

Differences in Length of Stay between Coronary Bypass and Valve Procedures

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Objective: Emphasis on cost reduction, national standardization of medical care, and quality improvement initiatives have led to reduced postoperative hospital stays after cardiac surgery. The present study was designed to verify the observation that valve patients have longer lengths of stay than bypass patients and to identify possible reasons. **Methods:** The inpatient records of 26 consecutive patients who underwent valve procedures at our institution were reviewed and compared with the records of 25 consecutive coronary bypass patients. Patients whose postoperative stays were longer than 2 weeks were considered outliers and were excluded from further review. **Results:** A total of 51 records were reviewed. There were no in-hospital deaths. Five patients in the valve group and two in the bypass group were excluded because of lengths of stay exceeding 14 days. The mean length of stay for the valve procedure group was 7.7 ± 2.1 days, vs. 5.7 ± 1.5 days for the coronary bypass group ($p = 0.001$). There were no reoperative procedures in either group, and the number of emergency procedures was higher in the bypass group. Both groups were similar with respect to age and sex. The frequencies of associated pulmonary disease and malnutrition were similar. Bypass patients had a higher incidence of vascular disease and/or renal disease. Sixty percent of valve procedures were complex operations. Valve patients had a higher incidence of cardiopulmonary bypass times exceeding 3 hours and more postoperative bleeding complications. Although not statistically significant, valve procedure patients were more likely to require prolonged mechanical ventilatory and circulatory support postoperatively. The frequencies of thrombotic complications, neurological complications, and nosocomial infections were similar for both groups. Postoperatively, more valve patients had atrial fibrillation, and all of them received anticoagulation. Multivariate analysis revealed only two factors to be significant with regard to length of stay: valvular surgery and the duration of postoperative ventilatory support. **Conclusions:** Cardiac valve procedures are associated with prolonged lengths of stay compared with isolated coronary bypass procedures. Despite recent trends toward earlier operation, valve patients tended to present with advanced disease. More than half of the valve patients required complex surgical procedures. This is reflected in longer bypass times, increased bleeding complications, and more postoperative support. The proportion of valvular surgery patients should be considered when analyzing lengths of stay for cardiac surgery cohorts.

Introduction

I ncreasing emphasis on cost reduction in health care has challenged some traditional practices. One example is the reduction in postoperative lengths of stay for technologically advanced procedures such as cardiac surgery. Fast tracking of cardiac surgical patients has reduced postoperative lengths of stay by 33 to 50%.¹ Indeed, length of stay has become a standard in quality improvement after cardiac surgery.^{2,3} The vast majority of these cases represent coronary bypass procedures, consistent with current practice patterns. In addition, many of these types of studies do not separate cardiac surgery patients by the type of operation. The few studies that have included the type of procedure in the analysis, however, have suggested that valve procedures are associated with prolonged hospitalization after cardiac surgery.^{4,5} There are few data available that quantify this relationship or offer any insight regarding why this might be so. Suspected factors that could be responsible for the longer length of hospitalization in valve patients include the need for anticoagulation, a higher incidence of postoperative atrial fibrillation, and the presence of advanced structural heart disease. Other factors that have been associated with prolonged lengths of stay after cardiac surgery include associated comorbidities, diminished left ventricular function, advanced age, female gender, malnutrition, extended cardiopulmonary bypass times, postoperative neurological events, prolonged intubation, prolonged hemodynamic support, and nosocomial infections.⁶⁻⁹ The present study was designed to examine these issues.

Methods

The inpatient medical records of 25 consecutive coronary artery bypass graft (CABG) patients and 26 consecutive valve procedure patients, accrued during the final 6 months of 1998, were used for data collection. In addition to the hospital registry number and procedure performed, the following data were collected.

Demographic and Preoperative Variables

The age (in years) and sex of each patient were recorded. Preoperative ejection fraction was considered normal if $\geq 50\%$ and was considered severely impaired if $< 35\%$. The status of the procedure and whether or not the procedure was a reoperation were recorded. An emergency procedure was defined as ongoing, refractory, unrelenting cardiac compromise in which there was no alternative to, or delay in, operative intervention. Associated vascular disease was considered present if the patient had symptoms of claudication or cerebrovascular insufficiency, physical evidence of lower extremity vascular compromise, a history of aneurysmal or occlusive disease, or had undergone

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previous peripheral vascular surgery. Renal disease was defined by a serum creatinine > 2.0 mg/dL with or without a history of dialysis. Pulmonary disease was defined by a history of chronic obstructive pulmonary disease or by abnormalities of baseline arterial blood gases or pulmonary function studies. Malnutrition was considered present if the preoperative albumin was less than 3.5 g/dL.

Intraoperative and Postoperative Variables

Cardiopulmonary bypass time (in minutes) was obtained from operative reports. Cardiopulmonary bypass times were considered prolonged if >3 hours (180 minutes). Timing of postoperative extubation was recorded as occurring on the day of the procedure, postoperative day 1, or postoperative day 2, or greater. The need for vasopressor, inotropic, or mechanical circulatory support was noted, if present, as well as the duration of support required. Values were recorded as no support required, <24 hours of support, or >24 hours of support. Bleeding complications included return to the operating room for bleeding or tamponade or ongoing blood losses requiring more than 2 units of packed red blood cell transfusion in the postoperative period. Thrombotic complications were defined as documented thromboembolic episodes or mechanical valve thrombosis. Atrial fibrillation was determined by routine postoperative electrocardiographic monitoring and considered present if lasting >2 hours. Nosocomial infection was defined as the presence of documented wound infection requiring antibiotics or culture-positive pneumonia or other infection requiring antibiotic therapy. Finally, the presence of documented transient ischemic attack, stroke, or central neurological deficit was recorded as a postoperative neurological event.

Length of Stay Determination

Both the date of the operative procedure and the postoperative day of discharge were recorded. This final value was used in determining postoperative length of stay.

Statistical Methods

Patients whose lengths of stay exceeded 14 days (>3 SD above the mean length of stay for the entire group) were considered outliers and were not included in the statistical analysis to avoid bias introduced by excessively long hospitalizations. The mean lengths of stay between the valve and bypass groups were compared using Student's two-tailed *t* test. Preoperative, intraoperative, and postoperative variables were compared between the two groups using χ^2 analysis or, where appropriate, Fisher's exact test. Multiple linear regression analysis was performed on those factors identified as being associated with prolonged length of stay.

Results

The records were obtained for all patients. There were no deaths among these 51 patients. Five patients in the valve groups and 2 patients in the CABG group were hospitalized longer than 2 weeks (>3 SD above the mean for the entire group) and were not included in the statistical analysis. The mean length of stay for those outliers was 42 ± 14 days. Thirteen of the 21 valvular surgery patients (62%) underwent complicated

valve procedures. These included multiple valve repair and/or replacement (4 patients), valve procedure combined with coronary bypass (8 patients), and aortic root replacement (1 patient).

Length of Stay

For patients undergoing isolated CABG, mean postoperative length of stay was 5.7 days (± 1.5 days [SD]) and the median was 6.0 days (Table I). Patients who underwent valve procedures had a mean postoperative length of stay of 7.7 days (± 2.1 days [SD]) and a median length of stay of 8.0 days. This difference was significant ($p = 0.001$).

Preoperative Variables

The preoperative variables were compared between the CABG group and the valve procedure group (Table II). There were no significant differences between the groups with regard to age, sex, and presence of pulmonary disease or malnutrition. There was a significant trend toward a higher incidence of emergency procedures in the CABG group vs. the valve procedure group (39% vs. none, $p < 0.01$). Although more patients in the CABG group had associated renal and/or vascular disease than in the valve procedure group (39% vs. 24%), this difference was not statistically significant. Finally, the incidence of impaired ventricular function was similar for both groups. Sixteen of 23 patients in the CABG group (70%) had normal ventricular function (ejection fraction $\geq 50\%$), compared with 16 of 21 patients in the valve procedure group (76%, $p = 0.60$ [not significant]). Similarly, the incidence of severely impaired ventricular function (ejection fraction $< 35\%$) was similar for both groups (CABG, 9%; valve procedure, 4%; $p = 0.79$ [not significant]). Therefore, no preoperative variable was identified that predicted the prolonged length of stay for valve patients compared with CABG patients.

Intraoperative and Postoperative Variables

A higher percentage of patients in the valvular surgery group had cardiopulmonary bypass times exceeding 3 hours (Table III). Eleven patients in the valve procedure group (52%) had prolonged cardiopulmonary bypass times, compared with three patients in the CABG group (15%). This difference was significant ($p = 0.01$) and reflects the complex nature of the operations required by a large number of patients in the valvular surgery group. Not unexpectedly, there was a higher incidence of postoperative support required for valve procedure patients, although the differences did not reach significance. More patients in the valve procedure group required ventilator support for 2 or more days (4 of 21, 20%) and circulatory support for more than 24 hours (4 of 21, 20%) compared with the CABG group (prolonged ventilator support, 2 of 23 patients [9%]; prolonged circulatory support, 1 of 23 patients [4%]). Again, however, these differences did not reach significance with the sample size studied. Bleeding complications were also higher in the valve proce-

TABLE I
POSTOPERATIVE LENGTH OF STAY

Procedure	n	Mean Length of Stay (days)	P
Isolated CABG	23	5.7 \pm 1.5	
Valve procedure	21	7.7 \pm 2.1	0.001

TABLE II
PREOPERATIVE RISK FACTORS

Risk Factor	CABG (n = 23)	Valve (n = 21)	p
Mean age (years)	62	61	0.90 (NS)
Sex (male)	19 (83%)	17 (82%)	1.00 (NS)
Pulmonary disease	4 (17%)	3 (14%)	1.00 (NS)
Malnutrition	3 (13%)	3 (14%)	1.00 (NS)
Renal or vascular disease	9 (39%)	5 (24%)	0.33 (NS)
Emergency procedure	9 (39%)	0	0.01
EF \geq 50%	16 (70%)	16 (76%)	0.60 (NS)
EF < 35%	2 (9%)	1 (4%)	0.79 (NS)

EF, ejection fraction; NS, not significant.

group (19% vs. none), and this difference was significant ($p = 0.04$). Only one patient experienced a thrombotic complication, and this patient was in the valve procedure group. The incidence of atrial fibrillation was two times greater for the valve procedure group (38% vs. 17%), although this difference did not reach significance ($p = 0.23$). Finally, there were no significant differences between the groups with regard to postoperative nosocomial infection or neurological events.

All patients in the valve procedure group received postoperative anticoagulation with sodium warfarin. No patients in the CABG group required postoperative anticoagulation. This difference could not be separated as an independent variable with regard to the procedure performed and length of stay; therefore, no statistical analysis was performed. Intuitively, however, this may represent a significant difference between the groups.

Multiple Linear Regression

A multiple linear regression analysis was performed using significant differences and trends, as identified above, with length of stay as the dependent variable (Table IV). These included valvular surgery as part of the procedure, prolonged cardiopulmonary bypass time, postoperative day of extubation, postoperative duration of circulatory support, and the presence of atrial fibrillation.

In addition, because there is a strong association of preoperative ventricular function and adverse outcomes in cardiac sur-

TABLE IV
MULTIPLE LINEAR REGRESSION

Factor	p
Valve as part of procedure	0.01
Postoperative day of extubation	0.02
Atrial fibrillation	0.48 (NS)
Postoperative days of hemodynamic support	0.93 (NS)
CPB > 3 hours	0.60 (NS)
LVEF < 35%	0.89 (NS)
LVEF \geq 50%	0.98 (NS)

CPB, cardiopulmonary bypass time; NS, not significant; LVEF, left ventricular ejection fraction.

gery, both normal and severely depressed ventricular functional status were included. Of these factors, only valvular surgery and the postoperative day of extubation were shown to be significantly correlated with length of stay (Table IV).

Discussion

Data from the American Heart Association show that in 1995 there were 573,000 coronary bypass procedures and 71,000 valve procedures performed in the United States.¹⁰ A review of the Society of Thoracic Surgeons National Database for 1995 shows that coronary bypass patients had an average length of stay of 6.9 days compared with valve procedure patients, whose average length of stay was 9.0 days.¹¹ These data are consistent with the data presented here, which indicate that valve patients had a significantly longer length of stay than bypass patients by an average of 2 full days. Interesting also was the higher number of outliers in the valve procedure group, more than double the number in the bypass group. The effect on length of stay of having a valve procedure was found to be independently significant on multiple regression analysis ($p = 0.01$).

There are few data from this study to suggest that differences in preoperative risk factors were responsible for the difference in length of stay between CABG and valve patients, because both groups were quite similar in all preoperative variables except for the higher number of patients requiring emergency surgery in the CABG group ($p < 0.01$) and the slightly higher associated

TABLE III
INTRAOPERATIVE AND POSTOPERATIVE FACTORS

Factor	CABG (n = 23)	Valve (n = 21)	p
CPB > 3 hours	3 (15%)	11 (52%)	0.01
Postoperative day of extubation			
Day of surgery	11 (48%)	9 (45%)	
POD 1	10 (43%)	7 (35%)	
POD 2 or more	2 (9%)	4 (20%)	0.55 (NS)
Postoperative days of inotropic support, pressors, or IABP			
None	10 (43%)	7 (33%)	
<24 hours	12 (52%)	10 (48%)	
\geq 24 hours	1 (4%)	4 (19%)	0.297 (NS)
Bleeding complications	0	4 (19%)	0.04
Thrombotic complications	0	1 (5%)	1.00 (NS)
Atrial fibrillation	4 (17%)	8 (38%)	0.23 (NS)
Nosocomial infection	1 (4%)	1 (4%)	1.00 (NS)
Postoperative neurological event	0	0	1.00 (NS)

CPB, cardiopulmonary bypass time; POD, postoperative day; NS, not significant; IABP, intra-aortic balloon pump.

vascular and/or renal disease in the CABG group ($p = 0.33$ [not significant]). Of the intraoperative and postoperative factors studied, it is noted that valve procedure patients were significantly more likely to have cardiopulmonary bypass times exceeding 3 hours ($p = 0.01$). This is not unexpected when one considers the complexity of disease in this group, with fully 62% of patients requiring complicated valve procedures, and the fact that these operations were done in a teaching institution, where residents performed the majority of procedures. Although the percentage of complex valve procedures at our institution is in line with published data from both the Society of Thoracic Surgeons database and New York State database,^{12,13} both of which represent a large number of teaching institutions, the cardiopulmonary bypass times were not published in these studies and therefore could not be compared with our data. The higher incidence of bleeding complications in the valve procedure group, 19%, vs. none in the CABG group ($p = 0.04$), would be expected with these extended bypass times and the associated platelet damage, need for prolonged heparinization, and activation of the coagulation, fibrinolytic, and inflammatory cascades. Likewise, although not statistically significant, the trend toward more ventilatory and circulatory support in valve procedure patients probably reflects the effects of prolonged cardiopulmonary bypass times. Of interest was the fact that on the multivariate regression analysis, timing of extubation, but not cardiopulmonary bypass time, significantly correlated with extended length of stay. Although some data suggest that timing of extubation is correlated with adverse outcomes after cardiac surgery, particularly length of stay,^{14,15} an association with major mortality has been difficult to document.^{15,16}

There was a higher incidence of atrial fibrillation in the valvular surgery group, 38%, vs. 17% in the CABG group ($p = 0.23$ [not significant]). Although this difference was not significant, because of the small sample size it is possible that a type II error occurred; a larger study would be able to determine if this difference was significant. Indeed, previous investigators have shown that valve procedures are associated with an increased incidence of atrial fibrillation and that atrial fibrillation prolongs the length of stay by approximately 2 days.^{17,18} Finally, all patients in the valve procedure group received anticoagulation with sodium warfarin. Because of the pharmacodynamics of warfarin and the half-lives of the vitamin K-dependent coagulation factors,¹⁹ clinical experience has led to the assumption that many postoperative valve patients are physiologically ready for discharge before they have achieved a therapeutic level of anticoagulation. This study was unable to assess the influence of anticoagulation on length of stay.

Conclusions

Cardiac valve procedures are associated with prolonged lengths of stay compared with isolated coronary bypass procedures. Despite recent trends toward earlier operation, more than half of valvular surgical patients required complex surgical procedures. This is reflected in longer bypass times, a trend toward more postoperative support, more bleeding complications, and prolonged postoperative lengths of stay. Valve surgery remained an independent predictor of prolonged length of stay on multivariate analysis. Therefore, the proportion of valvular surgery patients should be considered when analyzing

lengths of stay for cardiac surgery cohorts, particularly when comparing lengths of stay between different hospitals, surgical programs, or treatment groups.

Future studies, such as analysis of the large databases mentioned previously, are necessary to confirm these observations, particularly to determine the effect that more complicated procedures have on length of stay after cardiac surgery. In addition, further studies are needed to determine the effect of postoperative anticoagulation on length of stay, particularly in valvular surgical patients. It is hoped that cost-benefit studies will address more effective strategies for managing atrial fibrillation and initiating anticoagulation on an outpatient basis.

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