Congenital Heart Disease

Early Outcomes of Tricuspid Valve Replacement in Young Children

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Background—Early outcomes after tricuspid valve replacement in young children are ill defined. The experience of the Pediatric Cardiac Care Consortium (45 centers, 1984 to 2002) was reviewed to evaluate the results of tricuspid valve replacement in children <6 years of age.

Methods and Results—Ninety-seven patients who underwent initial tricuspid valve replacement are included in the present analysis. The most frequent cardiac diagnoses were Ebstein’s anomaly (40%), pulmonary atresia (11%), and tetralogy of Fallot (8%). Age at tricuspid valve replacement was 2.9±1.7 years (mean±SD). Mean patient weight was 12.7±6.1 kg. The major outcome was survival to discharge. Associations among age, diagnosis, valve type/size, and outcome were evaluated through the use of χ² analysis and logistic regression model fitting approaches. Hospital mortality was 26% and was very high (64%) in patients <1 year of age. A large size-to-weight ratio was the strongest predictor of mortality based on multivariable analysis (P<0.001). Mortality was 54% for patients with a size-to-weight ratio >2.5. Other complications included heart block requiring a pacemaker (13%) and thrombosis (5%). Pacemaker implantation was associated with the use of a mechanical valve (23% versus 6% bioprosthetic valve; P=0.01)

Conclusions—Tricuspid valve replacement in young children is associated with high mortality, especially in infants <1 year of age. Surgical options other than tricuspid valve replacement such as transplantation may need to be considered in infants. (Circulation. 2007;115:319-325.)

Key Words: heart defects, congenital ■ pediatrics ■ risk factors ■ surgery ■ tricuspid valve ■ valves

Tricuspid valve replacement is an infrequently performed procedure in young children. Most data on tricuspid valve replacement come from studies reporting the adult experience.1–7 In the adult population, the main indication for tricuspid valve replacement is tricuspid insufficiency. The underlying diagnoses vary by study and include congenital heart disease, mitral valve disease, rheumatologic disease, and endocarditis.1,3,8 Studies indicate a high 30-day mortality rate (14% to 37%) and a moderate late mortality rate (9.7% after 20 years).1,2 Risk factors associated with early death include prolonged cardiopulmonary bypass time, congenital heart disease, reoperative cases, and high New York Heart Association class.1,10,11 Analyses of the comparative performance of mechanical and bioprosthetic prostheses in adults have found no significant difference between valve types.4–7,12,13

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Existing reports of pediatric tricuspid valve replacement consist of small patient numbers from single institutions. Congenital heart disease is the most frequent indication for tricuspid valve replacement, with early postoperative mortality ranging from 9% to 36%.14–18 In young children <6 years of age, however, few data are available to describe the indications and outcomes for tricuspid valve replacement.

Studies of all valve replacements in children have demonstrated greater mortality in infants <1 year of age.14,19,20 Studies focusing on mitral valve replacement in children support this finding. Despite a high surgical mortality rate after the first mitral valve replacement, repeat mitral valve replacement outcomes were much improved with acceptable reoperation complication rates. A higher size-to-weight ratio, defined as the valve size divided by patient weight, is a predictor for early mortality in children who have mitral valve replacements.19,21

Valve replacement is usually performed when primary repair is inadequate or unfeasible. The purpose of the present study was to evaluate the early risks of tricuspid valve replacement in children <6 years of age and to identify risk factors that can potentially guide clinical decision making in the management of these patients.
Methods

Patients and Procedures

Deidentified documents from all cases of tricuspid valve replacement in children <6 years of age reported to the Pediatric Cardiac Care Consortium23 collated and accessible through December 2002 were reviewed. Incorporated in 1982, the Pediatric Cardiac Care Consortium receives all cardiac catheterization reports, operative records, and reports of in-hospital deaths from 45 participating institutions in North, Central, and South America in a prospective fashion. One hundred twelve patients were identified within the consortium database, and 397 reports for those patients were retrospectively reviewed. Ninety-seven patients had diagnostic data, operative reports, and completed consortium forms available for review and were used for analyses. Initial tricuspid valve replacement operations for these patients were performed between 1985 and 1999. Twenty-six of the 97 patients (27%) died before discharge; 35 patients had follow-up data that ranged from 16 days to 16.1 years; and 36 patients had no follow-up data after discharge. Follow-up data were available only if patients had a subsequent procedure performed at a consortium institution. The present study was approved by the University of Iowa Institutional Review Board.

Statistical Methods

Statistical analysis was performed with Statistica analysis software, version 5.1 (StatSoft, Tulsa, Okla), and procedures from the Statistical Analysis System (version 9.1; SAS Corp, Cary, NC). Data are presented as mean±SD, medians, ranges, and frequencies. Follow-up after hospital discharge was incomplete; therefore, the main outcomes of interest were in-hospital failure, defined as death (n=24) or cardiac transplantation (n=2), and the need for a pacemaker before discharge.

All comparisons of complication risks used the discharge date as the reference point and thus include complications recorded from the time of tricuspid valve replacement through hospital discharge. Crude associations for categorical variables were evaluated through the use of a χ² test or Fisher exact test. Multivariable analysis was conducted by fitting logistic regression analysis models to adjust for the effects of confounding factors while identifying significant predictors of failure or the need for a pacemaker before discharge. Indicator variables were constructed to allow inclusion of categorical variables with >2 categories in the logistic models. Because of the small sample size, exact confidence intervals (CIs) and probability values are reported for the multivariable models. For continuous variables, mean differences were evaluated with Student t test with a test for equal variances.

The authors had full access to the data and take responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

Results

Patient Characteristics

One hundred twelve patients <6 years of age at the time of tricuspid valve replacement were reported to the Pediatric Cardiac Care Consortium between 1984 and 2002. Operative and diagnostic reports were available for 97 patients with tricuspid valve replacements performed between 1985 and 1999; these patients are the focus of this analysis. Because of the lack of follow-up data after discharge for 37% of the patients, postoperative outcome data were defined as data until hospital discharge.

Eighteen of the 45 participating centers submitted data on tricuspid valve replacement. Three of the centers accounted for 64% of patients, each reporting ≥8 tricuspid valve replacements. The remaining 15 centers reported ≤5 operations, with 5 institutions reporting 1 operation each.

Demographic data are shown in Table 1. The mean age of patients was 2.9±1.7 years (range, 0.01 to 5.99 years). The age distribution is displayed in Figure 1. The gender distribution of patients was nearly balanced for the entire group.

Cardiac Diagnosis and Surgical History

The primary diagnoses were divided into 3 categories: a primary valve abnormality (n=53), the tricuspid valve as the systemic atroventricular valve (n=23), and conotruncal defects (n=21). The specific diagnoses and their classification are listed in Table 2. Tricuspid insufficiency was the dominant physiology leading to tricuspid valve replacement. One patient had tricuspid stenosis; 2 patients had mixed lesions.

More than one half of patients (56%) had prior cardiac surgery. Patients frequently (51%) had >1 prior operation (median, 1; range, 1 to 4) that included a median of 2 (range, 1 to 7) procedures. Procedures included central shunt (n=23), modification of the right ventricular outflow tract (n=17), tricuspid valve annuloplasty and/or valvuloplasty (n=14), ventricular septal defect repair (n=12), and atrial septal surgery (n=7). Most patients (n=73; 75%) had other procedures performed concomitantly with the tricuspid valve replacement. Common associated procedures, detailed in Figure 2, included atrial septal defect repair (n=26), atrioseptal (n=24), modification of the right ventricular outflow tract (n=9), ventricular septal defect repair (n=8), mitral valve replacement (n=6), branch pulmonary arterioplasty (n=4), division of the patent ductus arteriosus (n=4), central shunt (n=3), and cavopulmonary anastomosis (n=3).

| TABLE 1. Descriptive Data for Tricuspid Valve Replacement Patients by Age Group |
|-----------------|-----------------|-----------------|
|                  | Overall          | Patients <1 y of Age | Patients ≥1 y of Age |
| Patients, n      | 97              | 14              | 83              |
| Age, y           | 2.9±1.7         | 0.3±0.3         | 3.3±1.5         |
| Weight, kg       | 12.7±6.1        | 4.5±1.5         | 14.1±5.4        |
| Gender, f/m      | 46/51           | 4/10            | 42/41           |
| Valve size, mm   | 23±4            | 19±2            | 25±3            |
| Size-to-weight ratio, mm/kg | 2.3±1.2 | 4.7±1.6 | 1.9±0.5 |

Values are mean±SD when appropriate.

Figure 1. Age distribution for the 97 patients who had a tricuspid valve replacement.
Table 2. Clinical Diagnoses and Classification

<table>
<thead>
<tr>
<th>Primary Diagnosis Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary valve abnormality</td>
<td>53</td>
</tr>
<tr>
<td>Ebstein’s</td>
<td>38</td>
</tr>
<tr>
<td>Dysplastic TV</td>
<td>6</td>
</tr>
<tr>
<td>AV canal</td>
<td>4</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>Systemic AV valve</td>
<td>23</td>
</tr>
<tr>
<td>Single ventricle</td>
<td>11</td>
</tr>
<tr>
<td>D-TGA</td>
<td>6</td>
</tr>
<tr>
<td>L-TGA</td>
<td>6</td>
</tr>
<tr>
<td>Conotruncal defect</td>
<td>21</td>
</tr>
<tr>
<td>Pulmonary atresia</td>
<td>11</td>
</tr>
<tr>
<td>Tetralogy of Fallot</td>
<td>8</td>
</tr>
<tr>
<td>Truncus arteriosus</td>
<td>1</td>
</tr>
<tr>
<td>Interrupted aortic arch</td>
<td>1</td>
</tr>
</tbody>
</table>

AV indicates atrioventricular; TV, tricuspid valve; D-TGA, D-transposition of the great arteries; and L-TGA, L-transposition of the great arteries. Most patients with pulmonary atresia had an intact ventricular septum; 2 had a ventricular septal defect. Other diagnoses include iatrogenic tricuspid chordal dysfunction and transplantation rejection.

Valve Characteristics

Of the 44 patients (45%) who received a mechanical valve, 41 (93%) received a St Jude valve (St Jude Medical, St Paul, Minn), and 3 (7%) received a Carbomedics (Austin, Tex) valve. Of the 53 patients (55%) who received a bioprosthetic valve, 42 (79%) received a Carpentier-Edwards valve (Edwards Lifesciences, Irvine, Calif), 9 (17%) received a Hancock valve (Medtronic, Minneapolis, Minn), and 2 (4%) received an Ionescu-Shiley valve (Pfizer, Inc., New York, NY). There was a strong association between patient age and valve type. In patients <1 year of age, 79% received a mechanical valve, whereas only 40% of patients ≥1 year of age received a mechanical valve (P=0.007). There was also a strong association between diagnosis group and valve type. All patients with a tricuspid valve in the systemic position received a mechanical valve, whereas 62% and 75% of the patients with conotruncal defects and a primary valve abnormality, respectively, received a bioprosthetic valve (P<0.001).

The mean valve size for all patients was 23±4 mm. For patients <1 year of age, the mean valve size was 19±2 mm. For patients ≥1 year of age, the mean valve size was 25±3 mm (Table 1).

The ratio of valve size to patient weight, the size-to-weight ratio, was calculated. This ratio has been shown to be a significant factor in outcomes of mitral valve replacement in young children. The size-to-weight ratio was significantly higher in children <1 year of age at 4.7±1.6 mm/kg (range, 2.9 to 7.9 mm/kg) compared with 1.9±0.5 mm/kg (range, 0.7 to 4.0 mm/kg) in children ≥1 year of age (P<0.001). Ninety-five percent of the patients in the older age group had a size/weight ratio ≥2.8 mm/kg.

Outcomes

Complications recorded from the time of tricuspid valve replacement through hospital discharge were analyzed. Twenty-six patients (27%) did not survive to discharge (n=24) or required cardiac transplantation before discharge (n=2, considered failures for analysis) after tricuspid valve replacement. Failures included 9 of the 14 patients (64%) <1 year of age and 17 of the 83 patients (20%) ≥1 year of age (P=0.002). Of the 35 patients surviving to discharge with further data available, 13 (37%) are known to have died or undergone cardiac transplantation. The mean time to known failure after discharge was 1.5±1.8 years (median, 1.1 years; range, 51 days to 6.2 years).

Available postdischarge follow-up data showed that 28 patients (8 <1 year of age; 20 ≥1 year of age) required reoperation, with 20 of those (5 <1 year of age; 15 ≥1 year of age) for repeat tricuspid valve replacement. The average time to repeat tricuspid valve replacement was 2.7±2.6 years (median, 1.6 years; range, 8 days to 9 years). Other reoperations included prosthetic valve repair, revision of ventricular septal defect repair, pacemaker generator placement, and cardiac transplantation. Four of the repeat tricuspid valve replacement operations were combined with other procedures, including pulmonary valve replacement (n=3) and a right atrial Maze procedure.

Complications

Heart Block

Complications were common after tricuspid valve replacement (Figure 3). Heart block requiring pacemaker implantation occurred in 13 patients before discharge. The need for a pacemaker was significantly associated with use of a mechanical valve (23% versus 6% bioprosthetic valve; P=0.01). Given the poor survival rate and the significant valve type association among children <1 year of age, further analysis was focused on the older age group. The odds of needing a pacemaker before discharge remained significantly higher in patients ≥1 year of age who received a mechanical valve (odds, 10 of 23) relative to those who received a bioprosthetic valve (odds, 1 of 49; odds ratio [OR], 21.3; 95% CI, 2.6 to 166.7; P=0.005).
Further analysis of the older age group accounting for diagnosis category and valve type demonstrated that regardless of diagnosis, patients with mechanical valves had higher odds of requiring a pacemaker (Table 3). The reference group for the ORs displayed in Table 3 was made up of patients with a primary valve abnormality who received a bioprosthetic valve. This group had the largest number of patients. Among the other diagnosis category by valve type groups, those with a conotruncal defect who received a mechanical valve had significantly higher odds ($P=0.002$, Fisher exact test) of requiring a pacemaker before discharge relative to the reference group. Only 1 of the 50 patients ≥1 year of age who received a bioprosthetic valve required a pacemaker before discharge. Of note, the upper limits of the exact 95% CIs are extremely high, which is a reflection of the small number of patients in each group.

**Thrombosis and Transplantation**

Valve thrombosis occurred in 5 patients before discharge (2 patients <1 year of age; 3 patients who received a mechanical valve). Information about anticoagulation therapy was not available. Four of the 5 died before discharge. After discharge, 10 additional patients were reported as having valve thrombosis (from 51 to 720 days after surgery). All of these patients had a mechanical valve.

Four patients are known to have subsequently required cardiac transplantation, 2 before discharge.

**Risk Factors for Failure Before Discharge**

Twenty-six patients (27%) died or underwent cardiac transplantation (n=2) before discharge. Most failures occurred within 30 days of tricuspid valve replacement, giving a 30-day failure rate of 22%. The most common reason for failure before discharge was heart failure (19 patients; 73%), followed by multiorgan system failure (3 patients; 12%). Other causes included ventricular fibrillation, hemorrhage, and thrombosis.

The associations between individual perioperative predictors and failure before discharge are described in Table 4. Age <1 year, large size-to-weight ratio, thrombosis before discharge, and mechanical valve type were all associated with increased odds of failure in an univariable analysis. Patients <1 year of age, however, were far more likely to have a mechanical valve and a large size-to-weight ratio. Patients with a primary valve abnormality had lower odds of failure before discharge relative to patients with a systemic valve abnormality.

There was a crude association between age group and failure before discharge (Table 4); the odds of failure were significantly higher for children <1 year of age relative to those in the older age group ($P<0.001$ (Figure 3). In a multivariable model with age group, size-to-weight ratio, and valve type, however, age group and valve type were no longer significant (Table 4). This suggests that the crude age group association with failure can be explained largely by the association with size-to-weight ratio.

The risk of failure before discharge when the tricuspid valve replacement was performed at 1 of the 3 high-volume institutions (14 of 62; 23%) was compared to the risk at the 15 low-volume institutions (12 of 35; 34%). Center volume was not associated with failure before discharge ($P=0.21$).

Era of surgery was not associated with failure. The time from 1984 to 1999 represented by these surgeries was divided into 3 time frames: early (1984 through 1989), mid (1990 through 1995), and late (1996 through 1999). There was no association between the 3 time frames and failure before discharge, and there was no association between the 3 time frames and failure before hospital discharge.

### TABLE 3. Association of Diagnosis and Valve Type With Death and the Need for a Pacemaker Before Discharge in Children ≥1 Year of Age

<table>
<thead>
<tr>
<th>Primary Diagnosis Category</th>
<th>Valve Type</th>
<th>N</th>
<th>Requirement of Pacemaker Before Discharge</th>
<th>Death* Before Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve abnormality</td>
<td>Bioprosthetic</td>
<td>40</td>
<td>2 1.0§</td>
<td>15 1.0§</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>11</td>
<td>27 13.5 (1.0 to 786.5) 0.06</td>
<td>18 1.0 (0.1 to 7.6)</td>
</tr>
<tr>
<td>Systemic AV defect</td>
<td>Mechanical</td>
<td>15</td>
<td>20 9.3 (0.7 to 524.5) 0.12</td>
<td>40 3.2 (0.6 to 16.5)</td>
</tr>
<tr>
<td>Conotruncal defect</td>
<td>Bioprosthetic</td>
<td>10</td>
<td>0 1.0</td>
<td>20 1.6 (0.9 to 8.1)</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>7</td>
<td>57 42.6 (3.1 to 2619.4) 0.002</td>
<td>14 0.8 (0.01 to 9.2)</td>
</tr>
</tbody>
</table>

AV indicates atrioventricular.

*Includes 2 patients who had a transplant before discharge.

†No association between need for a pacemaker before discharge and diagnosis/valve type was rejected ($P<0.001$, Fisher exact test). No association between death before discharge and diagnosis/valve type was not rejected ($P=0.38$, Fisher exact test).

‡Adjusted for size-to-weight ratio (OR=2.6 for each 1-unit increase in size-to-weight ratio; 95% CI, 0.9 to 8.1; $P=0.07$; overall model, $P=0.25$).

§Reference group for estimation of ORs.
discharge: 23% (6 of 26) early, 26% (11 of 42) mid, and 31% (9 of 29) late (P=0.80).

Cardiac Diagnosis
There was an overall association between organ failure before discharge and diagnosis group (P=0.03; Table 4). Patients with tricuspid valve replacement in the systemic position served as the reference group for estimating ORs. That diagnosis group had higher odds of failure relative to both of the other diagnosis groups as reflected by ORs <1.0. Inclusion of the size-to-weight ratio in a multivariable model moderated slightly the OR for the primary valve abnormality diagnosis group relative to the reference group.

Nearly half of the systemic atrioventricular valve patients had single-ventricle physiology (n=11). Sixty-four percent of patients with single-ventricle physiology died or underwent transplantation before discharge, including all patients <1 year of age (n=4). Of the 12 systemic atrioventricular valve patients with 2-ventricle physiology, 4 died before discharge, including 1 of the 4 patients <1 year of age. Further statistical analyses of outcomes for single-ventricle versus biventricular physiology were not possible because of the small sample size.

There was no overall association between diagnosis category/valve type group and failure before discharge, with or without adjustment for size-to-weight ratio, for the patients in the older age group (Table 3).

Valve Characteristics
There was suggestion of an association between valve type and failure before discharge (P=0.06). Valve replacement with a mechanical valve was associated with increased odds of failure relative to replacement with a bioprosthetic valve with a crude OR of 2.5 (95% CI, 1.0 to 6.2; P=0.06). Among children ≥1 year of age, the odds of failure in patients who received a mechanical valve were 2 times the odds for patients who received a bioprosthetic valve (OR, 2.0; 95% CI, 0.7 to 5.8), but this was not significant (P=0.22). Because the majority of patients <1 year of age (79%) received a mechanical valve, an age group– and size-to-weight ratio–adjusted multivariable model was investigated (Table 4). The adjusted odds of failure associated with use of a mechanical valve relative to use of a bioprosthetic valve was 1.8 (95% CI, 0.5 to 5.8; P=0.41). Of the 13 patients known to have died (n=11) or undergone cardiac transplantation (n=2) after discharge, 85% had a mechanical valve.

Analysis of valve size relative to the weight of the patient, as plotted in Figure 4, serves as an indication of vital status. The size-to-weight ratio was positively associated with the odds of death before discharge. For every 1-unit increase in the size-to-weight ratio, the crude odds of failure increased by 2.6 times (95% CI, 1.5 to 4.4; P<0.001). Failure before discharge occurred in 18% of patients with a size-to-weight ratio of ≥2.5. Failure occurred in 54% of patients with a size-to-weight ratio >2.5.

Discussion
Few data exist to guide decisions on tricuspid valve replacement in young children. Adult studies demonstrate suboptimal outcomes with early mortality rates of 14% to
Studies of tricuspid valve replacement in adults with congenital heart disease demonstrate more favorable outcomes in the setting of Ebstein’s anomaly with an early mortality rate of 5.7%. Data on outcomes in children have demonstrated a rate of operative mortality similar to that observed in adults, ranging from 9% to 36%. The present study focused on young children and demonstrates a high hospital mortality rate, especially in those <1 year of age. Factors other than age, however, are more predictive of death. Several adult studies have compared mechanical and biological valve types for tricuspid valve replacement. A meta-analysis and the UK Heart Valve Registry study showed no superiority for biological or mechanical prostheses. Additionally, bioprosthetic valve replacement has had favorable durability in the tricuspid position. The data reported in the present study demonstrate that bioprosthetic valve type is advantageous for tricuspid valve replacement in young children. The risk of pacemaker implantation was lower with a bioprosthetic valve with a trend for improved survival.

The main predictor of postoperative mortality after tricuspid valve replacement is a large valve size relative to the patient’s weight, the size-to-weight ratio. This is consistent with outcomes from mitral valve replacement for young children and suggests that size disparity between the valve size and the ventricle may result in restriction of leaflet mobility. Implantation of oversized prosthetic valves may be intentional to delay subsequent reoperations necessitated by patient growth. We suggest that this strategy is disadvantageous. Selecting the valve size by the size-to-weight ratio may moderate this problem and improve early outcomes. Small valves have limited availability, however, and implantation of larger valves in children <1 year may be unavoidable.

Children <1 year of age had markedly worse outcomes than the older group of children with a 64% hospital mortality. This finding highlights the need to explore alternatives to tricuspid valve replacement for infants, including cardiac transplantation.

**Study Limitations**

Limitations of the present study include the retrospective nature and the lack of reliable long-term follow-up. Data beyond the last consortium entry were unavailable. Consortium data contain catheterization reports, operative reports, and deaths in the hospital. Thus, for patients who had no further intervention at a consortium institution, follow-up data are not available. Long-term mortality is likely underestimated because out-of-hospital deaths are not necessarily documented. Data were analyzed on the basis of outcome at hospital discharge. These results should be interpreted as representing early risks associated with tricuspid valve replacement.

**Conclusions**

Tricuspid valve replacement in young children is a procedure with a high risk of early postoperative death. Replacement with a valve sized on the basis of patient weight may decrease the risk of death. Selection of a bioprosthetic valve decreases the risk of a pacemaker and may decrease the risk of thrombosis. The data from the present study improve the ability to predict outcome in patients and may be useful in guiding decisions and consultation.

**Disclosures**

None.

**References**


CLINICAL PERSPECTIVE

The outcomes for children <6 years of age who underwent tricuspid valve replacement were analyzed, focusing on in-hospital morbidity and mortality. Results indicate that tricuspid valve replacement in young children is a high-risk procedure but that the risks can be moderated by use of a bioprosthetic valve sized relative to the patient’s weight. The majority of patients in the present study had congenital heart disease with an abnormality of the tricuspid valve. Prior operations were common, as were procedures concomitant with valve replacement. A bioprosthetic valve was used slightly more often (55%) than a mechanical valve. The risk of death was high. Twenty-six percent of patients died or underwent cardiac transplantation before discharge. The major predictor of death was a large valve size relative to the patient’s weight (>2.5 mm/kg). Children <1 year of age had worse outcomes than the older group of children in that 64% died, but this can be explained largely by the association with a large valve size for patient weight. Bioprosthetic valve type is advantageous for tricuspid valve replacement in young children. The risk of pacemaker implantation was significantly lower, and there was a trend toward improved survival. Early era of surgery and low institutional volume were not shown to be risk factors. These data improve the ability to predict outcome in patients and may be useful in guiding decisions and consultation.
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