Outcomes and Associated Risk Factors for Aortic Valve Replacement in 160 Children
A Competing-Risks Analysis

Tara Karamlou, MD; Karen Jang, MS; William G. Williams, MD; Christopher A. Caldarone, MD; Glen Van Arsdell, MD; John G. Coles, MD; Brian W. McCrindle, MD, MPH

Background—We sought to define patient characteristics, outcomes, and associated risk factors after aortic valve replacement (AVR) in children.

Methods and Results—Clinical records from children undergoing AVR from 1974 to 2004 at our institution were reviewed. Competing-risks methodology determined the time-related prevalence of 3 mutually exclusive end states: death, repeated replacement, and survival without subsequent AVR and their associated risk factors. Longitudinal echocardiographic data were analyzed by mixed linear-regression models. Children (n=160) underwent 198 AVRs, with 33 having >1. Competing-risks analysis predicted that 10 years from the initial AVR, 19% had died without subsequent AVR, 34% underwent a second AVR, and 47% remained alive without replacement. Risk factors for death without a second AVR included lower weight (P<0.001) and younger age at AVR (P=0.04), performance of aortic arch reconstruction together with AVR (P=0.03), and nonautograft use (P=0.03). Risk factors for a second AVR included earlier operation year (P=0.04) and implantation of a bioprosthetic or homograft valve (P=0.004). Analysis of serial echocardiographic measurements showed that pulmonary autograft use was associated with slower progression of peak aortic gradient (P=0.002), smaller left ventricular dimension (P=0.04), and decreased prevalence of aortic regurgitation (P=0.04).

Conclusions—Mortality and repeated valve replacement are common after initial AVR in children, especially in younger patients and those with bioprosthetic or homograft valves. Pulmonary autograft use is associated with decreased mortality, slower gradient progression, and smaller left ventricular dimension. (Circulation. 2005;112:3462-3469.)

Key Words: heart defects, congenital ■ follow-up studies ■ pediatrics ■ aortic valve ■ valvuloplasty

Aortic valve disease is one of the most common congenital cardiac defects, occurring in ~5% of all children with heart disease,1,2 and aortic valve replacement (AVR) is sometimes required. AVR in children poses unique challenges that have hampered identification of the ideal prosthesis.3-6 Homograft and bioprosthetic valves achieve superior hemodynamic result initially but at the cost of accelerated degeneration.7-9 Small patient size and the risk of thromboembolism limit the usefulness of mechanical valves, and somatic outgrowth is a universal problem with all available prostheses. The Ross operation (use of the pulmonary valve as an autograft) introduced in 196710 has emerged as an attractive alternative, but concerns persist about the fate of the neoaortic valve, the potential for development of neoaortic valve insufficiency, and the lack of consistent long-term outcome data.11-14 In addition, autograft use often necessitates repeated interventions for right ventricular outflow tract obstruction.3,12

In addition to prosthesis failure and reoperation, children are simultaneously at an increased risk of death after AVR. Although outcomes after AVR in children have been reported elsewhere,2-4,8,15,16 previous studies have not used competing-risks methodology nor examined longitudinal data to evaluate functional performance of different prostheses over time. We therefore sought to use competing-risks analysis to determine the time-related prevalence and associated risk factors of 3 mutually exclusive end states: death, repeated replacement, and survival without subsequent AVR. We also sought to define the time course of hemodynamic parameters and left ventricular dimensions as impacted by prosthesis type according to longitudinal data analysis.

Methods

Study Subjects
Patients ≤18 years of age who underwent initial AVR at our institution between January 1974 and June 2004 were identified from computerized databases.
Data Collection and Measurements

The study was approved by the institutional research ethics board. Data collected from medical record review included patient demographics, preoperative cardiac and noncardiac diagnoses, clinical condition, previous procedures and complications, echocardiographic and cardiac catheterization assessments and procedures, operative data, and postoperative and follow-up clinical status, including repeated echocardiographic measurements. Echocardiographic measurements included peak instantaneous gradient across the prosthetic valve, subjective grade of prosthesis insufficiency, and left ventricular end-diastolic dimension (LVEDD, which was converted into Z-scores from regression equations based on previously published nomograms17,18). Prosthesis Z-score was likewise determined as the number of standard deviations from mean normal aortic valve size.19

Data Analysis

Data are given as frequency, median with range, or mean±SD as appropriate, with the number of nonmissing values indicated. All data analyses were performed with SAS statistical software (version 9.1, SAS Institute, Inc). Both replaced valve failure with subsequent repeated replacement and mortality were modeled as time-dependent events by using both Kaplan-Meier estimates and parametric methods, with the association with risk factors being explored in multivariable analysis with bootstrap bagging20 to guide variable selection and assess reliability of inclusion in the final regression models. Competing-risks analysis was used in a manner as previously reported.20–27 In brief, parametric probability estimates of freedom from repeated valve replacement and death were generated from models based on the decomposition of the hazard function into multiple, overlapping phases of risk (available for use with the SAS system4 at http://www.clevelandclinic.org/heartcenter/hazard). The HAZARD procedure uses the method of maximum likelihood to aid in resolving up to 3 phases of the distribution of times until an event (early decreasing or peaking hazard, constant hazard, and late increasing hazard). Although 3 phases are potentially present for any time-related event, model validity does not require that separate scaling parameters be specified for all 3 phases, because realistically, many events have only 1 or 2 discrete phases of risk. Once the characteristic equation (hazard function) for each competing state is specified, competing-risks analysis is used to integrate them (with the function for remaining alive without death or subsequent replacement being the mathematically derived remainder given by [1−[proportion experiencing mortality−proportion experiencing repeated replacement]]) to show the proportion of patients within all of the specified states at any given time point. Post-AVR serial echocardiographic assessments of peak instantaneous prosthetic valve gradient and LVEDD Z-score were modeled, and risk factors were sought by using mixed linear regression. Factors associated with the presence of prosthetic valve insufficiency after AVR were sought by repeated-measures ordinal outcome models.

Results

Patient Characteristics

Initial demographic and morphological characteristics are listed in Table 1. During the study period, 160 children underwent an initial AVR. The underlying valve disease was congenital in 84% (59 of whom had a bicuspid valve), rheumatic in 7%, isolated endocarditis in 2%, or other valve pathology in 7%. Associated cardiac defects were found in 52%, the most prevalent of which included mitral valve dysfunction in 23%, truncus arteriosus or Shone’s syndrome in 8%, and ventricular septal defect in 7%. The level of left ventricular outflow tract (LVOT) obstruction was predominantly valvar in 76%, subvalvar in 10%, supravalvar in 9%, and secondary to a hypoplastic valvar annulus in 3%. Multiple levels of obstruction were found in 15%. Patients with predominant subvalvar or supravalvar obstruction all had concomitant aortic valve pathology, including important regurgitation, stenosis, or valvar dysplasia of sufficient magnitude to warrant AVR.

AVR Episodes

A flowchart depicting events after the initial AVR is shown in Figure 1. Of the 160 patients, during the study interval 127 had only 1 AVR (24 subsequently died), 33 patients had a second AVR (2 subsequently died), and 5 patients had a third AVR (3 subsequently died), for a total of 198 AVR episodes. The characteristics at the initial and subsequent AVR episodes are shown in Table 2. Median age at initial AVR was 11 years (range, 2 days to 18 years). The age at initial AVR was significantly younger in those with associated cardiac anomalies versus those with isolated aortic valve disease (P=0.04), although those with associated defects predominated throughout all ages. Patients receiving tissue valves were significantly younger (8.9±6.0 versus 11.4±4.6 years,
than those receiving mechanical prostheses. The need for concomitant aortic arch enlargement or aortic reconstruction was associated with slightly longer cardiopulmonary bypass time (166±57 versus 152±26 minutes for those without reconstruction; \( P = 0.15 \)). Overall time-related survival for all patients regardless of subsequent procedures was 85%, 78%, and 70% at 1, 5, and 15 years, respectively.

**Postoperative Clinical Course**

There were 13 deaths within 30 days of AVR. Postoperative complications in 73 patients included postoperative hemorrhage in 12 patients (8%), severe sepsis in 11 (7%), pericardial effusion in 11 (7%), temporary or permanent heart block in 6 (4%), arrhythmia requiring medical therapy in 7 (5%), stroke in 3 (2%), and other complications in the remainder. A reoperation before hospital discharge was performed in 12 patients (8%), including exploration for bleeding in 4 (3%) and repair and replacement of the prosthesis in 1 patient each.

**Late Complications**

There was also important morbidity in 147 patients whose course was not complicated by death or subsequent replacement within 30 days. Nine patients (6%) had an episode of bleeding related to anticoagulation, with stroke and transient ischemic attack occurring in 1 patient each. Late arrhythmia occurred in 7 patients (5%), and another patient underwent pacemaker implantation for complete heart block. Paravalvular leak and prosthesis thrombosis were uncommon, occurring in 1 patient each. Anticoagulation at latest follow-up assessment included warfarin in 37%, aspirin in 26%, both aspirin and warfarin in 8%, and no anticoagulation in 26%. Anticoagulation was more frequently used for patients receiving mechanical prostheses but was used in 23 patients with bioprosthetic prostheses and in 6 autograft recipients. There were 3 late deaths among the 33 patients who underwent repeated AVR; 1 occurred 6 years after the first repeated replacement, and 2 occurred >5 years after a third AVR.

**Competing Risks for Death or Subsequent Prosthesis Replacement After Initial AVR**

During follow-up of the 160 initial AVR episodes, 33 prostheses were subsequently replaced and 24 patients died without further AVR. The hazard function for time-related transition to a second AVR was characterized by a constant-hazard phase (32 constant-phase events) and a late phase (1 late-phase event). The hazard function for time-related transition to death without a second AVR was characterized by a very steep early hazard phase (7 early-phase events) and a prolonged late phase (17 late-phase events). Competing-risks analysis predicted that after 10 years from initial AVR, 19% had died without a second AVR, 34% underwent a second AVR, and 47% remained alive without repeated replacement (Figure 2). Late-phase risk factors for death without a second AVR and for constant-phase risk factors for a subsequent second AVR after the initial AVR were sought and are shown in Table 3. The unfavorable effect of lower weight on mortality after initial AVR but before subsequent repeated replacement is shown in Figure 3. The predicted outcomes displayed in Figure 3 represent a specific solution to the

![Figure 1. Flow chart depicting events after initial AVR. There were 160 children who underwent 198 AVRs during the study period. There were 29 total deaths, 24 occurring without re-replacement, 2 occurring after a second AVR, and 3 occurring after a third AVR.](http://circ.ahajournals.org/)

**TABLE 2. Procedural Characteristics at Initial and Subsequent AVRs Combined (n=198 Procedures in 160 Patients)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Missing</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age at AVR, y (range)</td>
<td>198</td>
<td>0</td>
<td>12 (0 to 28)</td>
</tr>
<tr>
<td>Median weight at AVR, kg (range)</td>
<td>186</td>
<td>12</td>
<td>40 (0 to 180)</td>
</tr>
<tr>
<td>Mean duration of cardiopulmonary bypass, min, ±SD</td>
<td>182</td>
<td>16</td>
<td>166±55</td>
</tr>
<tr>
<td>Mean duration of aortic cross clamping, min, ±SD</td>
<td>173</td>
<td>25</td>
<td>124±72</td>
</tr>
<tr>
<td>Type of AV replacement, n (%)</td>
<td>185</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Bjork-Shiley</td>
<td>45</td>
<td>(24)</td>
<td></td>
</tr>
<tr>
<td>St. Jude Medical</td>
<td>35</td>
<td>(19)</td>
<td></td>
</tr>
<tr>
<td>Pulmonary autograft</td>
<td>31</td>
<td>(17)</td>
<td></td>
</tr>
<tr>
<td>Allograft</td>
<td>30</td>
<td>(16)</td>
<td></td>
</tr>
<tr>
<td>Hancock</td>
<td>15</td>
<td>(8)</td>
<td></td>
</tr>
<tr>
<td>Ionescu-Shiley</td>
<td>10</td>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td>Carbomedics</td>
<td>9</td>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td>Carpentier-Edwards</td>
<td>5</td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td>Other mechanical</td>
<td>5</td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td>Mean size of AV implant, mm, ±SD</td>
<td>186</td>
<td>12</td>
<td>23±3</td>
</tr>
<tr>
<td>Bjork-Shiley</td>
<td>23</td>
<td>±3</td>
<td></td>
</tr>
<tr>
<td>St. Jude Medical</td>
<td>23</td>
<td>±3</td>
<td></td>
</tr>
<tr>
<td>Pulmonary autograft</td>
<td>20</td>
<td>±6</td>
<td></td>
</tr>
<tr>
<td>Allograft</td>
<td>19</td>
<td>±3</td>
<td></td>
</tr>
<tr>
<td>Hancock</td>
<td>24</td>
<td>±4</td>
<td></td>
</tr>
<tr>
<td>Ionescu-Shiley</td>
<td>21</td>
<td>±4</td>
<td></td>
</tr>
<tr>
<td>Carbomedics</td>
<td>22</td>
<td>±4</td>
<td></td>
</tr>
<tr>
<td>Carpentier-Edwards</td>
<td>25</td>
<td>±2</td>
<td></td>
</tr>
<tr>
<td>Other mechanical</td>
<td>23</td>
<td>±3</td>
<td></td>
</tr>
<tr>
<td>Mean Z-score of AV prosthesis, ±SD</td>
<td>186</td>
<td>12</td>
<td>4±2</td>
</tr>
</tbody>
</table>
multivariable equations for death without a second AVR for a hypothetical patient without autograft implantation or concomitant aortic arch reconstruction, with specific values assigned for the 2 other significant explanatory variables found to influence mortality within this competing-risks model. Similarly, Figure 4 demonstrates the unfavorable effect of earlier year of operation on survival to a second AVR. This graph represents a specific solution to the multivariable equation for survival to a subsequent AVR for a hypothetical patient with implantation of a tissue prosthesis at 3 different time intervals. A stratified graph of valve longevity by different types of initial prosthesis shows that autografts had superior longevity when compared with mechanical prostheses (Caromedics [Sulzer Carbomedics, Inc], Bjork-Shiley [Shiley, Inc], and others) (Figure 5).

Longitudinal Analysis of Serial Echocardiographic Measurements After AVR
Peak instantaneous echocardiographic Doppler prosthetic valve gradient was available for 124 patients, with a total of 524 measurements up to a maximum interval of 19 years (mean, 3.1 years). Progression of the prosthetic valve gradient over time was nonlinear, with a rapid initial rise followed by a prolonged gradual rise thereafter ($P<0.001$). Use of a prosthesis other than a pulmonary autograft was associated with more rapid gradient progression ($P<0.005$). Other significant independent factors associated with higher peak gradient at any time during follow-up included younger age at initial operation ($P<0.02$) and earlier year of operation ($P<0.03$). Figure 6 shows that implantation of an autograft effectively blunted the early accelerated progression of the peak prosthesis gradient that was evident after implantation of all other prosthetic types.

TABLE 3. Incremental Risk Factors for Time-Related Transition From Initial AVR (N=160) to Either Death or a Second AVR

<table>
<thead>
<tr>
<th>Reliability*</th>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>$P \pm SE$</th>
<th>Value, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>For death without subsequent AVR†</td>
<td>Lower weight at operation (per 1 kg)$§$</td>
<td>$9.52\pm2.00$</td>
<td>$&lt;0.001$</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Younger age at operation (per 1 y)$§$</td>
<td>$6.20\pm3.00$</td>
<td>0.04</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Concomitant performance of aortic arch reconstruction</td>
<td>$1.32\pm0.59$</td>
<td>0.03</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Nonuse of autograft</td>
<td>$2.30\pm1.00$</td>
<td>0.03</td>
<td>51</td>
</tr>
<tr>
<td>For survival to a subsequent AVR‡</td>
<td>Earlier year of operation (per 1 y)</td>
<td>$4.10\pm0.37$</td>
<td>0.0001</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Use of a bioprosthetic or homograft valve</td>
<td>$1.17\pm0.40$</td>
<td>0.01</td>
<td>69</td>
</tr>
</tbody>
</table>

*Percentage refers to the reliability determined by bootstrap bagging (variable resampling) method.
†Risk factors were sought only for late-phase events because of the paucity of events in the early phase.
‡Risk factors were sought only for constant-phase events because of the paucity of events in the late phase.
§After inverse transformation.
LVEDDs (expressed as Z-scores) were similarly available for 121 patients, with a total of 524 measurements performed up to a maximum interval of 19 years (mean, 3.1 years). The relation between LVEDD and time was also nonlinear, with a rapid decline initially followed by a constant slope thereafter ($P<0.001$). Incremental risk factors associated with higher LVEDD Z-scores at any point during follow-up also included lower weight at initial operation ($P<0.01$), younger age at AVR ($P<0.001$), and use of a prosthesis type other than an autograft ($P=0.04$), as shown in Figure 7.

Data on the presence of important prosthetic valve insufficiency (subjective grade on echocardiography of more than mild) were available for 118 patients, with a total of 240 measurements performed up to a maximum interval of 18 years (mean, 3.1 years). The relation between prosthetic valve insufficiency and time was nonlinear, with an initial rise followed by a constant slope thereafter ($P<0.001$). Incremental risk factors associated with the presence of prosthetic valve insufficiency at any point during follow-up also included female sex ($P=0.02$), higher Z-score of implanted prosthesis size ($P=0.05$), and use of a prosthesis type other than an autograft ($P=0.04$).

Discussion

Our study reports a single institution’s experience with AVR in 160 children. The results of the competing-risks analysis...
provide valuable information about the time-related prevalence of death without repeated replacement and prosthetic longevity. In addition, the results of the longitudinal data analysis corroborate those of the competing-risks models and provide insight for the superior outcomes associated with use of a pulmonary autograft.

Competing-risks analysis was chosen because our patients were simultaneously at risk for 2 mutually exclusive events: death and prosthetic replacement. Conventional time-related analyses consider individual events such as death or reoperation either in isolation or as a combined end point. Though useful, they do not address the question of how often an event may occur in the presence of other events for which a patient is at simultaneous risk. In addition, the incremental risk factors associated with each competing outcome (e.g., death and reoperation) are often disparate, and therefore, using combined end points may be misleading.

**Mortality**

We identified younger age and lower weight at initial AVR to unfavorably influence mortality without repeated replacement, especially in the extreme case of very young age or very low weight. Previously published reports that have shown that neonates and those <6 months of age compose the highest-risk group agree with these findings. There are several reasons for poor outcome in this population. First, young age at initial operation was significantly associated with the presence of other cardiac anomalies, including important mitral valve dysfunction, which accounted for substantial mortality in our series. Others have noted that those with concomitant cardiac lesions fare worse than those with isolated aortic valve disease. Second, the preoperative clinical status of younger patients, especially neonates, is likely to be considerably worse than those undergoing later AVR. Detailed preoperative information was not available in sufficient numbers in our cohort, but the correlation between poor preoperative left ventricular function (fractional shortening <25%) and late mortality has been established by others. Finally, younger patients (and those with lower weight) are at highest risk for prosthesis outgrowth necessitating subsequent repeated replacement or intervention, which may contribute to increased mortality.

The need for concomitant aortic arch reconstruction or augmentation was also identified as an incremental risk factor for death without a second AVR. Extensive aortic reconstruction in our series was associated with slightly longer cardiopulmonary bypass time. We have previously shown that prolonged cardiopulmonary bypass time is an important risk factor for death in children undergoing mitral valve replacement.

Use of a pulmonary autograft, compared with all other prostheses, was protective with respect to death without repeated prosthetic replacement. In our series, only 3 patients died after autograft implantation, and none required repeated replacement. From our mixed regression analysis, autograft use was associated with a decreased prevalence of prosthetic valve insufficiency, retarded early progression of the peak instantaneous prosthetic valve gradient, and a more rapid decrease in the LVEDD. More favorable hemodynamics in this context may be secondary to growth of the autograft, thereby neutralizing prosthesis outgrowth. Maintenance of low transvalvular gradients in patients receiving pulmonary autografts has been reported previously. In their series of 105 patients undergoing the Ross operation, Savoye and colleagues found no progression of autograft peak gradients as measured by echocardiography (5.0 ± 2.8 mm Hg at discharge versus 5.5 ± 3.5 mm Hg at last follow-up, P = NS) during a 7-year study interval and further noted that autograft gradients were similar to those of native aortic valves. Normalization of ventricular dimensions and regression of ventricular hypertrophy have also been well described. The longitudinal data analysis used in this study provides more direct evidence of the hemodynamic and functional impact of particular valve substitutes and facilitates an empirical approach to prosthesis selection.

Despite the advantages of autograft use, concern exists about dilatation of the neoaortic root and potential development of neoaortic valve insufficiency after the Ross operation. We have shown that autograft use is not associated with an increased prevalence of neoaortic regurgitation. This finding may reflect the absence of anatomic mismatch between the aortic and pulmonary valves in our series, because placement of an oversized prosthesis was correlated with the development of aortic insufficiency. Recent literature addressing these issues has generated conflicting reports. Simon et al documented rapid adaptation of the pulmonary autograft to systemic pressure and normal growth trajectories thereafter, with 95% of patients free from important regurgitation at 4 years. A proportional increase in the LVOT root diameter (indexed to patient body surface area) was similarly documented in a larger study of 260 patients (136 of whom were <18 years of age). Other authors have reported progressive dilatation of the autograft with differential prevalence, depending on the definition used (generally 4.0 cm or greater), the method used for detection, and the duration of follow-up. Predisposing factors favoring dilation have included anatomic mismatch between the pulmonary and aortic root and a complete aortic root replacement technique without pericardial buttressing of the ascending aorta and annulus.

**Valve Longevity**

We identified 2 risk factors for decreased time to a repeated AVR after the initial AVR: (1) earlier year of operation and (2) use of a bioprosthetic or homograft valve. The protective effect of the more recent era has been documented in other complex congenital lesions coincident with improvements in patient triage, preoperative and postoperative care, diagnostic modalities, myocardial protection, and operative technique. In addition, our recent experience favored autografts and avoided the use of bioprostheses, which likely contributed to improved outcomes over time.

The choice of initial prosthesis is still debated. In this report, bioprosthetic valves and allografts had decreased freedom from prosthetic replacement when compared with mechanical valves and with autografts after adjustment for all other significant variables. Patients receiving tissue valves in our series were significantly younger than those receiving...
mechanical prostheses, because the larger size of mechanical valves often precludes their use in this setting. In addition, bioprosthetic valves were more commonly used early in our experience, contributing to suboptimal outcomes. Accelerated degeneration, calcification, and structural failure of bioprostheses have led to inferior longevity compared with mechanical valves in most published series.\(^5\)\(^6\) The improved durability of mechanical valves, however, must be tempered by the long-term requirement for anticoagulation and thromboembolism. Nine children with mechanical valves developed important bleeding related to warfarin use during follow-up, and thromboembolic complications occurred in 3 patients. Patient quality of life, though not directly assessed in this study, has been shown to be compromised by required thromboembolic prophylaxis.\(^3\)\(^4\)

The data on allograft longevity are somewhat more controversial, because important risk factors influencing durability, such as younger age and smaller prosthetic size, are often more prevalent in allograft recipients. A favorable effect on ventricular function and dimensions was noted by Hasnat et al\(^11\) in a study of 144 patients undergoing re-replacement with an allograft. Lupinetti and colleagues\(^8\) also noted that comparable freedom from death and reoperation were achieved with use of either an allograft or a pulmonary autograft. In contradistinction, other authors have reported less favorable outcomes with allograft use.\(^6\)\(^5\)\(^3\)\(^5\)\(^3\)\(^7\) The unresolved issue of potential sensitization leading to accelerated degeneration of allografts further complicates decision making.\(^3\)\(^8\)

Limitations

The present report is a retrospective analysis of patients from a single institution with diverse anatomy who underwent operation during a 30-year period. Undoubtedly, indications for valve replacement, timing of operation, and operative technique were not constant over time. In addition, prosthesis selection and operative procedures were not standardized or randomized, and the comprehensive set of options was not available throughout the study period. Data on reinterventions directed against the right ventricular outflow tract, an important potential complication of pulmonary autograft use, were not collected in this study. Finally, although a comprehensive set of variables was used in all analyses, unmeasured covariates may have contributed to disparate outcomes in the recipient populations.

Conclusions

We have used competing-risks methodology and longitudinal data analysis to define outcomes in 160 children after AVR. We have demonstrated that younger age, lower operative weight, concomitant performance of aortic root replacement or reconstruction, and use of prosthesis type other than a pulmonary autograft are significant predictors of death without a repeated AVR. Furthermore, the use of a bioprosthetic or allograft valve type and earlier year of operation were identified as significant risk factors for earlier repeated AVR. Autograft use was not associated with an increased prevalence of prosthetic valve insufficiency. Blunted early progression of the peak prosthetic valve gradient and a rapid decrease in the LVEDD may account for the favorable outcomes in autograft recipients.

References


Outcomes and Associated Risk Factors for Aortic Valve Replacement in 160 Children: A Competing-Risks Analysis
Tara Karamlou, Karen Jang, William G. Williams, Christopher A. Caldarone, Glen Van Arsdell, John G. Coles and Brian W. McCrindle

Circulation. 2005;112:3462-3469
doi: 10.1161/CIRCULATIONAHA.105.541649
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2005 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/112/22/3462

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/