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Intersurgeon variability in long-term outcomes after transatrial repair of tetralogy of Fallot: 25 years' experience with 675 patients

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Objective: To compare the long-term reoperation rates among surgeons performing transatrial repair of tetralogy of Fallot.

Methods: The data set of 675 patients undergoing transatrial repair of tetralogy of Fallot at 1 institution from 1980 to 2005 was analyzed for intersurgeon differences in the reoperation rates.

Results: A follow-up period >15 years was available for 5 surgeons, allowing for comparison (541 patients; >80 patients/surgeon). The reintervention rate at 10 years varied from 8.8% (95% confidence interval [CI], 5.3%-14.5%) to 26.7% (95% CI, 14.9%-44.9%; hazard ratio, 3.4; $P = .001$). The procedures of 1 surgeon resulted in a reoperation rate of 10.5% at 20 years (95% CI, 5.4%-25.3%). The type of reoperation required varied among the surgeons. One surgeon had had no reoperations for pulmonary artery stenosis. Of the 5 surgeons, 2 (surgeons 2 and 5) had equivalent overall 10-year reoperation rates (24.1%, 95% CI, 12.9%-42.3%; vs 26.7%, 95% CI, 14.9%-44.9%; $P = .32$). Surgeon 5 had reoperation almost exclusively for right ventricular outflow tract obstruction (20.6%; 95% CI, 12.4%-33.1%) and surgeon 2 for right ventricular dilation (17.4%; 95% CI, 7.8%-36.3%). None of the patients treated by surgeon 5 required implantation of a valved conduit.

Conclusions: An analysis of the reoperation rate during the long-term follow-up of transatrial repair of tetralogy of Fallot identified variability in the outcomes among 5 surgeons. The analysis of these differences suggested that an optimal amount of opening of the right ventricular outflow tract can lead to a decreased reintervention rate. The analysis of intersurgeon variability in outcomes should be encouraged, because it will lead to improvements in cardiac surgery outcomes. (J Thorac Cardiovasc Surg 2014;147:880-8)

In a large proportion of the patients undergoing tetralogy of Fallot repair, relief of the right ventricular (RV) outflow tract (RVOT) obstruction necessitates a transannular incision and patching of the hinge points of the pulmonary valve.[1-3] It has been estimated that 20 years after undergoing Fallot repair, 30% to 40% of patients could require the implantation of a valved conduit in their RVOT because the created pulmonary insufficiency has resulted in RV dilatation.[4-6]

Two main surgical techniques are available for repair of tetralogy of Fallot: the transventricular technique, after which the ventricular septal defect is closed through the ventriculotomy; and the transatrial technique, after which the ventricular septal defect is closed through the tricuspid valve.[2,7] It has long been suspected that patients would have a reduced incidence of late RV dilatation if their RVOT remained slightly restrictive after repair.[1,3,8] The recent publication of a long-term follow-up study and an animal experiment have seemed to confirm this hypothesis.[9,10] It has been postulated that patients undergoing repair with the transatrial technique would have a smaller incision on the RVOT and, therefore, a reduced incidence of RV dilatation requiring valvulation of the RVOT.[1,8]

We have recently reported the long-term outcomes of all patients treated with a transatrial repair at the Royal Children's Hospital, Melbourne, with a policy of repair delayed beyond the neonatal period.[11] With the use of this technique and policy, we observed hospital mortality of 1% and only 2 sudden deaths of 668 survivors of the repair. The veracity of these data was ascertained in the National Death Registries. Only 15% of our patients required the implantation of a valved conduit in their RVOT in the 20 years after repair.

We believed that under the generic term "transatrial repair," the surgeons of our team would vary in the methods used to perform this operation, in particular, in the amount of opening of the RVOT. We hypothesized that patients

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Abbreviations and Acronyms
CI = confidence interval
HR = hazard ratio
MRI = magnetic resonance imaging
RV = right ventricular
RVOT = right ventricular outflow tract

treated by surgeons who would proceed with a larger opening would have a greater risk of reoperation for RV dilatation and those treated by surgeons practicing more restrictive opening of the RVOT would have a greater risk of reoperation for RVOT obstruction (Figure 1). To determine the effect of this potential variation in practice, we analyzed the intersurgeon variability in long-term outcomes after transatrial repair of tetralogy of Fallot performed within the same center.

METHODS

The local hospital ethics committee approved the design of the present study. The data set of a previous analysis of outcomes after transatrial repair performed at the Royal Children's Hospital was reanalyzed for differences in late outcomes among surgeons, a parameter that had not been previously investigated.[11] The exclusion criteria were an associated atrioventricular septal defect, pulmonary atresia, and double outlet right ventricle. After 1981, transatrial repair became the sole operative technique used in our center. From 1980 to 2005, 675 consecutive patients underwent transatrial repair of tetralogy of Fallot at our center. Their outcomes data were recently collected. Seven patients could no longer be located; the mean follow-up of the remaining population was 11.7 ± 6 years.

Mode of Referral

During the study period, the Royal Children's Hospital has remained the sole institution in Victoria, Australia, offering pediatric cardiac surgery, providing this service for Victoria, South Australia, Tasmania, Northern Territory, and, up to the 1990s, in Western Australia. During the study period, acceptance for surgery and decision-making followed the same rules. All cases referred for surgery by individual cardiologists were discussed at the Royal Children's Hospital case conference, in which all cardiologists and surgeons present made decisions concerning acceptance of surgery, type of surgery recommended, and timing of surgery. Cases were allocated among the surgeons of the team by the head of the department. Reoperations were preferably addressed to the surgeon who had performed the initial operation if the surgeon was still working at the center. Decisions concerning reinterventions were all discussed during the same case conference. No set guidelines were used to determine the need for reintervention. In recent years, magnetic resonance imaging (MRI)-determined RV volumes have been used as the predominant criteria for reintervention indicated for RV dilatation. Because of the unreliability of the results of interventional catheterization for pulmonary artery origin stenosis and the lower threshold to perform these noninvasive procedures, only surgical procedures were considered as adverse outcomes.

Reoperations for congenital heart disease have all been performed at a limited number of centers in Australia, all of which were contacted to gather the follow-up data for the patients.

Policy and Surgical Technique

The center maintained a constant policy during the study period. All patients had undergone repair after a minimum of 4 months of age. Patients presenting with persistent cyanosis, spells, or small pulmonary arteries before that age received a systemicopulmonary shunt. This policy resulted in the prerepair palliation with shunting of 220 of the 675 patients (33%). The median age at repair was 2 years (interquartile range, 15 months to 3.4 years) from 1980 to 1987 and 10 months (interquartile range, 7-14) from 2000 to 2005. The details of the surgical technique of transatrial repair have been previously described.[7] RV pressure measurements were not routinely performed at our center.

Statistical Analysis

Of the 675 patients, 7 did not survive to successful Fallot repair and 8 were excluded because of a requirement for a RV–pulmonary artery conduit at repair. The remaining 660 patients had undergone surgery by 13 different surgeons, who had treated a total of 1, 1, 1, 5, 17, 17, 19, 39, 81, 84, 85, 127, and 164 patients. The surgical outcomes for the 5 surgeons who had treated >80 patients each were compared for 2 separate endpoints. The first was the risk of requiring a first reintervention for 3 indications: RV dilatation, RVOT obstruction, and pulmonary origin stenosis. The second was the risk of undergoing implantation of a valved conduit in the RVOT at any point during the follow-up period. Kaplan-Meier analysis was used to assess the freedom from reintervention for the various indications. An examination of the risk factors for reintervention had been previously performed in our overall cohort.[11] Direct comparisons of the outcomes among the surgeons, with adjustment for the primary confounders of age at repair and previous palliation, were conducted using Cox regression analysis. The postrepair RVOT gradient was not considered as a confounder, because it was judged to be a consequence of the surgical technique. The results of risk analyses accounting for the competing risk of mortality were also examined; however, these were essentially the same as those obtained by Cox regression analysis (owing to the small number of late deaths after Fallot repair). To facilitate the comparison of the patient characteristics treated by each of the 5 surgeons, the patients treated by the 8 surgeons who each had had <80 repairs were combined into a single reference group. We considered the distribution of RVOT gradients immediately after Fallot repair for each surgeon to provide an indication of the amount of opening of the RVOT. Differences in the average gradient among the surgeons were tested using a nonparametric test of equality of the median. The relationship between the risk of subsequent reoperation and the RVOT gradient after Fallot repair was examined using fractional polynomial regression analysis.

RESULTS

Five surgeons had accumulated enough outcomes data to allow a comparative analysis. These 5 surgeons had treated 541 patients, with an accumulated mean follow-up period of 11.9 ± 6.3 years. Surgeons 1 and 4 were operating during the same era as surgeons 2 and 5. The comparison of the patient characteristics treated by these 5 surgeons is displayed in Table 1.

For the 5 surgeons compared, the 90 reinterventions were classified according to their main indication as follows: RV dilatation (n = 29), RVOT obstruction (n = 44), and pulmonary artery origin stenosis (n = 17). A comparison of the freedom from intervention for each of these indications for each of the 5 surgeons is displayed in Figure 2.

The 10-year rate of first reintervention for any of these 3 indications varied from 8.8% (95% confidence interval [CI], 5.3%-14.5%) to 26.7% (95% CI, 14.9%-44.9%). This variation corresponded to a univariate hazard ratio