# Prosthetic valve in the pulmonary position, a late complication after total correction of tetralogy of fallot, a new controversial topic in cardiac surgery

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***Abstract:***

***Background and context :*** Pulmonary regurgitation (PR) is the most important residual lesion remaining after repairing tetralogy of Fallot. Through a thorough review of the literature, we attempted to determine the Pathophysiology of chronic right ventricular volume load after tetralogy of Fallot repair .The risks , benefits, indications and timing of pulmonary valve replacement are controversies that we are going to pay attention to them in this article.

***Materials and Methods:*** Database search for articles in MEDLINE up to the year 2007, in which. chronic pulmonary valve insufficiency after repaired tetralogy of Fallot had been discussed were selected and if it could have a message regarding the answers to these questions,its message and methodology or results and conclusions were analysed and discussed.

***Results and data synthesis :***18 articles paying attention to the above mentioned questions and controversies were found and their findings are explained and discussed here.

***Conclusions:*** Although right ventricular volume load due to severe pulmonary regurgitation after repaired tetralogy of Fallot can be tolerated for years, there is now evidence that the compensatory mechanisms of the right ventricular myocardium ultimately fail and that if the volume load is not eliminated or reduced the dysfunction might be irreversible. In light of that data and with better understanding of risk factors for adverse outcomes late after tetralogy of Fallot repair, many centers are now recommending early pulmonary valve replacement before symptoms of heart failure develop.

***Key Words:*** Tetralogy of fallot(TOF), Pulmonary regurgitation (PR), pulmonary valve replacement(PVR)

***Introduction***

Repaired tetralogy of Fallot (rTOF) has an excellent long-term prognosis; however, survival is somewhat less than normal. Of all the residual lesions and sequellae after rTOF, pulmonary regurgitation (PR) is the most important, correlating with right ventricular (RV) size, exercise intolerance and serious ventricular arrhythmias. Pulmonary valve replacement (PVR) has beneficial effects on RV size and function, provided it is performed early, before irreversible RV dysfunction ensues(1) . This article reviews the pathophysiology of chronic right ventricular volume load after tetralogy of Fallot repair , the risks , benefits, indications and timing of pulmonary valve replacement.In our center(Rajaee heart center) we have been performing total correction of tetralogy oaf fallot(TOF) since 1980,and from about 3 years ago,cases of severe PR are being refferd for PVR,so that PVR following TOF repair is a common operation in our ward now.We have not had any systematic analysis of these patients in our country ,but needless to say,as in other parts of world,it is a problem that we will encounter in future and many questions and controversies remain to be answered. To solve the problem of decision making for thses patients the following analysis of literature is provided.Hoping this article to be a trigger for beginning clinical trials for determination of different aspects of treatment modalities for these patients.

***Materials and Methods***

Database search for articles in MEDLINE up to the year 2007,in which. chronic pulmonary valve insufficiency after

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repaired tetralogy of Fallot had been discussed were selected and if it could have a message regarding the answers to these questions,its message and methodology or results and conclusions were analysed and discussed. what we were looking for were pathophysiology of chronic right ventricular volume load after tetralogy of Fallot repair , the risks , benefits, indications and timing of pulmonary valve replacement.Sometimes other aspects of the subject are mentioned and discussed here too.

***Results and discussion***

Complete correction of Tetralogy of Fallot, the most common cyanotic congenital heart defect, has now become routine. However, late residual lesions, primarily chronic pulmonary valve insufficiency, may have a negative impact on right-ventricular function, leading to the need for reoperation to insert a competent valve at the right-ventricular outflow(2). Debate on the proper timing of pulmonary valve replacement (PVR) after repair of tetralogy of Fallot (TOF) is still continuing. Significant pulmonary regurgitation (PR) could result in right ventricular (RV) dysfunction, exercise intolerance, arrhythmia, and sudden death(3). Large right ventricular outflow (RVOT) akinetic and aneurysmal regions are frequent and further compromise RV function; therefore, resection during PVR should be attempted (1). The wide variability in clinical status, extent of RV dilatation, and dysfunction at the time of presentation for surgical intervention has resulted in disparate surgical results after pulmonary valve insertion. With increasing use of magnetic resonance imaging, quantitative measures of RV volumes, function, and pulmonary regurgitant fraction have enabled a more systematic analysis of results. While there is a group of patients that responds favorably to pulmonary valve insertion, there is also a large subgroup that does not; this requires further analysis of the mechanisms responsible(4). Timing of pulmonary valve replacement (PVR) is subject to discussion, because the effect of PVR on RV function in adults is unclear(5). After total repair of tetralogy of Fallot (TOF-R) with transannular patching (TAP), severe pulmonary regurgitation (PR) is reported to develop in up to 30% of patients at a follow-up of 20 years, and 10-15% or more need pulmonary valve replacement (PVR) (6). Late pulmonary valve replacement after tetralogy repair significantly improves right ventricular function, functional class, and atrial arrhythmias, and it can be performed with low mortality. Subsequent re-replacement may be necessary to maintain functional improvement(7). Right ventricular (RV) dysfunction has adverse effects on long-term outcome in patients with repaired tetralogy of Fallot (TOF)(8)

***Cesnjevar R*** et al,from Universitätsklinik Erlangen-Nürnberg, Germany,in a retrospective case series study,and by reviewing hospital records of patients operated on for TOF at their institution between 1960 and 2002 and interviewing the patients ,conclude that, obstructive lesions (RVOTO, PA stenosis) and residual defects are frequently observed in patients needing late PVR and may play a crucial role in the development of RV failure. Timely valve replacement with repair of all obstructive lesions proximal and distal to the implanted valve is the key to preserving RV function(9).

***Gatzoulis MA*** et al from University of Toronto Congenital Cardiac Centre for Adults, reviewed 10-year records of 95 patients (53 men) with TOF followed in their clinic who underwent at least 2 serial radionuclide angiographies (RNA) between 1987 and 1997. Most patients were well by the end of the study (80% were New York Heart Association class I, 17% were class II, and 3% were in class III). Fifteen patients underwent RV outflow reoperations (15 underwent pulmonary valve replacement; 7 had relief of RV outflow obstruction); RV systolic function during exercise in these 15 patients was significantly impaired before and returned to similar levels after surgery, compared with the rest of the patients. Overall, RV and LV function remained stable in the whole group at a mean interval of 5.7 +/- 2.2 years between first and last RNA. This group of closely followed adults with TOF remained well over 10 years with a low incidence of sudden death and stable RV and LV systolic function, despite a relatively large number of RV outflow reoperations. Aggressive intervention for right-sided hemodynamic abnormalities may have contributed to this outcome. Preserved ventricular function may herald a favorable long-term outlook in this group(8). ***Therrien J*** et al,from the same center, studied 25 consecutive adult patients who underwent PVR for significant PR late after repair of TOF. Radionuclide angiography was performed in all at a mean of 8.2 months (+/- 8 months) before PVR and repeated at a mean of 28.0 months (+/- 22.8 months) after the operation, Right ventricular (RV) end-systolic volume (RVESV), RV end-diastolic volume (RVEDV) and RV ejection fraction (RVEF) were measured. Mean RVEDV,

RVESV and RVEF remained unchanged after PVR.They conclude that, Right ventricular recovery following PVR for chronic significant pulmonary regurgitation after repair of TOF may be compromised in the adult population. In order to maintain adequate RV contractility, pulmonary valve implant in these patients should be considered before RV function deteriorates(10). ***Vliegen HW*** et al,from Leiden University Medical Center, used Magnetic resonance imaging(MRI) to assess the hemodynamic effects of pulmonary valve replacement in adults late after repair of tetralogy of fallot in 26adult patients. Cardiac MRI was performed at a median of 5.1+/-3.4 months before and 7.4+/- 2.4 months after PVR .Their findings showed that.: In adult patients with PR and RV dilatation, late after total correction of tetralogy of Fallot, MRI measurements show remarkable hemodynamic improvement of RV function after PVR and then a trend towards earlier PVR compared to conservative management(5). In a recent research (march 2007) Henkens IR et al,from Leiden University Medical Center, analyzed the influence of pulmonary regurgitation severity and RV size and function before PVR on the outcome of RV size and function after PVR in 27 adult Fallot patients who had cardiac magnetic resonance imaging before and after PVR. RV dimensions were indexed for body surface area. They conclude that, Timing of PVR should be based on indexed RV end-systolic volume and corrected RV ejection fraction rather than on severity of pulmonary regurgitation(11). ***Van Straten A*** et al,from Leiden University Medical Center,believe that, In adult patients late after total repair of Tetralogy of Fallot, rapid volume unloading after PVR increases systolic performance, whereas improvement in diastolic function requires long-term remodeling(12). In another report by the previous author(***Van Straten A*** et al), Cardiac magnetic resonance (MR) imaging was performed before, 7 months after, and 19 months after PVR in 25 consecutive patients with tetralogy of Fallot with a 1.5-T MR imager amd RV function was assessed with gradient-echo sequences in the short-axis plane. Pulmonary flow was assessed with a velocity-encoded phase-contrast sequence.The results of their assessments showed that: RV function improves rapidly after PVR and is sustained at 19-month follow-up in most patients; however, recurrence of PR after PVR appears to reduce recovery of RV systolic function(13). ***Oosterhof T*** et al,from Academic Medical Center, in Netherlands, for facilitating the optimal timing of pulmonary valve replacement, they analyzed preoperative thresholds of right ventricular (RV) volumes above which no decrease or normalization of RV size takes place after surgery. Between 1993 and 2006, 71 adult patients with corrected tetralogy of Fallot underwent pulmonary valve replacement in a nationwide, prospective follow-up study. Patients were evaluated with cardiovascular magnetic resonance both preoperatively and postoperatively Overall, they could not find a threshold above which RV volumes did not decrease after surgery. Preoperative RV volumes were independently associated with RV remodeling and also when corrected for a surgical reduction of the RV outflow tract. However, normalization could be achieved when preoperative RV end-diastolic volume was <160 mL/m2 or RV end-systolic volume was <82 mL/m2(14). Dave HH et al,from University Children's Hospital Zurich, Switzerland,showed that, improvement in ventricular dimensions and functions directly correlates with the timing of pulmonary valve insertion. Early insertion leads to normalization and late insertion leads only to improvement. These observations, along with a low morbidity for these reoperations, justify earlier reintervention in cases of chronic pulmonary regurgitation. A RV end-diastolic volume index of 150 mL/m2 seems to be a practical cutoff value to prescribe pulmonary valve insertion.They used PVR in 39 patients (aged 14 to 39 years) when the right ventricular (RV) end-diastolic volume index on magnetic resonance imaging (MRI) exceeded 150 mL/m2. Changes in morphology and function of the RV were prospectively analyzed by an MRI at 6 months postoperatively (available in 21 patients)(15). ***Buechel ER*** et al,from University Children's Hospital, Zurich, Switzerland, sought to assess the remodelling of the RV after early PVR in children, using cardiovascular magnetic resonance, 20 children with severe pulmonary regurgitation and RV dilatation and mean age 13.9 +/- 3 years underwent CMR evaluation 5.6 +/- 1.8 months before and 5.9 +/- 0.6 months after PVR.What they found was that : Prompt RV remodelling, with reduction of RV volume and mass, is observed after performing PVR if the RV end-diastolic volume exceeds 150 mL/m(2). Early PVR may prevent the detrimental complications of severe pulmonary regurgitation(16). ***Warner KG*** et al,from Tufts-New England Medical Center and Boston Floating Hospital in Boston,believe that, Timely insertion of a competent pulmonary valve in children, adolescents, and young adults with significant PR after tetralogy of Fallot repair results in subjective and objective improvement

in exercise capacity and is associated with reduction in right ventricle size(17). ***Lim C*** et al ,from Seoul National University Bundang Hospital, South Korea,in studied 58 patients (38 males and 20 females) receiving PVR after repair of TOF,conclude that : In patients with significant PR after repair of TOF, PVR had clinical benefits including symptomatic improvement with low mortality and morbidity. Proper timing must be carefully selected according to objective evaluation of RV function.They stress that, earlier PVR prior to symptomatic manifestation showed beneficial effects(3).

### *Conclusion*

Surgical management of tetralogy of Fallot results in anatomic and functional abnormalities in the majority of patients. Although right ventricular volume load due to severe pulmonary regurgitation can be tolerated for years, there is now evidence that the compensatory mechanisms of the right ventricular myocardium ultimately fail and that if the volume load is not eliminated or reduced the dysfunction might be irreversible. In light of that data and with better understanding of risk factors for adverse outcomes late after tetralogy of Fallot repair, many centers are now recommending early pulmonary valve replacement before symptoms of heart failure develop(18).

The decision to operate should be based on the balance between progressive RV dilatation, exercise intolerance, symptoms, arrhythmias and the fact that further reoperations will be needed. Research on the ideal valve for RVOT reconstruction is ongoing. Prospective follow-up of patients with rTOF with exercise testing and assessment of RV size and function, preferably with magnetic resonance, will define better the natural history of the disease and will probably provide firm guidelines for PVR timing especially in asymptomatic patients(4-6).
Surgical management of tetralogy of Fallot results in anatomic and functional abnormalities in the majority of patients. Although right ventricular volume load due to severe pulmonary regurgitation can be tolerated for years, there is now evidence that the compensatory mechanisms of the right ventricular myocardium ultimately fail and that if the volume load is not eliminated or reduced the dysfunction might be irreversible. In light of that data and with better understanding of risk factors for adverse outcomes late after tetralogy of Fallot repair, many centers are now recommending early pulmonary valve replacement before symptoms of heart failure develop(5) . Therefore, the decision to operate should be based on the balance between progressive RV dilatation, exercise intolerance, symptoms, arrhythmias and the fact that further reoperations will be needed. Research on the ideal valve for RVOT reconstruction is ongoing. Prospective follow-up of patients with rTOF with exercise testing and assessment of RV size and function, preferably with magnetic resonance, will define better the natural history of the disease and will probably provide firm guidelines for PVR timing especially in asymptomatic patients(1).

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