

RESEARCH LETTER

# Percutaneous Edge-to-Edge Repair for Systemic Atrioventricular Valve Regurgitation in Patients With Congenital Heart Disease: The First Descriptive Cohort

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In patients with congenital heart diseases (CHD) such as congenitally corrected transposition of the great arteries (ccTGA), transposition of the great arteries with surgical atrial switch, or functional single ventricles, systemic tricuspid regurgitation (STR) is frequent. STR may be the consequence or the origin of systemic right ventricular dysfunction and can lead to progressive heart failure and death. Surgical correction of STR is a high-risk procedure, especially when systemic right ventricular dysfunction is severe, and heart transplantation may be the only alternative.<sup>1</sup>

In adults with degenerative mitral or tricuspid regurgitation, percutaneous edge-to-edge repair (PETER) using a clip device is effective and leads to a reduction of valvular regurgitation and improvement of clinical status.<sup>2</sup> This approach could be extended to patients with CHD with complex mitral and/or tricuspid failure.<sup>3</sup> However, available literature is mostly dedicated to the mitral valve. Recently, we described the first percutaneous repair of STR with successful implantation of the

MitraClip system in a patient with TGA with surgical atrial switch.<sup>4</sup>

Here, we report our experience with PETER in a series of 12 patients with CHD with STR using the MitraClip system. All data and supporting materials have been provided with the published article. The study was approved by the institutional review committee and all patients gave their informed consent.

Twelve patients (median age, 35 years; 83% men) with severe STR (ccTGA [n=5], atrial correction for TGA (acTGA) [n=3], single ventricles [n=4]), at high-risk for surgical treatment, gave informed consent for treatment using PETER. The procedures were performed in 5 French tertiary CHD centers between June 2019 and September 2021, following institutional review board approval. The XTR MitraClip device (Abbott, Santa Clara, CA) was used. At baseline, 7 of 12 patients were in New York Heart Association functional class ≥III. Standard femoral venous access was successfully used in 10 of 12 patients. In patients with single

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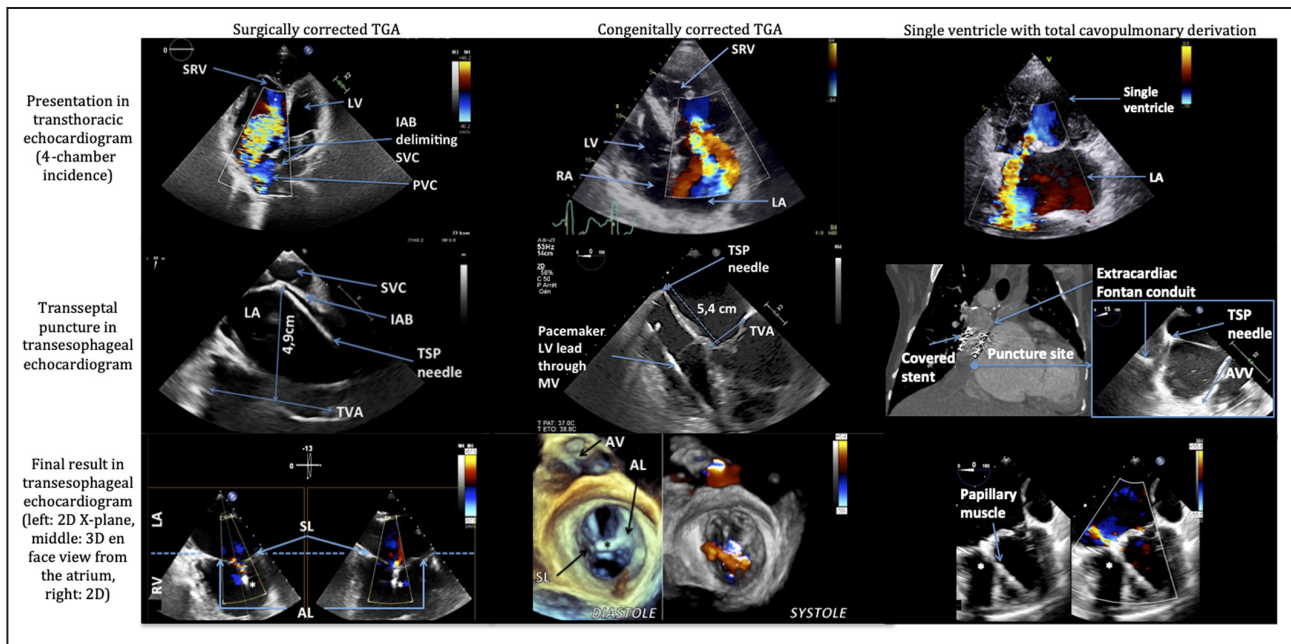
ventricles, the systemic valve was accessed directly through the right atrium (n=2), after a Fontan conduit puncture (n=1), or after direct atrial surgical access (n=1). In patients with TGA, either transeptal (patients with ccTGA, n=4) or transbaffle (patients with TGA with surgical atrial switch, n=3) puncture was performed.<sup>4</sup> In 1 patient with situs inversus, levocardia, and ccTGA, a first attempt using the right femoral access did not allow a correct orientation of the clip on the tricuspid valve owing to complex anatomy, and a direct left atrium surgical access via right thoracotomy was used.

MitraClip devices were successfully implanted in 11 of 12 patients (1 device: n=9, 2 devices: n=2) at first attempt in 10 patients<sup>3,4</sup> (Figure) and after a second procedure requiring surgical access and 2 devices in the patient with situs inversus, levocardia, and ccTGA. One procedural complication was reported for a patient with a single ventricle in whom a septal leaflet rupture occurred following clip release, leading to severe STR; the patient died from refractory cardiac failure 1 week later. Peri-procedural complications included 1 case of left femoral vein injury treated by implantation of a covered stent and 1 case of atrial flutter treated by catheter ablation. After a median follow-up of 12 months (range, 1–25) following device implantation, no death had occurred. The patients had significant reduction in STR (from severe to moderate in 10 of 11 patients) and clinically improved (10 of 11 patients were in New York Heart Association class I or II). Cardiac magnetic

resonance performed in 6 patients at 6 months, showed a decrease in median right ventricular end-diastolic volumes from 201 mL/m<sup>2</sup> (range, 126–260) to 161 mL/m<sup>2</sup> (range, 115–227) and an improvement of right ventricular ejection fraction from 37% (range, 28%–50%) to 49% (range, 37%–62%).

To the best of our knowledge, this is the first case series of patients with CHD with STR treated by PETER. This series confirms the technical feasibility of the procedure and its positive impact on patients' symptoms and right ventricular function after a median follow-up of 12 months. In patients with STR, the main difficulty is to navigate the clip through complex anatomies, which may not allow orientation of the device perpendicularly to the tricuspid annulus, thus leading to procedural failure. This technical issue, which is frequent in patients with TGA, was reported in our series for 1 patient with ccTGA presenting with situs inversus and levocardia.

Concerns about the potential damage caused by failed PETER therapy compromising subsequent surgery have been raised following treatment of mitral regurgitation<sup>5</sup> and are legitimate when the clip is used to address STR. Nevertheless, because patient survival and STR recurrence tend to be worse after STR repair than after STR replacement, tricuspid replacement is the preferred procedure when surgery is required.<sup>2</sup> Hence, the risk that PETER could be a limitation for subsequent surgical tricuspid valve repair seems irrelevant. In our series, 1 patient had a leaflet rupture following



**Figure.** Standard percutaneous edge-to-edge repair procedure in patients with transposition of the great arteries with surgical atrial switch, patients with congenitally corrected transposition of the great arteries, and patients with single ventricle.

AL indicates anterior leaflet; AV, aortic valve; AVV, atrioventricular valve; IAB, interatrial baffle; LA, left atrium; LV, left ventricle; MV, mitral valve; PVC, pulmonary venous channel; RA, right atrium; SL, septal leaflet; SRV, systemic right ventricle; SVC, superior vena cava; TGA, transposition of the great arteries; TSP, transseptal puncture; and TVA, tricuspid valve annulus. \*MitraClip.

clip release leading to refractory heart failure, but bailout surgery was precluded by poor global condition.

To conclude, percutaneous edge-to-edge therapy of STR in patients with CHD is feasible, safe, and effective to reduce STR and systemic right ventricular dilatation. This reduction is associated with a significant clinical improvement. Larger studies and longer follow-up are warranted to confirm these promising results.

## ARTICLE INFORMATION

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## REFERENCES

1. Scherptong RW, Vliegen HW, Winter MM, Holman ER, Mulder BJ, van der Wall EE, Hazekamp MG. Tricuspid valve surgery in adults with a dysfunctional systemic right ventricle: repair or replace? *Circulation*. 2009;119:1467–1472. doi: [10.1161/CIRCULATIONAHA.108.805135](https://doi.org/10.1161/CIRCULATIONAHA.108.805135)
2. Baumgartner H, Falk V, Bax JJ, De Bonis M, Hamm C, Holm PJ, lung B, Lancellotti P, Lansac E, Rodriguez Muñoz D, et al. 2017 ESC/EACTS guidelines for the management of valvular heart disease. *Eur Heart J*. 2017;38:2739–2791. doi: [10.1093/eurheartj/ehx391](https://doi.org/10.1093/eurheartj/ehx391)
3. Alshawabkeh L, Mahmud E, Reeves R. Percutaneous mitral valve repair in adults with congenital heart disease: Report of the first case-series. *Catheter Cardiovasc Interv*. 2021;97:542–548. doi: [10.1002/ccd.29238](https://doi.org/10.1002/ccd.29238)
4. Iriart X, Guérin P, Jalal Z, Thambo J-B. Edge to edge repair using a MitraClip for severe tricuspid valve regurgitation after a Mustard operation. *Catheter Cardiovasc Interv*. 2021;98:E108–E114. doi: [10.1002/ccd.29681](https://doi.org/10.1002/ccd.29681)
5. Monsefi N, Zierer A, Khalil M, Ay M, Beiras-Fernandez A, Moritz A, Stock UA. Mitral valve surgery in 6 patients after failed MitraClip therapy. *Tex Heart Inst J*. 2014;41:609–612. doi: [10.14503/THIJ-13-3626](https://doi.org/10.14503/THIJ-13-3626)