

## Case Report

# Concomitant Repair of Mitral Valve Papillary Muscle Rupture and Tricuspid Valve Avulsion in a Pediatric Patient after a Motor Vehicle Collision

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**Abstract:** We report the case of an 8-year-old patient with severe acute mitral regurgitation and tricuspid regurgitation after a motor vehicle collision caused by traumatic injuries of the supporting structures of both valves. An echocardiogram showed avulsion of the posteromedial papillary muscle of the mitral valve and a severely prolapsed anterior tricuspid valve leaflet. In addition, there was a near-complete defect in the left ventricular side of the interventricular septum, with diffuse

hematoma of the akinetic septal muscle. After emergency mitral and tricuspid valve repairs, consisting of re-implantation of the posteromedial papillary muscle and anterior tricuspid leaflet chordal support, the patient completely recovered with no residual valvular pathology. **Keywords:** mitral and tricuspid valve repair, mitral and tricuspid valve rupture, pediatric, motor vehicle collision, pediatric cardiopulmonary bypass. *JECT.* 2009;41:180–182

Although infrequent, blunt trauma to the chest carries the highest rate of mortality and morbidity among all non-penetrating injuries in the pediatric population (1). In particular, blunt cardiac trauma accounts for 40% of pediatric mortalities as the result of a motor vehicle collision (MVC) (2,3). Blunt cardiac trauma in children can lead to myocardial contusion, left ventricular aneurysm, arrhythmias, ventricular laceration or rupture, and valvular incompetence. However, concomitant injuries to both the mitral and tricuspid valves have not been reported (4–7). In this report, we describe the presentation, diagnosis, surgical management, and the post-operative course of an 8-year-old patient with concomitant acute severe mitral and tricuspid

regurgitation, as well as interventricular septal injury, after a MVC.

## CASE REPORT

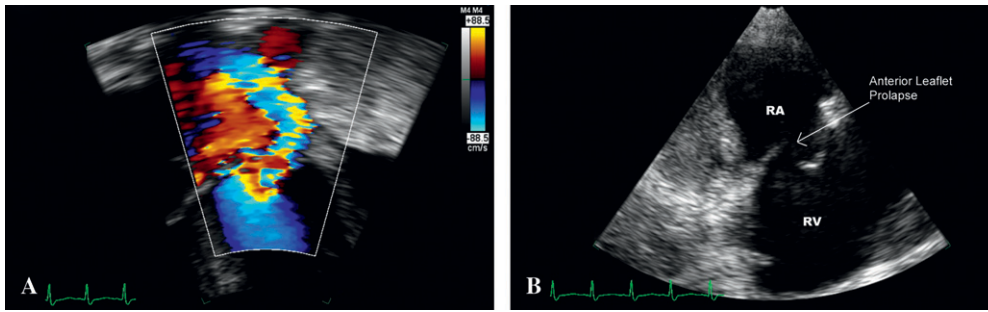
### Patient History

The patient is an 8-year-old boy with a history of autism who was a rear seat, restrained, passenger of a car that was struck at high speed from behind. He was found lodged between a spare tire and the front seat. He received cardiopulmonary resuscitation in the field and underwent emergent splenectomy for a ruptured spleen at the receiving hospital. His additional injuries included liver laceration, bilateral pulmonary contusions, and bilateral first rib fractures. A chest computed tomography (CT) ruled out aortic injury. After surgery, he had another episode of cardiac arrest and remained hemodynamically unstable, requiring high-dose epinephrine. A subsequent echocardiogram showed severe mitral and tricuspid regurgitation. He was transferred urgently to the Medical University of South Carolina (MUSC).

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**Figure 1.** Pre-operative color flow Doppler TEE study showing severe mitral valve regurgitation (A) and tricuspid valve anterior leaflet prolapse (B). TEE, transesophageal echocardiography; RA, right atrium; RV, right ventricle.

On admission, he was hemodynamically stable on high doses of epinephrine (.15  $\mu\text{g}/\text{kg}/\text{min}$ ), milrinone (.5  $\mu\text{g}/\text{kg}/\text{min}$ ), and 100%  $\text{FiO}_2$  to maintain adequate oxygenation. Chest x-ray showed bilateral fulminant pulmonary edema/contusion. Detailed Doppler/echocardiogram showed avulsion of the posteromedial papillary muscle, severe prolapse of the anterior tricuspid leaflet, and a near-complete defect in the interventricular septum, which was akinetic and had significant hematoma (Figures 1 and 2). Because of worsening oxygenation and pulmonary edema, he was taken to the operating room emergently.

#### Case Management

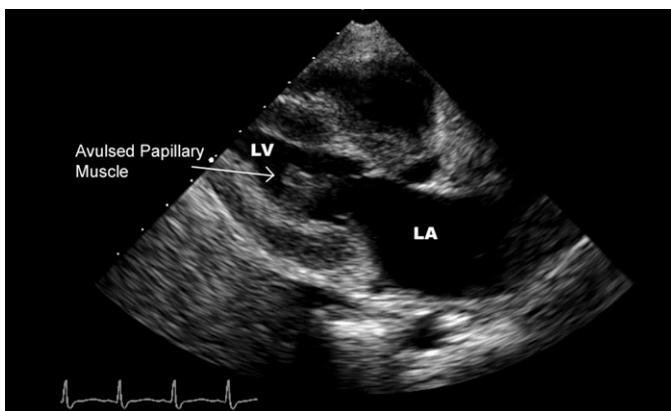
The patient's height was 138 cm and he weighed 30 kg (body surface area of 1.07  $\text{m}^2$ ), therefore, the cardiopulmonary bypass circuit was constructed with 1/4-in arterial line, 3/8-in venous line, a D 736 New Born Filter 40 Micron (Sorin Group USA, Arvada, CO) arterial line filter with PHYSIO, a Capiiox RX 15 (Terumo Cardiovascular Systems, Ann Arbor, MI) oxygenator, and a reduced prime Sorin BCD Vanguard cardioplegia system (Sorin Group USA). The total circuit prime volume was 289 mL, consisting of 100 mL of 25% albumin, 15 mL of sodium bicarbonate (15 mEq), 1 mL of heparin (1000 units), 30 mL of 25% mannitol (7500 mg), and 15 mL of tranexamic acid (900 mg); the remainder was Plasmalyte-A. On entering the pericardial sac and both pleural spaces, a gross amount of serosanguinous

fluid was observed. The posterior pericardium was torn from the diaphragm, and on the left side, it was held only by the phrenic nerve. After systemic heparinization, cardiopulmonary bypass was established between a 16-Fr aortic cannula and bi-caval venous cannulae (16-Fr superior vena caval and 18-Fr inferior vena caval). A 16-Fr left atrial vent was placed through the right superior pulmonary vein. Once moderate systemic hypothermia was achieved at 28°C, the aorta was cross-clamped, and 30 mL/kg of antegrade blood cardioplegia (4:1 blood:cardioplegia) was delivered over 3 minutes. The patient achieved diastolic arrest, and topical hypothermia with ice-cold saline was applied.

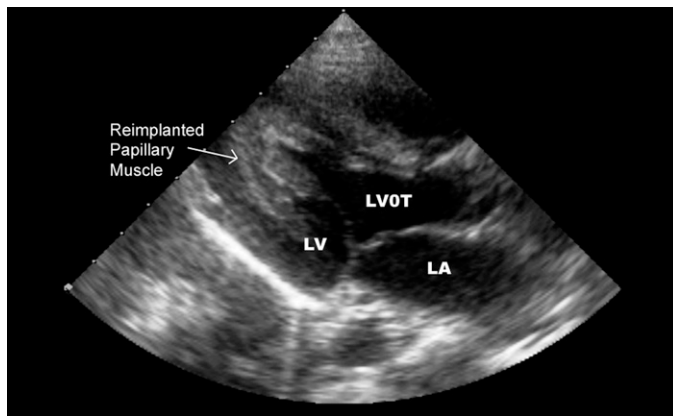
#### Mitral and Tricuspid Valve Repairs

Through an oblique right atriotomy, it was determined that the patient had an intact atrial septum. Examination of the tricuspid valve showed a prolapsing anterior leaflet with avulsed primary chordal support. The ventricular septum had significant hematoma and ecchymosis, but no ventricular septal defect was noted. The mitral valve was assessed through a surgical atrial septal defect. The leaflets were normal appearing; however, the anterior leaflet was prolapsed. Examination of the subvalvular apparatus showed an almost complete avulsion of the posteromedial papillary muscle with scant attachment at the medial aspect. Approximately two thirds of the papillary muscle was ischemic and appeared necrotic. Pledged horizontal 4-0 mattress Prolene suture was placed at the base of the avulsed papillary muscle to provide anchoring. Four loops of Prolene sutures were placed to encircle the torn papillary muscle longitudinally, to hold the chords to the base of the papillary muscle. The papillary muscle was re-implanted back to the native insertion site on the left ventricular endocardium, with the sutures passed through the heart and tied on the epicardial surface, away from the coronary arteries. Testing of the mitral valve showed good competence.

The tricuspid valve was repaired by re-implanting the torn primary chords to healthy, non-hematomatous aspects of the right ventricular septum. Testing with saline injection into the right ventricle showed good competence. The atrial septal defect was closed primarily, and 10 mL/kg of retrograde, enhanced (glutamate/aspartate) cardioplegia was



**Figure 2.** TEE showing the avulsed posteromedial papillary muscle of the mitral valve. LA, left atrium; LV, left ventricle.



**Figure 3.** Post-operative TEE showing no residual mitral regurgitation and re-implanted posteromedial papillary muscle of the mitral valve. LA, left atrium; LV, left ventricle; LVOT, left ventricular outflow tract.

delivered through the coronary sinus before removing the aortic cross-clamp. Right and left atrial lines were placed. After re-warming and adequate de-airing, the patient was weaned from cardiopulmonary bypass on milrinone at  $.5 \mu\text{g}/\text{kg}/\text{min}$  and dopamine at  $5 \mu\text{g}/\text{kg}/\text{min}$ . Modified ultrafiltration removed 300 mL of ultrafiltrate over 10 minutes. A transesophageal echocardiogram showed trivial mitral and tricuspid regurgitation (Figure 3). Total cardiopulmonary bypass time was 122 minutes, with 71 minutes of aortic cross-clamp.

### Postoperative Course

The patient had an uncomplicated postoperative course, remained hemodynamically stable, and was extubated on postoperative day 2. He was subsequently discharged to a rehabilitation unit for further physical therapy on postoperative day 18.

### DISCUSSION

High-speed MVC can lead to blunt cardiac injury, with a reported incidence of 12.5% in children involved in an MVC (1). However, most of these are myocardial contusions, and significant intracardiac injuries are rare. Overall mortality rate is 31.9% among all ages, but patients with valvular injury carries a 77.7% mortality rate (3). There have been only few reported cases of concomitant blunt mitral and tricuspid valve injury as a result of blunt cardiac trauma and even fewer involving children (4–7). Most acute mitral valve injuries were managed with prosthetic valve replacement (8). This case report is the only one we are aware of where successful concomitant mitral and tricuspid valve repairs were accomplished in a child after blunt cardiac trauma.

As shown by this case report, acute intra-cardiac valvular injury is easily overlooked in the setting of multiple injuries after blunt trauma (3). The suspicion for cardiovascular injury was high, as supported by the bilateral first rib fractures and pulmonary contusions. Although the primary concern is to rule out aortic injuries, such as a tear or dissection, a CT scan did not show the intracardiac pathology. An echocardiogram is not routinely used in the evaluation of trauma patients, especially in children. However, past reports, including ours, highlight the value of early echocardiography in the timely diagnosis of intracardiac injury and improved outcomes in patients with high probability of blunt cardiac trauma (3–7). Early surgical intervention is indicated in the face of acute, severe mitral and tricuspid regurgitation and worsening cardiopulmonary function (7).

In summary, an 8-year-old patient with acute severe mitral and tricuspid regurgitation after blunt cardiac trauma underwent successful bi-valvular repair and had a good recovery. This case illustrates the need for high vigilance for intra-cardiac injury in high-speed acceleration–deceleration trauma and the importance of early echocardiography to assess valvular and ventricular functions in these patients.

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### REFERENCES

1. Dowd DM, Krug S. Pediatric blunt cardiac injury: Epidemiology, clinical features, and diagnosis. *J Trauma*. 1996;40:61–7.
2. Lancey RA, Monahan TS. Correlation of clinical characteristics and outcomes with injury scoring in blunt cardiac trauma. *J Trauma*. 2003;54:509–15.
3. Calkins CM, Bensard DD, Partrick DA, Karrer FM. A critical analysis of outcome for children sustaining cardiac arrest after blunt trauma. *J Pediatr Surg*. 2002;37:180–4.
4. Bailey PL, Peragallo F, Karwande SV, Lapunzina P. Mitral and tricuspid valve rupture after moderate blunt chest trauma. *Ann Thorac Surg*. 2000;69:616–8.
5. Petkov MP, Napolitano CA, Tobler HG, et al. A rupture of both atrioventricular valves after blunt chest trauma: The usefulness of transesophageal echocardiography for a life-saving diagnosis. *Anesth Analg*. 2005;100:1256–8.
6. Pellegrini RV, Copeland CE, DiMarco RF, et al. Blunt rupture of both atrioventricular valves. *Ann Thorac Surg*. 1986;42:471–2.
7. Choi J, Kim E. Simultaneous rupture of the mitral and tricuspid valves with left ventricular rupture caused by blunt trauma. *Ann Thorac Surg*. 2008;86:1371–3.
8. Pye S, Bornemeier R, Moss M, et al. Mitral valve avulsion after a four-wheel all-terrain vehicle crash. *J Trauma*. 2004;57:175–6.