Case Report

Traumatic Aortic Valve Injury with Atrial Septal Rupture Due to Blunt Chest Trauma

Atsuhiko Onaka, Kenji Nakai, Yoshiki Toma, Tatsuya Nakamura
Hiroshi Sakae, Hisayuki Tabuse and Shigeaki Ootake

A previously healthy 22-year-old man was promptly transported to our hospital after sustaining blunt chest trauma in a high-speed motorcycle crash. On admission, he was alert and dyspneic, with a blood pressure of 110/50 mmHg, and a pulse rate of 114 beats per minutes. He had a large hematoma on the left neck and multiple small contusions on his anterior chest wall. The breath sounds of the left lung were diminished, and a grade 3/6 aortic regurgitation murmur was audible in the aortic area. Abdominal examination was benign.

Pulse oximetry showed good oxygenation during the breathing of room air. Chest X-ray revealed mild bilateral lung contusions, widened mediastinum, left apical cap sign, left hemopneumothorax, and first and second rib fractures on the left side (Fig. 1). Transthoracic echocardiogram showed aortic regurgitation, but pericardial effusion was not present. Due to a suspicion of aortic and/or aortic valve rupture, enhanced computed tomographic scans of the chest and abdomen were obtained. CT scans of the chest showed the bilateral lung contusions, left hemopneumothorax, and hematoma in the mediastinum, but extravasation of the contrast medium was not observed. No intraabdominal injuries were identified with abdominal CT scans. We performed aortography, which showed severe aortic regurgitation and obstruction of left vertebral artery but no aortic rupture (Fig. 2). Transesophageal echocardiogram demonstrated a rupture of the left coronary cusp of the aortic valve (Fig. 3, 4) and atrial septal defect (Fig. 5).

Correspondence: Atsuhiko Onaka, MD
Osaka Prefectural Nakakawachi Medical Center of Acute Medicine
3-4-13 Nishiiwata, Higashiosaka, Osaka 578-0947, Japan

Fig. 1. Chest radiogram demonstrates bilateral mild lung contusions, a widened mediastinum, left apical cap sign, a left hemopneumothorax, and first and second rib fractures of the left side.

Cardiac monitoring with a pulmonary artery catheter demonstrated high cardiac output due to left-to-right shunt [cardiac output (CO) 9.0 l/min; cardiac index (CI) 4.9 l/min/m²] and normal pulmonary capillary wedge pressure (PCWP) of 7mmHg. Since his hemodynamic and respiratory status were stable despite left hemothorax, the patient was scheduled for elective surgery. Tube thoracostomy and mechanical ventilation improved hemothorax and lung contusion within a few days. In the following days, he remained well-compensated hemodynamically except for a gradual and persistent elevation in CO and PCWP. On postinjury day 4, higher outputs (CO, 11.8 l/min; CI, 6.4 l/min/m²), high PCWP
Blunt aortic valve injury with atrial septal rupture

(21 mmHg), aortic regurgitation (Seller's III) and high left-to-right shunt (Qp/Qs 1.96) were observed. Chest X-ray revealed severe lung edema in spite of conservative treatment. Surgery to repair the aortic valve and atrial septal defect was performed on day 5.

The operation was performed under cardiopulmonary bypass support. A perforation of the left coronary cusp in its right coronary cusp side (5mm) and a slit-shaped defect (2.5 cm) of the atrial septum beside the fossa ovalis were identified (Fig. 6, 7). The atrial septal defect had a rough edge suggesting traumatic laceration, and avulsion of normal aortic valve was noted. Aortic valve replacement with a 27-mm mechanical aortic valve prosthesis (St. Jude Medical, St. Paul, Minnesota, USA) and direct suture of atrial septal defect were performed. The postoperative course was uneventful except for mild pericardial effusion.

Discussion

Aortic valve injury with atrial septal rupture caused by blunt chest trauma is very rare. The first report was made by Mackintosh et al. in 1981. In that case, surgical treatment took place 12 months after the injury. The second
case was reported by Tsai et al\textsuperscript{2} in 1999. In their report, surgical treatment was performed on day 10 postinjury. We experienced a third case of aortic valve injury and atrial septal rupture due to blunt trauma. We were able to repair the damage successfully during the early period after injury.

The diagnosis of traumatic aortic valve injury is generally made from the history of blunt chest trauma, absence of history of heart disease, sudden onset of signs and symptoms of aortic insufficiency, and thoracic aortography or echocardiography. Transesophageal echocardiography is particularly useful in defining details of aortic valve injury.

The mechanism of aortic valve injury is generally believed to be a sudden increase of pressure inside the aorta during a severe chest impact, and it is called “water hummer stress”\textsuperscript{3,4}. The aortic valve is vulnerable during early diastole when it is closed and the pressure is low because of the empty left ventricle. Pretre et al\textsuperscript{3} reviewed 37 patients with aortic valve injury and described that it
was important to consider associated cardiac injuries regarding aortic valve injuries. They described associated intracardiac injuries (a ruptured mitral valve, ruptured ventricular septum, and communication between the left ventricle and right atrium) were due to the jet flow of blood through the perforated valve. However, our patient had only an atrial septal rupture.

Unlike aortic valve injury, the mechanism of atrial septal rupture is not clear because of the small number of reported cases. Survivors of atrial septal rupture are rare because the high-pressure shock waves are transmitted in all directions, leading to injuries of the ventricles, the vena cava, and the pulmonary vessels. Thus patients with atrial septal ruptures usually die of associated injuries. To our knowledge, only eight survivors of traumatic atrial septal defect (ASD) are reported. Our patient is the ninth (Table 1). Of the 9 patients with traumatic ASD, one had exacerbated patency of the foramen ovale (case 5, Table 1). His ASD closed without surgery. The other eight patients underwent repair of the ASD with direct suture or patch closure. Associated cardiac injuries were observed in eight of the nine. Three had aortic regurgitation due to aortic valve injury. Two had mitral regurgitation due to

<table>
<thead>
<tr>
<th>Report</th>
<th>Sex/Age</th>
<th>Associated</th>
<th>Operation cardiac injuries</th>
<th>Interval to repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rao</td>
<td>M/34</td>
<td>(−)</td>
<td>resection of aneurysm</td>
<td>7 months</td>
</tr>
<tr>
<td>2 Mackintosh</td>
<td>M/46</td>
<td>AR</td>
<td>ASD repair</td>
<td>1 year</td>
</tr>
<tr>
<td>3 Markewitz</td>
<td>M/16</td>
<td>(−)</td>
<td>ASD repair</td>
<td>5 years</td>
</tr>
<tr>
<td>4 Baumgartel</td>
<td>F/17</td>
<td>RA rupture</td>
<td>RA/ASD repair</td>
<td>4 years</td>
</tr>
<tr>
<td>5 Baumgartel</td>
<td>M/33</td>
<td>RA rupture</td>
<td>RA repair</td>
<td>(−)</td>
</tr>
<tr>
<td>6 Jenson</td>
<td>M/52</td>
<td>MR</td>
<td>MVR ASD repair</td>
<td>5.5 months</td>
</tr>
<tr>
<td>7 End</td>
<td>M/50</td>
<td>MR</td>
<td>ASD/MV repair</td>
<td>1.5 years</td>
</tr>
<tr>
<td>8 Tsai</td>
<td>M/36</td>
<td>AR</td>
<td>AVR ASD repair</td>
<td>10 days</td>
</tr>
<tr>
<td>9 Onaka</td>
<td>M/32</td>
<td>AR</td>
<td>AVR ASD repair</td>
<td>5 days</td>
</tr>
</tbody>
</table>

ASD = atrial septal defect; AR = aortic regurgitation; MR = mitral regurgitation; CABG = coronary bypass graft; AVR = aortic valve replacement; MVR = mitral valve replacement; RA = right atrium; MV = mitral valve
mitral valve injury, and another two had right atrial rupture. These associated cardiac injuries were treated operatively. In these reports, aortic valve injury was the cardiac injury most commonly associated with traumatic ASD.

Mechanisms of blunt cardiac rupture were quoted in some reports of atrial septal rupture. The seven mechanisms, summarized by Getz and his colleagues, are as follows: ① direct, a blow to the anterior part of the chest; ② indirect or hydraulic, injury secondary to crushing injury of abdomen and lower extremities; ③ bidirectional, forces from compression of the heart between the sternum and vertebral bodies; ④ acceleration/deceleration, atrial tear at the venous insertions; ⑤ blast forces, resulting in septal or ventricular rupture; ⑥ concussive, resulting in fatal arrhythmia; ⑦ penetration, puncture of the heart by a fractured rib or sternum. They described that atrial rupture occurs during late systole, when distension is maximal and atrioventricular valves are closed.

Jenson et al described mechanisms of atrial septal injury as direct, indirect, bidirectional, and acceleration/deceleration. In 1992, Baumgertel et al reported 2 cases of right atrial wall and septal rupture. They described bidirectional forces and penetration as mechanisms of injuries. In our case, the patient crashed into the loading platform of a truck while he was driving a motor cycle. We suspect that an extreme force was added on upper part of his left anterior chest wall. But, he had no abdominal injuries, injuries of lower extremity, sternal fracture, or fatal arrhythmia. In addition, the location of his atrial septal rupture was not located at venous insertions. Therefore, we suspect that the mechanism of aortic valve injury with atrial septal rupture in our case is direct or massive blast forces at the earliest diastole post impact, when the aortic valve is closed and the atrioventricular valves are not yet open.

The timing of surgical treatment is an important issue in patients with cardiac valvular injuries. Surgery should be undertaken without delay, but the risk of hemorrhage due to heparinization must be carefully evaluated for patients with multiple injuries. When sudden development of severe aortic valve regurgitation occurs, the normal ventricle can not compensate the increased work load and cardiac decompensation occurs. In our case, the decision to postpone surgery was made because the patient had stable hemodynamics. On postinjury day 5, when the risk of hemorrhagic complications from bilateral contused lungs and left hemothorax had decreased and lung edema had gradually developed, the surgery was undertaken uneventfully.

Conclusions

Aortic valve rupture and atrial septal rupture caused by blunt chest trauma are very rare. In cases of aortic valve rupture with atrial septal rupture, cardiac decompensation becomes more severe because left-to-right shunt due to atrial septal rupture worsens lung edema. Thus, early diagnosis and appropriate timing of surgical treatment are very important. The decision to undertake surgical treatment should be made carefully in each case with special consideration to cardiac decompensation and the risk of heparinization.

References
ABSTRACT

Atsuhiko Onaka¹, Kenji Nakai¹, Yoshiki Toma¹, Tatsuya Nakamura¹
Hiroshi Sakae¹, Hisayuki Tabuse¹ and Shigeaki Ootake²

¹Osaka Prefectural Nakakawachi Medical Center of Acute Medicine
²Department of Cardiovascular Surgery, Osaka University School of Medicine

Aortic valve injury with atrial alve injury with atrial septal rupture confirmed by transesophageal echocardiogram. The patient was treated successfully with a prosthetic valve replacement and direct suture of septal defect on postinjury day 5. The postoperative course was uneventful except. The decision to undertake surgical treatment should be made carefully in each case with special consideration to cardiac decompensation and the risk of heparinization.

(JJAAM 2001; 12: 302-7)

Key Words: aortic valve injury, atrial septal rupture, blunt chest trauma

Received for publication on November 2, 2000 (00-082)