Review

Traumatic pulmonary artery injury: a review of the recent literature

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Abstract

Pulmonary artery injury (PAI) is rare, lethal clinical entity. Traumatic PAI is anatomically classified into transection/rupture/laceration, pseudoaneurysm, dissection and fistula. In addition, traumatic PAI is clinically classified into two major categories: iatrogenic and non-iatrogenic, depending on the mechanism of the trauma. The frequency, clinical symptoms and treatment differ between the two clinical categories. If PAI can be managed appropriately and promptly in patients without cardiac arrest, the patient may be saved, as PAI can be easily controlled with appropriate procedures due to the low pressure in the PA circulation.

Keywords: Pulmonary artery, trauma, iatrogenic

INTRODUCTION

Pulmonary artery injury (PAI) is a rare, lethal clinical entity. Most vital emergencies involve proximal PAI. However, if PAI can be managed appropriately and promptly in patients without cardiac arrest, the patient may be saved, as PAI can be easily controlled with appropriate procedures due to the low pressure in the PA circulation, provided the injury site is small[1]. In this review article, traumatic PA is anatomically classified into four categories and clinically classified into two major categories: iatrogenic and non-iatrogenic, depending on the mechanism of the trauma. The frequency, clinical symptoms and treatment differ between the two clinical categories. The references are limited to reports in the English literature published since 1990.
ANATOMICAL CLASSIFICATION

Anatomically, traumatic PAI is classified into transection/rupture/laceration, pseudoaneurysm, dissection and fistula.

A transection, rupture, disruption, perforation, tear or laceration of the PA is thought to be a near-complete tear through all layers of the PA due to trauma; however, there is no consistent definitive terminology\(^1\). Clinical symptoms due to such trauma include cardiac arrest or hemodynamic insufficiency due to massive hemorrhaging or cardiac tamponade, and dyspnea due to hemothorax or hemoptysis\(^{1,2}\). Chest pain due to concomitant thoracic cage injury has also been reported. Rarely, this PAI, which involves hemostasis by clotting, is incidentally found on enhanced computed tomography (CT) without specific symptoms, as whole-body enhanced CT is routinely performed in patients following a high-energy accident\(^{3,4}\).

A pseudoaneurysm is an encapsulated hematoma in communication with the lumen of a ruptured vessel. This may form when re-epithelialization of the perforation does not occur, and a delayed diagnosis can occur even 60 years later\(^5\). The pseudoaneurysm may stabilize and spontaneously resolve or expand and rupture, depending on the etiology, size and intravascular pressure\(^1\). A pseudoaneurysm can be asymptomatic or characterized by symptoms of hemoptysis, shortness of breath and chest pain\(^6,7\). An iatrogenic pseudoaneurysm of the PA is most common, followed by trauma-induced events. A pseudoaneurysm of the PA can also be congenital or have a non-traumatic cause, which includes infections and neoplasms\(^6,7\).

An arterial fistula is an abnormal connection between the artery and other lumen organs. If an abnormal connection between an artery and a vein occurs, this is called as an arteriovenous (AV) fistula. In a trauma setting, arterial fistulas can be asymptomatic or characterized by right ventricular dysfunction, acute respiratory failure or transient ischemic attack (TIA)\(^8-12\). Traumatically, fistulas occur between the PA and left atrium, internal mammary artery, aorta or pulmonary vein. Non-traumatic pulmonary AV fistulas can also be associated with hereditary hemorrhagic telangiectasia\(^13\). The initial clinical manifestations include thrombotic or embolic stroke, brain abscess and TIA but can also be asymptomatic in non-traumatic cases\(^15\). The clinical trial of cyanosis, exertional dyspnea and digital clubbing is common, but there have been no reports describing triads due to trauma\(^13\).

PA dissections (PADs) are created by the occurrence of a small tear in the tunica intima, which allows blood to enter and cause the intima layer to strip away from the media layer, in effect dividing the muscle layers of the vascular wall. The mechanism of blunt traumatic PAD is likely similar to that seen in the aorta as a result of shearing forces and differential deceleration of the mediastinum and the spine. However, unlike aortic dissection, PAD progresses rapidly and typically ruptures rather than developing a reentry site, which causes cardiogenic shock or sudden death, especially in non-traumatic cases with pulmonary hypertension\(^14\). Five major etiological groups can be identified: congenital malformation, infection or inflammation, acquired cardiac diseases, iatrogenic causes and trauma\(^13,17\). Traumatic PADs usually resolve or remain stable unless associated with pulmonary hypertension, in which case the risk of bleeding can be quite high\(^1,16\).

IATROGENIC PAI

The most common cause of PA ruptures and pseudoaneurysms is iatrogenic, with PA catheters being a particularly common culprit\(^1,18-20\). Other iatrogenic causes include intraoperative surgical procedures\(^21-24\), indwelling chest tubes\(^25,26\), pacemaker implantation\(^27\), central venous catheterization\(^28\) and Kirschner wire migration\(^29\).

The incidence of PAI induced by catheters is not very high, averaging 0.01%-0.47\%\(^2\). The mortality rate of PAI induced by catheter averages 50% but can be as high as 75% in anticoagulated patients. If death occurs,
it is usually secondary to asphyxia rather than hypovolemic 
[2]. The initial presentation may be as obvious as massive pulmonary hemorrhaging or as subtle as a cough associated with minimal hemoptyis, or it may even be totally asymptomatic 
[30].

When catheter-induced PAI happens during insertion of a fluoroscope, it is relatively easy to retract the PA catheter a few centimeters and re-inflate the balloon under direct vision. It may therefore be possible to stop the bleeding 
[2]. Additional diagnostic angiography and embolization also can be easily performed at that point.

In addition to treatments for PAI, the patient may need selective intubation to obtain lung isolation in accordance with clinical symptoms. Lung isolation can be performed with different techniques, including selective intubation with a standard endotracheal tube, bronchial blocker or double-lumen tube (DLT) 
[2]. A bronchial blocker can be used for lung separation when a DLT is not immediately available or when it is difficult to insert the DLT. Bronchial blockers can be used to tamponade the bleeding side while waiting for diagnostic and therapeutic interventions. The most important aspects of treatment are lung isolation using selective intubation, bronchial blockers, or DLT as a temporary measure; rapid movement is important for more definitive therapy as it can avoid clotting of the entire lung on one side, which effectively causes pneumonectomy. Surgery, including pulmonary artery ligation, segmentectomy, lobectomy or pneumonectomy, is reserved for extreme cases, since these procedures are technically challenging and entail high morbidity 
[2].

NON-IATROGENIC PAI
A majority of non-iatrogenic PAI cases occur due to chest trauma; however, most chest trauma cases do not involve PAI. PAI accounts for a small percentage of thoracic trauma cases. Epidemiologically, Kulshrestha et al. 
[31] reported 102 patients sustaining cardiac injuries over a 4-year period. There were 45 blunt trauma, 36 stab injuries, and 21 gunshot injuries 
[31]. The injury involved the ventricle in 85 patients, atrium in 7 and the PA in 5 (5%) and resulted in crush injury to the heart in the remaining 5 cases. Thirty-three patients (32.3%) died at the scene, and 58 (56.9%) died during transportation. Only 11 patients (10.8%) reached the hospital alive, and 10 of these survived following thoracotomy and repair of the cardiac injury. The patients with ventricular injuries had a greater prehospital mortality than those with atrial or PA injuries.

Deneuville 
[32] reported 88 cases of penetrating chest trauma, focusing on non-iatrogenic PAIs. Of these 88 cases, 6 with PAI reached the hospital alive 
[32]. All cases underwent urgent operation, and 4 survived. The mortality appears to be high in patients presenting with complex lesions involving vascular and pulmonary structures. As a result, they concluded that isolated injuries of the PA were amenable to surgical repair and had a good prognosis if the patients arrived at the hospital alive.

We summarized the cases of non-iatrogenic PAI in Tables 1 and 2. Most cases were reported as case reports, except for the findings of Deneuville 
[32]. Penetrating injuries were more frequent than blunt ones. Similar to Deneuville 
[32], 46/50 (92%) cases survived. The diagnosis was made based on intraoperative findings, enhanced CT or pulmonary arteriography. The main treatment method was surgery or an interventional approach. These findings suggest that if hemorrhaging is not noted and the vital signs are stable, conservative treatment can be selected. There are no strict guidelines concerning the management of PAI, and the preferred approach depends on the lesion, patient and institution 
[3].

CONCLUSION
PAI is a rare, lethal clinical entity; most vital emergencies involve proximal PAI. Anatomically, traumatic PAI is classified into transection/rupture/laceration, pseudoaneurysm, dissection and fistula. Iatrogenic
<table>
<thead>
<tr>
<th>No.</th>
<th>Reporter</th>
<th>Year</th>
<th>Age (year)</th>
<th>Gender</th>
<th>Type of injury</th>
<th>Cause of injury</th>
<th>Type of injury</th>
<th>Symptom</th>
<th>Treatment</th>
<th>Outcome</th>
<th>Arrest</th>
<th>Other</th>
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procedures are the most common cause of iatrogenic PAI rupture and pseudoaneurysm, with PA catheters being a particularly common culprit. Non-iatrogenic PAIs occur due to chest trauma but most chest trauma does not involve PAI. Penetrating injuries were more frequent than blunt injuries. The diagnosis was made based on intraoperative findings, enhanced CT or pulmonary arteriography. The main treatment method was surgery or an interventional approach. If PAI can be managed appropriately and promptly in patients without cardiac arrest, the patient may be saved.

Table 2. Summary of non-iatrogenic injury of the pulmonary artery since 1990

<table>
<thead>
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<th>Total</th>
<th>50 cases</th>
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<td>Range 5-91</td>
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<tr>
<td>Gender</td>
<td>Male 40 (80%); Female 20 (20%)</td>
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<tr>
<td>Type of injury</td>
<td>Blunt 19 (38%); Penetrating 31 (62%)</td>
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<tr>
<td>Cause of injury</td>
<td>Gun 15 (30%); Traffic accident 13 (26%); Knife 10 (20%); Others 9 (18%)</td>
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<tr>
<td>Type of PAI</td>
<td>Rupture 26 (52%); Pseudoaneurysm 17 (34%); Fistula 5 (10%); Dissection 2 (4%)</td>
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<td>Symptom</td>
<td>Hemothorax 21 (42%); No specific 20 (40%); Tamponade 3 (6%); Others 3 (6%)</td>
</tr>
<tr>
<td>Treatment</td>
<td>Surgical sutures 22 (44%); Endovascular 10 (20%); Conservative 6 (12%); Other surgical maneuver 10 (20%); Other treatment 2 (4%)</td>
</tr>
<tr>
<td>Survival</td>
<td>Number and rate 46 (92%)</td>
</tr>
</tbody>
</table>

PAI: pulmonary artery injury
DECLARATIONS

Authors’ contributions
Designed the study, gathered data and wrote the manuscript: Yanagawa Y
Gave technical support, conceptual advice and edited the manuscript: Ishikawa K, Nagasawa H, Takeuchi I, Jitsuiki K, Ohsaka H, Omori K

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Conflicts of interest
The authors declare no conflicts of interest in association with this study.

Patient consent
Not applicable.

Ethics approval
This review article was approved by the review board of Juntendo Shizuoka Hospital, and all examinations were conducted according to the standards of good clinical practice and the Helsinki Declaration.

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