Review

Blunt Injury of the Innominate Artery: A Case Report and Review of Literature

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Innominate artery injury after blunt trauma is uncommon and mostly observed at its origin from the aorta. We report here an unusual case of distal innominate artery injury associated with acute right subclavian occlusion. MEDLINE search of blunt traumatic injury to the innominate artery revealed a total of 132 case reports by the end of 2003, including this case report, and all these published studies were reviewed. (Ann Thorac Cardiovasc Surg 2004; 10: 218–23)

Key words: blunt trauma, innominate artery, review

Introduction

Innominate artery (IA) injury after blunt trauma is uncommon. We previously reviewed a total of 117 blunt IA injuries and reported on this series in 1997.[1] Since then, an additional 15 cases of blunt IA injury, including this case, have been reported by the end of 2003 to our knowledge.[2-13] Here we report a case of distal IA injury associated with right subclavian occlusion. Previously reported cases of blunt IA injury were also reviewed.

Case Report

A 56-year-old male was involved in an unrestrained roll over motor vehicle accident (MVA) and brought into the emergency room at level I Trauma Center. He did not recall the event, but otherwise was fully alert, oriented, and followed all commands. Vital signs were stable. He complained of chest pain. On physical examination, right upper extremity pulse was absent. Chest X-ray demonstrated mediastinal widening and right clavicular dislocation. Computed Tomographic (CT) scan with contrast showed mediastinal hematoma. Head and cervical spine CT were negative. The patient underwent emergent angiography, which disclosed disruption of the intima of the IA and occlusion of the right subclavian artery (Fig. 1). The distal right subclavian artery was filled with retrograde flow from the right vertebral artery (Fig. 2).

The patient was taken to the operating room. Under general anesthesia, midline sternotomy extending to the right neck was performed. Hematoma was observed in the thymic fat and soft tissue of the neck. The innominate vein was taped and retracted away. The pericardium was opened and the ascending aorta was exposed. No hemopericardium was noted. The IA was mobilized in its entire length. The IA had pulsation; however, a pseudoaneurysm was observed in the distal IA involving its bifurcation. The proximal right common carotid and right subclavian arteries were mobilized until healthy looking adventitia was encountered. The recurrent nerve was identified and preserved. After 3,000 units of heparin was given, the distal right subclavian, the right common carotid, and proximal IA were clamped. A longitudinal arteriotomy was made on the IA and it was extended distally to the common carotid artery. Inspection of the lumen of the IA revealed an intimal tear and subintimal hematoma originating from the distal IA extending to the bifurcation and occluding the right subclavian artery. Primary repair of these vessels was not feasible, thus graft replacement of the IA, right common carotid and subclavian artery was carried out. The IA was transected just distal to the clamp and the stump was oversewn. Then a side-biting clamp was applied onto the ascending aorta, and the proximal end of the Y graft was anastomosed to

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Fig. 1. Angiography of the aortic arch and great vessels of the patient. The intimal tear originated from the distal innominate artery (arrow) and extended to the right subclavian artery. The right subclavian artery was completely occluded.

Fig. 2. Delayed phase of angiography of the patient demonstrated retrograde flow via the right vertebral artery filling to the right subclavian artery (arrow).

the ascending aorta. After completion of the proximal anastomosis the side-biting clamp was released, another clamp was applied to the graft, and then the limbs of the Y graft were brought up under the innominate vein. The right limb of the graft was anastomosed with the right subclavian artery beyond the area of intimal disruption in an end to end fashion. The arteriotomy on the right common carotid artery was extended more cephalad until normal looking intima was encountered, and then it was anastomosed with the other limb of the graft. Upon completion of the distal anastomoses, the graft was flushed and then all the clamps were removed. The chest was closed after adequate hemostasis was achieved.

The postoperative course was uneventful. Postoperative magnetic resonance angiography demonstrated a patent Y graft (Fig. 3). The patient was discharged to home without any complication.

Review of Literature

The first successful repair of an IA injury after blunt trauma was reported by Binet in 1962.[14] We previously reviewed 117 cases of IA injury by blunt trauma reported in English literature up until 1997.[1] Since then, an additional 15 cases of blunt IA injury including this study were reported as far as we know.[2-13] Thus, a total of 132 cases were available for review.

The patients' demographics were available in a total of 80 patients, which consisted of 69 (86.3%) male and 11 (13.8%) female , with a mean age of 29.7±12.5 (mean ± standard deviation).

The mechanisms of injury were mentioned in 90 patients: MVA in 80 (88.9%), crush injury in 8 (8.9%), and fall in 2 (2.2%). Timing of diagnosis was noted in 94 patients. Most of the IA injuries (82, 87.2%) were diagnosed in the early phase of trauma but 12 patients (12.3%) were diagnosed more than 10 days after blunt chest trauma.[1,7]

Associated injuries are common (Table 1): concomitant aortic or aortic branch injury (27 injuries), pneumothorax (18 patients), rib fracture (16 patients), head trauma (15 patients), and long extremity bone fracture (13 patients). Clavicle fracture was observed in 6 other patients.[15-19]

Results of pulse exams were available in 34 patients. Abnormal pulse exams were documented in 20 patients (58.8%); including blood pressure discrepancy between left and right arms in 8, pulse deficit in 10, and bruit in 5 (some patients had 2 or more abnormal pulse exams), while normal pulse exams were documented in 14 pa-

Fig. 3. The postoperative magnetic resonance angiography demonstrated patent Y graft from the ascending aorta to the right subclavian artery and right common carotid artery (short arrow). The innominate artery stump were also visualized (long arrow).

tients (41.2%).

The details of chest radiographs were available in a total of 68 patients. Widened mediastinum was observed in 59 patients (86.8%), while no mediastinal widening was observed in 9 cases (13.2%).

The method of diagnosis of the IA injuries was described in 88 cases, and all 88 patients underwent an angiography. The location of the IA injury was proximal in 72 (81.8%), middle in 4 (4.5%),[9,18-20] distal in 8 (9.1%),[6,21-25] diffuse injury in 2 (2.3%),[5, 26] and double injuries (isolated proximal and distal lesions) in 2 (2.3%).[27,28] CT scan was used in 15 patients, and mediastinal hematoma was detected;[3,5,8-13, 29] however, specific diagnosis of the IA injury was documented in only one case of IA pseudoaneurysm.[5] Local diagnosis of IA injury was made by angiography in all patients.

Surgical repair was performed in most IA injuries (130/132, 98.5%). Cerebral precautions were employed in 57 patients, including cardiopulmonary bypass (18 patients), carotid shunting (10 patients), electroencephalogram monitoring (7 patients), and measurement of back pressure of the distal stump of the IA or the right carotid artery (22 patients). No specific cerebral precautions were performed in 28 patients.

Reconstruction of the injured IA was specified in 75 patients; primary repair was performed in 15 patients and graft placement in 60 patients (Table 2).

The overall mortality was 6.8% (9/132) and morbidity directly related to the IA revascularization operation was 9.1% (12/132). Postoperative stroke was observed in 6 patients (4.5%). The mortality and morbidity rates before 1985 were 11.9% (8/67) and 14.9% (10/67), respectively, and they significantly decreased after 1986 to 1.5% (1/65) and 3.1% (2/65), respectively ($p<0.05$, by Fisher's test).

Discussion

Most of IA injury occur at its origin.[1)] Anatomically, the IA is tightly fixed onto the aortic arch while the distal part of the IA is more mobile and flexible.[30)] In most of MVAs, abrupt deceleration causes simultaneous hyperextension of the neck and rotation of the head, which creates great tension on the proximal IA. Furthermore, chest compression against a steering wheel results in sudden increase of intra-mediastinal pressure, in the closed space between the sternoclavicular joint and the vertebral column. This compression force may further stretch the aortic branches. Both mechanisms together maximize shear stress at the origin of the IA, and cause proximal IA injury.[1,30)]

Most frequent types of IA injury are intimal tear and pseudoaneurysm formation. Hemorrhagic shock is relatively rare unless the patient has had avulsion injury or concomitant aortic injury.[1,30)] Cardiac tamponade from isolated IA injury is impossible because of anatomical location of the IA and the pericardial sac. If cardiac tamponade is observed, cardiac injury or ascending aortic injury should be suspected. Bleeding from blunt IA injury is usually contained in the upper mediastinum. Mediastinal hematoma may or may not be detected by chest X-ray, but should be detected by CT scan.[3)] Recent IA injury has been suspected by CT scan.[2,3,5,8-13,29)] However, the specific diagnosis of IA injury by CT scan is still limited.[29)] We believe that the aortogram is still the gold standard for the diagnosis of IA injury. Thus, once mediastinal hematoma is detected by CT regardless of the size or location of the mediastinal hematoma, the patient should undergo angiogram to rule out injury of the aorta or major branches without delay.[1)] If the CT is normal, the chance of a great vessel injury of the aortic arch in the hemodynamically stable patient is low and an angiogram may not be necessary. Both IA injury and head trauma may cause neurological abnormalities.[1,30)] Chest trauma

Table 1. Associated injuries

Associated injuries		Number of injuries
Major vascular injuries		27
	Right common carotid artery	6
	Left common carotid artery	6
	Intrathoracic aorta	4
	Right subclavian artery	5
	Left subclavian artery	2
	Aortic valve	1
	Bovine arch	3
Thoracic injuries		61
	Pneumothorax	18
	Rib fracture	16
	Bronchotrachial injury	5
	Hemopnuemothorax	3
	Sternal fracture	5
	Clavicle fracture	6
	Pulmonary contusion	2
	Other chest injury	6
Head injury		15
Cervical spine injury		2
Facial injury		10
Extremity long bone fracture		13
Shock		4
Abdominal injury		1

Table 2. Surgery of innominate artery injury

Innominate artery repair		Number of cases	
Graft		60	80.0%
	Ascending-IA graft	16	
	Arch-IA graft	5	
	Ascending-right common carotid graft	1	
	Ascending-right subclavian graft	1	
	Other nonspecified aorto-IA graft	2	
	Interposition (IA-IA) graft	14	
	Aorto-right common carotid and right subclavian bifurcated graft	3	
	Aorto-IA and left common carotid bifurcated graft	6	
	IA-right common carotid and right subclavian bifurcated graft	1	
	Not specified	11	
Primary repair		15	20.0%
	End-to-end	5	
	Re-implantation	2	
	Vein patch	1	
	End-to-side	1	
	Not specified	6	
Total number of cases with documented IA repair		75	

IA: innominate artery

victims with a normal head CT with focal signs of the neurological exams should be investigated to exclude injuries of the aorta or its major branches.[31)]

Once diagnosis is established, surgical repair is mandatory. Median sternotomy with extension to the right neck provide excellent exposure of the entire course of the IA and other aortic branches.[1)] Cerebral protection is an important consideration for IA repair.[1)] Young healthy individuals may tolerate temporary occlusion of the IA.[32)] However, various modalities to protect and/or monitor

the cerebral perfusion have been utilized: cardiopulmonary bypass, retrograde perfusion, electroencephalogram monitoring, hypothermia, carotid shunting, and back pressure monitoring. A patient with good collateral flow via the contralateral carotid or vertebral arteries will tolerate simple clamping of the IA during its reconstruction. Back flow pressure of more than 50 mmHg is considered to be the threshold for this technique. In patients with decreased back flow or absence of carotid pulses, temporary shunting should be performed to maintain cerebral flow.[33] The use of cardiopulmonary bypass should limited to the patients with concomitant aortic or cardiac injury, or patients requiring anastomosis under circulatory arrest.

The current IA injury had some interesting features. First, this patient had an isolated distal IA lesion which involved the right subclavian and common carotid artery. This pattern of injury of the IA after blunt trauma is rare.[6,21-25] The possible mechanism of this IA injury is a direct force of the dislocated clavicle against a maximally stretched IA by sudden deceleration. Second, the disrupted intima from the IA acutely occluded the right subclavian artery. Concomitant right subclavian artery occlusions associated with blunt IA injury have been reported in only four cases previously.[20,34-36] Among these four patients, three patients presented in the chronic phase of injury (more than six months after trauma). Third, the right arm of our patient was perfused via the retrograde flow from the ipsilateral vertebral artery. This collateral route from the right vertebral artery to the right upper arm may have been stealing the cerebral blood flow via the circle of Willis and may have lead to cerebral ischemia or subclavian steal syndrome. Blunt IA injury related subclavian steal syndrome was reported in two cases in the literature; however, both were observed in the chronic phase of innominate injury,[36,37] and acute subclavian steal syndrome after IA injury have not been reported to our knowledge. Finally, to prevent distal embolization, the diseased part of the innominate and carotid arteries were resected and the stump of the IA was ligated. The graft was anastomosed to the most healthy looking common carotid and subclavian arteries. The reported long-term patency rates of aorto-IA bypass is more than 96% at 10 years,[38] which is comparable to primary repair.

In summary, we report an unusual case of distal IA injury associated with acute subclavian occlusion. IA injury was suspected by physical exam, chest X-ray and CT scan; however, the final diagnosis was made by angiogram. Cerebral protection during the IA repair may not be necessary if there is enough collateral flow. Aorto-innominate bypass can be performed if primary repair is not feasible.

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