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Subclavian arterial injury associated with clavicle fracture

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Abstract

Reports on clavicle fractures with subclavian artery injury have been rare. Damage to vessels may result in threatening limb perfusion and potentially devastating hemorrhage. There should be an accurate diagnosis in order to prevent delays in management and subsequent complications. This research aimed to evaluate the pattern of subclavian artery damage due to the clavicle fracture. A 10-year retrospective analysis from a level one trauma center between 2012 and 2021. We treated 1054 cases with clavicle fractures. The frequency of subclavian arterial injury associated with clavicle fracture was 0.85%. Our data's findings revealed typical clinical indicators that signify subclavian artery injury. Most patients initially had ischemic symptoms (77.8%). The most common type of injury (71.42%) was the Allman's classification group I fracture or midshaft fracture with displacement. The common associated lesions were brachial plexus injuries (100%), rib fracture (66.66%), pneumohemothorax (44.44%), and scapular fracture (44.44%). As a minimally invasive therapeutic option, endovascular management is a good substitute for traditional surgical procedures. A high index of clinical suspicion combined with the correlation of associated physical findings is the primary diagnosis for subclavian arterial injury.

Keywords: Clavicle fracture, Subclavian artery injury, Vascular trauma, Arterial transection, Endovascular procedures, Surgical procedures

1. Introduction

Clavicle fractures are common injuries in childhood and adulthood [1]. The literature indicates that 2.6% of all fractures are clavicular fractures [2,3]. The majority of clavicle fractures occur in the midshaft and their management in most cases remains conservative with good results [4]. Neurovascular bundles are adjacent to the clavicle, which can be damaged when a fracture occurs. A rapid deceleration injury of the suddenly impacted force to the clavicle within the moving vehicle or direct force to the clavicle may cause damage to the subclavian vessel [5]. Traumatic subclavian vascular injury secondary to the clavicle fracture is an uncommon condition [6]. A review of 466 patients with clavicular fractures from Demetrios's center presented only one case of subclavian vascular trauma (0.4%) [7]. Subclavian artery damage correlated with clavicle fracture is a complicated surgical issue. Importantly, the signs of subclavian arterial trauma may be subtle because of the excellent collateral circulation to the upper extremity. Delayed diagnosis and treatment can result in amputation and even death [8]. It is unclear from a clinical perspective whether these relation injuries are the root cause of devastating problems. The aim of this study is to assess clavicle fractures and their relationship with injuries to the subclavian artery after trauma. Moreover, the prevalence of traumatic subclavian arterial injury combined with a clavicle fracture, injury patterns, clinical characteristics, surgical treatments, and therapeutic outcomes are retrospectively described in this study.

2. Materials and methods

A retrospective chart review inclusion of all patients admitted to Srinakarind Hospital, an academic level trauma center in Khon Kaen, Thailand, from 2012 to 2021. Patients who died during emergency department care were excluded from this study.

Patients' data, which includes demographics, comorbidities, injury mechanisms, vital signs, characteristics of subclavian artery injury and clavicle fractures, Abbreviated Injury Scale (AIS), concomitant injuries, and intraoperative and postoperative data including major complications, and treatment outcomes, were collected and recorded.

The AIS is a trauma scoring system that classification the severity of injuries based on anatomical parameters.

Allman's system was used to determine the anatomic location of the clavicle fracture. The lesions were divided into three groups. Type I fracture occurs at the midshaft. Types II and III were characterized by lateral and medial third clavicle fractures.

The descriptive statistical analysis of data including mean, standard deviation, medians, and interquartile ranges was reported. IBM SPSS statistics Version 26 was used to analyze the data.

3. Results

There were 1054 clavicle fractures. Traumatic subclavian artery accounted for nine cases (0.85%) (Table 1). The mean age was 31.44 (11.82) (from 17 to 56) years. All of them were male patients (100%). The majority of injuries were motor vehicle collision accidents (88.9%) (Table 2). The injury severity score mean was 26.00 (7.66) (from 13 to 36) (Table 3). The dominant site of clavicle fracture was midshaft (77.8%), and 71.42% of the fractures were displaced (Table 4). The most frequent accompanying injuries were brachial plexus (100%), rib fracture (66.7%), scapular fracture (44.4%), and pneumohemothorax (44.4%).

Table 1 A summary of cases involving subclavian arterial injury associated with clavicle fracture.

Case	Age	Gender	Mechanism of injury	Side	Location of clavicle fracture	Associated injury	Vascular injury pattern	Methods of repair
1	23	Male	Motor vehicle collision	Right	Mid clavicle	Brachial plexus, right femur fracture	Incomplete transection	PTFE graft interposition
2	25	Male	Motor vehicle collision	Left	Mid clavicle	Brachial plexus, left scapula fracture, 1st-3rd left rib fracture, left pneumohemothorax, c6 spinous process and left transverse process of T6-T9 and T11 vertebra fracture, subarachnoid hemorrhage at posterior fossa	Complete transection	Endovascular stent
3	17	Male	Motor vehicle collision	Left	Mid clavicle	Brachial plexus, right transverse process of L2 vertebra fracture, splenic injury	Complete transection	Reverse saphenous vein graft interposition
4	34	Male	Motor vehicle collision	Left	Distal clavicle	Brachial plexus, 2nd-6th left rib fracture, left subclavian vein injury, left femur, and tibia fracture	Complete transection	Left arm amputation (severe left arm soft tissue injury)

Table 1 (continued) A summary of cases involving subclavian arterial injury associated with clavicle fracture.

Case	Age	Gender	Mechanism of injury	Side	Location of clavicle fracture	Associated injury	Vascular injury pattern	Methods of repair
5	37	Male	Motor vehicle collision	Left	Mid clavicle	Brachial plexus, 6th left rib fracture, left pneumohemothorax, subdural hemorrhage left tentorial cerebelli	Complete transection	PTFE graft interposition
6	40	Male	Motor vehicle collision	Left	Mid clavicle	Brachial plexus, left scapula fracture, left humerus, and proximal radius fracture	Complete transection	PTFE graft interposition
7	28	Male	Motor vehicle collision	Left	Distal clavicle	Brachial plexus, 2nd-4th left rib fracture, left scapula fracture,	Contusion and thrombosis	Endovascular stent
8	23	Male	Motor vehicle collision	Left	Mid clavicle	Brachial plexus, 2nd-6th left rib fracture, left scapula fracture, left pneumohemothorax, fracture spinous process C7	Laceration	Endovascular stent
9	56	Male	Motorcycle accident	Right	Mid clavicle	Brachial plexus, 1st-2nd right rib fracture, right pneumohemothorax	Complete transection	Subclavian artery ligation

Table 2 The demographic and clinical characteristics of patients prior to surgery who were diagnosed with subclavian arterial injury in association with clavicle fractures.

Demographics	
Male, n (%)	9 (100.00)
Age (year), mean (SD)	31.44 (11.82)
External causes of injuries, n (%)	
- Car accidents	8 (88.89)
- Motorcycle accidents	1 (11.11)
Side of subclavian artery injury: Left, n (%)	7 (77.78%)
Shock grade, n (%)	
1	7 (77.78)
2	0 (0.00)
3	2 (22.22)
4	0 (0.00)
Clinical	
Pulsatile bleeding, n (%)	1 (11.11)
Expansile hematoma, n (%)	3 (33.33)
Audible bruit, n (%)	0 (0.00)
Palpable thrill, n (%)	0 (0.00)
Ischemic symptoms, n (%)	7 (77.78)
History of hemorrhage at the scene, n (%)	0 (0.00)
The peripheral neurological deficit, n (%)	2 (22.22)
Injury proximal to a major vessel, n (%)	0 (0.00)
Decreased pulse, n (%)	0 (0.00)

Table 3 Associated injuries of nine patients with subclavian arterial injury associated with clavicle fracture.

Variable	
Injury severity score, mean (SD)	26.00 (7.66)
Subclavian vein injury, n (%)	2 (22.22)
Brachial plexus, n (%)	9 (100.00)
Scapular fracture, n (%)	4 (44.44)
Rib fracture, n (%)	6 (66.66)
Pneumohemothorax, n (%)	4 (44.44)
Spine fracture, n (%)	3 (33.33)
Intracranial hemorrhage, n (%)	2 (22.22)
Splenic injury, n (%)	1 (1.11)
Long bone fracture, n (%)	3 (33.33)

The AIS, mean (SD).

Table 4 Perioperative data, type of clavicle fracture, and subclavian artery injury pattern of patients who underwent surgery.

Perioperative data	
Allman classification system, n (%)	
Fractures involve the middle: Group 1	7 (77.78)
Fractures involve distal to the coracoclavicular ligament: Group 2	2 (22.22)
Fractures involve the medial third: Group 3	0 (0.00)
Vessel injury pattern, n (%)	
-Laceration	1 (11.11)
-Complete transection	6 (66.67)
-Incomplete transection	1 (11.11)
-Contusion and thrombosis	1 (11.11)
Fasciotomy, n (%)	1 (11.11)
Operative times (min), mean (SD)	189.25 (102.58)
Intraoperative blood loss (mL), mean (SD)	591.43 (536.14)

The diagnosis of arterial injury was based on clinical assessment. The patients were initially characterized by hypoperfusion or ischemic features the of limb (pain, pallor, pulselessness, poikilothermia (cold), paresthesia, and paralysis) (77.8%), expansile hematoma (33.3%), and pulsatile bleeding (11.1%). Completed arterial transactions were found in six cases (66.7%). The Mangle Extremity Severity Score of patients was 6.50 ± 2.45 (from 5 to 12). The chest radiographic findings included widening of the mediastinum (55.56%), first rib fracture (44.44%), and apical pleural hematomas (33.33%) (Figure 1). Computed tomographic angiography has evolved as the primary modality for diagnosis (88.89%). The signs of arterial injuries were extravasation of the contrast material, narrowing of the lumen, and occlusion of a segment of the artery (Figure 2).

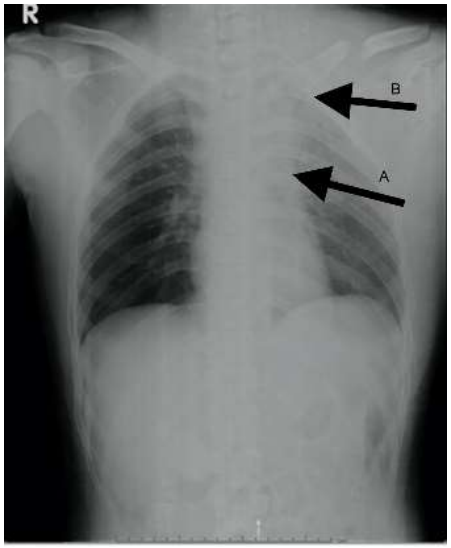

Figure 1 Chest radiograph of case with subclavian arterial injury associated with clavicle fracture showing left clavicular fracture with a widening of the mediastinum (A) and left apical pleural hematoma (B).

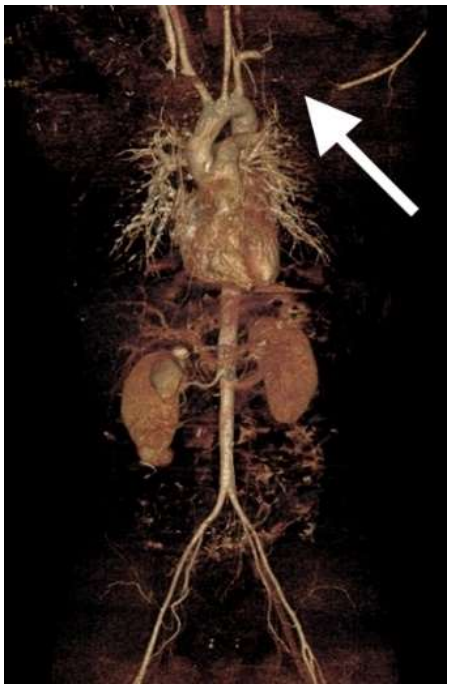

Figure 2 Computed tomography angiography showing occlusion of the distal left subclavian artery.

Treatment included interposition graft in four cases, arterial ligation in two cases, and endovascular intervention in three cases (Table 5). An initial amputation was required in one patient who suffered from extensive unreconstructible soft tissue. Two cases of clavicle fractures were treated with internal fixation.

Table 5 Surgical approach and treatment of subclavian artery injuries.

Operative data	
Incision, n (%)	
Infraclavicular	6 (66.67)
Percutaneous puncture	3 (33.33)
Type of repair, n (%)	
Polytetrafluoroethylene interposition grafts	3 (33.33)
Reverse interposition vein graft	1 (11.11)
Arterial ligation	2 (22.22)
Endovascular stent	3 (33.33)

Procedure-related complications did not occur. There was no in-hospital death (Table 6). All patients were discharged home with limitations on the basis of the degree of associated nerve injury.

Table 6 Description of the postoperative adverse events and in-hospital complications that occurred after surgery.

Postoperative adverse events	
Vasopressor requirement, n (%)	0 (0.00)
Reoperation due to bleeding, n (%)	0 (0.00)
In-hospital complications	
Acute renal failure, n (%)	0 (0.00)
Respiratory failure, n (%)	0 (0.00)
Limb compartment syndrome, n (%)	0 (0.00)
Sepsis, n (%)	3 (33.33)
In-hospital mortality, n (%)	0 (0.00)
30-day mortality, n (%)	0 (0.00)

4. Discussion

The anatomical relation describes the low prevalence of subclavian artery injury. The subclavian vessels are well protected from injury by the thoracic cage components including the clavicle, ribs, scalene muscle, subclavian

muscle, and fascia. The damage to the border structures has been associated with an increased risk of subclavian vasculature injury [9].

The clavicle is an S-shaped long bone that is located between the sternal manubrium and the acromion of the scapula [10]. This bone provides an essential role in the function of the motion of the shoulder and the anatomic protection of the subclavian vessels and brachial plexus [11]. The fractures can be a risk of injury to the underlying structures [12]. Vascular complications of clavicle fracture are rare [13,14]. It can result in intrathoracic vascular injury and massive haemothorax. These injuries may potentially cause significant blood loss, which may lead to death [15]. The initial management includes early recognition and treatment of any life-threatening conditions [16]. Direct pressure and compressive dressing are effective in controlling bleeding in an urgent situation. For early diagnosis, a high level of clinical suspicion is necessary [17,18]. To determine a possible injury, a physical examination is helpful. An accurate diagnosis of arterial injury is key to preventing morbidity and mortality [19].

All patients in this study were male. A previous study has also reported that most patients were male. The occupations and alcohol consumption lifestyle may be associated with a higher rate of trauma exposure events.

The most common mechanism of injury in Thailand was road traffic accidents [20]. The majority of patients (96.6%) who were admitted to our center had blunt trauma. Motor vehicle accidents were the leading mechanism of injury in this study. A direct force on the clavicle is the predominant cause of fracture [21]. The displaced bone fracture can compress or cut the adjacent vascular structures [22]. The incidence of subclavian vessel injury after clavicle fractures has not been described in the literature [18,22]. Our study demonstrated that the frequency of subclavian arterial injury associated with clavicle fracture was 0.85%.

The mainstay of diagnosis of subclavian artery injury in our study was based on clinical assessment. The clinical features of vascular injuries can be divided into “hard” signs and “soft” signs. The hard sign is clear evidence of vascular injury. Hard signs comprise pulsatile bleeding, expansile hematoma, bruit, thrill, and ischemic symptoms. Soft signs include a history of hemorrhage at the scene, a peripheral neurological deficit, injury proximal to a major vessel, and decreased pulse. Most patients in this study are initially characterized by ischemic features the of limb (pain, pallor, pulselessness, poikilothermia (cold), paresthesia, and paralysis). Owing to the rich collateral vessels in the injury region, the peripheral pulse may be detectable [23]. The transmitted pressure waves through a small clot or intimal flap can produce a distal pulse and misleading diagnosis [24]. A case report by Marco et al. showed subtotal disruption of the left subclavian artery with pulsatile large hematoma in the supraclavicular region with palpable radial pulse [25]. The diagnosis should be made based on the appearance of expansile hematoma, peripheral neurological deficit, or pulsatile hemorrhage should lead to the diagnosis.

Midshaft clavicular fractures were the most frequent location of injuries. With the midshaft fracture displacement, artery injury should be anticipated. Subclavian arterial injury is rarely seen with clavicular fracture alone [26]. There was a close anatomic relationship between the subclavian artery and the brachial plexus. The subclavian artery is located at the roots of the brachial plexus between the anterior and middle scalene muscles. The high kinetic injury mechanism to the clavicle and subclavian artery can affect the brachial plexus. The data showed that all patients had brachial plexus injuries. The other commonly associated lesions were rib fracture, pneumohemothorax, and scapular fracture. Based on the results of this study data, a complete vascular examination of the clavicle fractures accompanied by these injuries is recommended.

Widened mediastinal was the most frequent feature manifestation of chest radiography in patients with associated subclavian artery injury. The preoperative diagnosis was confirmed via computed tomography angiography. The keys to successful treatment of arterial injuries are bleeding control, restoration of the distal perfusion, and prevention of compartment syndrome and reperfusion injury [27]. Due to anatomical structures, surgical subclavian artery exposure is difficult to attain. The approach to obtain adequate exposure may require median sternotomy, high anterolateral thoracotomy, and supraclavicular or infraclavicular incision [28]. Revascularization via endovascular technique is a highly effective procedure. An endovascular repair is less invasive when compared with surgical repair and has high technical success with a significant advantage in perioperative morbidity [29,30].

This study has some limitations. Subclavian artery injury is a very rare complication after a fracture of the clavicle. All reviews of the medical literature were case reports. We collected retrospectively a small sample size.

5. Conclusion

Clavicle fractures usually present as an isolated injury. Vascular complications may be seen secondary to trauma. A meticulous physical examination and a high index of suspicion in patients with a fracture or dislocation result in accurate diagnosis and management. The common manifestations are signs and symptoms of acute ischemia, active expanding hematoma, pulsatile bleeding, and neurologic deficit. Computed tomographic angiography is an effective imaging modality for investigation. Prompt conventional surgical intervention and endovascular treatment may allow limb salvage and lifesaving.

6. Ethical approval

The Center for Ethics in Human Research of Khon Kaen University. (reference number: HE641010) approved the present study.

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