**Research topic: Evaluation of Subclavian, Thoracic Aorta and Innominate Artery Injuries in Blunt Trauma Mechanisms: A Systematic Review of Case Reports and Case Series**

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**Abstract**

**Background:** Blunt thoracic arterial injuries are one of the uncommon presentations in trauma clinical experiences. Most reports are case reports and case series and no significantly consolidated data is available. This is an attempt to organize case reports and case series.

**Methodology:** Pubmed and Google scholar were utilized to find case reports and case series on each artery separately with data search limited to publications between 2000 and 2019. The retrieved data are extracted using tables with specific components for data interpretation and the data was finally entered and analyzed using SPSS version 23.

**Results:** The mean ages were between 35.9 and 44.3 years with male proportions were 76.5% to 89.7% across the three groups of patients. Motor vehicle related injuries contributed between 49.9% and 81.2% in the three groups. Blood pressure/pulse deficit was recorded in 34.8% and 20,7% of patients with Subclavian and Innominate artery injuries respectively with chest pain and hemodynamic instability found in 23.5% and 20.5% of Aortic injury patients respectively. Clavicular fracture was evident in 42.2% of Subclavian artery injury patients. Computed tomography was performed in 21.7%, 47.1%, 27.6% of patients with Subclavian artery, Aortic and Innominate artery injuries respectively. Endovascular procedure was performed in 44.1% of patients with Subclavian artery injury.

**Conclusion:** Injury to Subclavian artery is relatively common among older population and the causative trauma is often trivial. Blood pressure or pulse discrepancy could point to either Subclavian or Innominate artery injury and Patients presenting with chest pain or hemodynamic instability in the presence of significant trauma should be investigated for Aortic and Innominate artery injuries. Computed Tomography can be efficiently used in all the Arteries but there is poor experience with regard to use in Innominate artery injuries for this reason lower threshold for Conventional angiography should be in place. Endovascular procedure can be considered in all patients but has to be individualized based on patient and facility factors.

**Keyword**: Psuedoaneurysm, Transection, Dissection, Endovascular, Hybrid, Cerebrovascular accident**Evaluation of Subclavian, Thoracic Aorta and Innominate Artery Injuries in Blunt Trauma Mechanisms: A Systematic Review of Case Reports and Case Series**

**Introduction**

Trauma is still the most common cause of mortality in the young, 1-44 years segment of the population.[1] Blunt trauma in general is the commonest mechanism of trauma in most civilian trauma centers.[2,3] Motor vehicle accidents are the leading cause of blunt trauma accounting for 1.3 million annual death toll, 20-50 million non fatal injuries and 29% of all trauma causes.[4,5] Even though such large proportion of blunt trauma exists presence of vascular injury from trauma cases is more common among patients with penetrating injuries than blunt with overall vascular injury incidence of less than 5%.[6,7] Furthermore, Blunt thoracic vascular trauma is even a rarity among literatures representing less than 5% of traumatic vascular injuries.[8] This is a certain underestimation as the difference between prehospital mortality incidence of and in-hospital incidence of thoracic vascular trauma is staggering. One has to always be reminded that vascular thoracic trauma is second to head trauma in early trauma death postmortem examinations.[9,10]

This rarity has led to few published data mostly of case reports and case series to which have quite varied patient population, assessment and management methods.[11] These literatures in singleton create significant problem in drawing a single conclusion on presentation, diagnosis and management of this group of patients.

Here the researcher gathered 96 case reports and case series on blunt trauma induced subclavian, innominate arteries and Aortic injuries published from January of 2000 to 2019 in an attempt to analyze the demographics, clinical presentations, associated injuries, diagnostic modalities and management along with outcomes and possible complications collected from each individual studies.

**Methods**

**Data source and search strategy:**

PubMed and Google scholar was utilized to search all database on October of 2019, with limiting factors of dates of publication between January 2000 and September 2019 publications posing no language restrictions. Some references with limited information were individually searched for an alternative publication of similar case report or case series.

**Eligibility criteria of collected data:**

All case reports and case series have been reviewed before hand to determine the mechanism of trauma with exclusion of all penetrating and iatrogenic mechanisms. Admissions for a different pathology with a patient stating a previous history of chest trauma or specific vascular injury have also been excluded from the review.

There was no age, sex, geographic area, mechanism of injury, delay in presentation, center of treatment or modality of treatment based exclusion of any case report or case series.

**Data extrication and handling**

Each patient’s data was handled as individual with all information sought for and retrieved from the individual reports. Few data of could not have been retrieved from patient data, but no effort to communicate authors have been made for any individual case to retrieve a missing data.

From each patient report, year of reported case, age at presentations, sex, mechanism of injury, general complaint/clinical presentations, associated injuries, specific vertebral injury, intracranial injury, associated vascular injuries in addition to the injured vessels under study, chest wall injuries, pulmonary injuries, facial injuries, limb injuries, abdominal injuries, diagnostic modality, specific type of vascular injury for the main thoracic arterial injuries under question, diagnostic modality utilized, treatment given, type of open surgical treatment provided and outcome with specific complications pertaining to the vascular injury and mortality.

The availability of data for the variables set forward was not complete in all of the individual cases reported and case series reviewed.

**Data synthesis and analysis**

Generated data were entered into SPSS version 23 in the same categories mentioned above and accuracy of data was assured.

After data entry and cleanup was complete, data analysis was done using the same software, SPSS version 23, and the graphics was performed using Microsoft excel 2007.

**Results**

**Subclavian artery injury**

Total of 46 patients with Subclavian artery injuries have been reviewed. (Table 1) The mean age is 44.33(SD: 21.11) years and 73.8% are male. Motor vehicle collision was 32.6%, hemodynamic instability was recorded in 21.7% of the patients as a main clinical presenting sign/symptom and polytrauma was reported in 10(21.7%) of the patients. The most common clinical manifestations of motor vehicle related injuries(motor vehicle collision, pedestrian motor vehicle accident and motor cycle injuries) are blood pressure/pulse deficit, 9(45%) and hemodynamic instability 7(35%). Patients presenting after falling down accidents reported progressive supraclavicular swelling in 63.5%(5) cases. 3 of 5 patients’ presenting with sports related injury presented with blood pressure/pulse deficit. Motor vehicle related injuries were reported in 13(65%) of patients younger than 45 years of age presenting with Subclavian artery injury and in 10(45.4%) of 45 years or older patients with the later group of patients presenting with history of falling down accident in 36.4% of the reported cases. Female patients have been reported to present after falling down accident in half of the cases with subclavian artery injuries. Clavicular fracture was reported with or without rib fracture in 24 (52.2%), with (15 of 24 cases) 62.5% of the Clavicular fractures occurring in patients 45 years of age or older. 4(8.7%) of reports with traumatic brachial plexopathy with 10(21.7%) of the patients presenting with polytrauma. 15(32.6%) of reviewed patients had pneumothorax, hemothorax or both at presentation. (Table 2)

Regarding diagnostic modalities utilized, 44 cases reported either one or more imaging utilization. Conventional/digital subtracted angiography was utilized in 13(28.3%) of the reported cases with doppler ultrasonography, Contrast CT and CT angiography utilization in 3(6.5%), 10(21.7%) and 12(26.1%). One patient had Chest X-ray as a sole imaging modality for diagnosis and combination of CT angiography and conventional angiography with Doppler ultrasonography was done in 2(4.3%) patients each. The type of vascular injuries diagnosed using imaging modalities or with intra-operative findings has been reported in all 46 patients in this review. Pseudoaneurysm and dissection were reported in 20(43.5%) and 8(17.4%) of the cases respectively. Rupture, laceration and compression occurred in (4)15.2%, 6(13%), (3)6.5% and one patient presented with spasm of the Subclavian artery.

Treatment modalities were specified in all 46 cases reported with open surgical repair done in 21(45.7%) and endovascular hybrid procedures were performed in 17(37%) and 5(10.9%) respectively. 3 patients underwent conservative/medical therapy. From the open surgical repair group 11(57% of open repair) underwent graft repair. The graft repair patients underwent prosthetic interposition graft, prosthetic carotid Subclavian bypass and prosthetic carotid axillary bypass graft 3(27.3%), 2(18.1%), 2(18.1%) respectively. 3(27.3%) patients underwent saphenous bypass graft. 8(42.1% of open repair) patients had direct repair with end to end anastomosis, simple suture and ligation done in 2(25%) patients each and one patient underwent patch repair.

Outcome and complications were reported in 45 of 46 cases with 73.9% of patients reported to have experienced total resolution, 6(13%) of the cases reported had upper limb complications of which 4 were confirmed brachial plexopathy. Repeat intervention and death was reported in 2(4.3%) patients each and one patient had cerebrovascular accident.

**Thoracic Aorta injury**

Total of 34 Aortic injury patients’ data have been retrieved from literatures between 2000 and 2019. (Table 3) The mean age of patients with Aortic injuries is 35.9(SD: 18.9) years and 26(76.5%) of the reported cases were male. 23(67.6%) of cases presented after motor vehicle collisions and 28(82.4%) had injuries related to motor vehicles (including pedestrian motor vehicle accident and motor cycle injuries). Hemodynamic instability (hypotension) and chest pain were the chief clinical features in 7(20.6%) and 8(23.5%) of cases reported. Polytrauma was reported in 17(50%) of the patients. 21(84%) of patients with age less than 45 years had motor vehicle related injury compared to 7(77.7.%) in group of patients with age 45 years or more. Female patients had motor vehicle accident 87.5% of the cases compared to 80.7% in male patients.

Rib fracture was the most common associated chest wall injury presenting in 9(26.9%) of the cases alone and in 3(8.8%) and 1(2.9%) cases with sternum and clavicle fractures respectively. Hemopneumothorax was reported in 5(14.7%) and 3(8.8%) of patients alone and with lung contusion respectively. 5(14.7%) of patients had associated Innominate artery injury. 13(38.2%) patients had associated Traumatic brain injury. (Table 4)

Most common imaging modality utilized were contrast CT scan and CT angiography in 16(47.1%) and 7(20.6%) respectively, and conventional/digital subtracted angiography was performed in 10(29.4%) of reports. Isthmus and Descending Aorta is the most common site of injury with 18(52.9%) of reported cases. Aortic arch and ascending aorta were injured in 13(38.2%) and 3(8.8%) patients respectively. Psuedoanurysm was reported among 18(52.9%) of the patients either using imaging modality or intraoperative findings. Rupture was diagnosed in 11(32.4%) and dissection with or without thrombosis in 5(14.7%).

Regarding treatment, 13(38.2%) underwent open surgical repair with endovascular repair performed in 15(44.1%) and hybrid method in 6(17.6%). In the open repair group 10 of 13, 76.9%, patients underwent repair using prosthetic graft and 3(23.1%) undergone patch repair. Majority of open procedures, 7(53.8%) was performed under complete cardiopulmonary bypass with deep hypothermic arrest and centrifugal pump was used in 3(23.1%). 2 patients underwent simple clamp and stitch procedure with no bypass

For outcome and complications in Aortic injury patients, 76.5% of patients had complete resolution with 2 deaths out of the 34 patients reported. 3(9%) patients had chronic cerebral sequale with 2 of the 3 cases caused by traumatic brain injury.

**Innominate artery injury**

Total of 29 patients data have been retrieved from reports from 2000 to 2019. (Table 5) The mean age patients with Innominate artery injury was 36.4(SD: 12.8) years and 26(89.7%) are male. Motor vehicle collision contributed to 19(65.5%) of Innominate artery injury patients in the case reports and case series with motor vehicle associated injury of 79.3%. Regarding clinical presentations for patients presenting with Innominate artery injury, chest pain and blood pressure/pulse deficit have been reported in 7(24.1%) and 6(20.7%) of patients respectively. Polytrauma was reported among 8(27.6%) of patients.

Rib fracture is reported in 9(31%) and 4(13.8%) alone and with sternum fracture respectively in patients with Innominate artery injury. Lung contusion is reported in 3(10.3%) of patients alone and another 3(10.3%) of patients along with hemopneumothorax. 8(27.6%) of cases reported facial injuries. Extremity injury was reported in 8 of 29, 27.6% of reported cases and 6(20.7%) had a seatbelt ssign.(Table 6)

Regarding diagnostic imaging and treatment modalities, Angiography (conventional/digital subtracted) was utilized in 18(62.1%) of patients. Contrast CT scan and CT angiography was performed in 8(27.6%) and 3(10.3%) patients respectively. Pseudoaneurysm was reported either using imaging modalities or intraoperative findings in 58.6% of the reported cases while 24.1% of cases had Dissection with or without intravascular thrombosis and rupture in 13.8%. No type of vascular injury was reported in 1 patient. 24(82.8%) of patients underwent open surgical repair with 3 patiets treated with endovascular technique and 1 patient with hybrid method. 21 of 24(87.5%) patients treated with open repair had undergone graft repair and one patient was treated with direct suture repair. The rest 2, had no reported method of open repair used. From patients in graft repair group, 10(47.6%) had Ascending aorta to Innominate artery bypass graft while 3(14.3%) patients had Aorto-right common carotid and right subclavian bifurcated bypassgraft. Interposition graft was done in 4(19%) patients, and Ascending aorta to common carotid artery bypass, Innominate to axillary artery bypass graft and Ascending aorta to subclavian artery bypass procedures were don in one patient each.

Regarding Outcome and complications of patients with Innominate Artery injury, 69% of the patients had complete resolution and were symptom free on follow up and 10.3% of the patients had cerebrovascular accident pertaining to the arterial injuries and One patient required a repeat intervention.

**Discussion**

**Subclavian artery injury**

Subclavian artery injury was more common in males, 73.8% in this review which corresponds with report of Sturm and colleagues in 1984 with 80% (12 out of 15 patients) male patients. [108] The mean age for this review, 44.33 years is relatively older compared to older report of 26.2 in Sturm *et al,* but relatively younger than a case series published in 2001 from cases treated before 1998, which reported a mean age of 57 years. [107,108]

Motor vehicle related injuries were reported in almost half(49.9%) of cases as a cause, which in comparison is lower compared to 12 out of 15 cases evaluated in Sturm *et al,* 4 out of 7 cases reported in Katras *et al* and 11out of 15 reported cases by Costa and Robbs*.* [107,108] This may be explained by increased rate of clavicular fracture in older people in the last 2 decades due to which is often due to trivial trauma rather than significant injury as in younger counterparts which has decreased the proportion of motor vehicle related Subclavian artery injuries. [109] This assumption is also evidenced by the fact that 15 of the 24 clavicular fractures in this review occurred in patients older than 44 years of age. Motor vehicle related injuries were found to be more common among male than female in this review corresponding to a significantly higher motor vehicle related fatalities among males than females. [110]

With respect to clinical presenting signs and symptoms, most features were blood pressure/pulse deficit and hemodynamic instability. This is certainly not an outlier when discussing blunt Subclavian artery injuries, Katras *et al* reported 7 out of 15 patients with hypotension (unstable hemodynamic status) and diminished/absent pulse among 7 of the 15 patients evaluated. [107] More patients with Subclavian artery injury after falling down accident had a less dramatic, but more progressive presentation of progressive supraclavicular swelling pointing towards a more vigilant follow up in these cases.

Clavicular fracture was the most common associated fracture in patients with Subclavian artery injuries with more than half of patients presenting with this fracture. Similarly, Katras *et al* reported Clavicular fracture in 4 of 7 patients in the series and of the 15 patients reported by Sturm and colleagues, 7 had fracture of the clavicle alone or Clavicular fracture with rib fracture simultaneously. [107,108] In addition 8.7% of the patients had traumatic brachial plexopathy, which was reported in 1 of the 7 patients in Katras *et al.* [108] But report from 15 patients by Costa and Robbs showed a higher result with 8 of the 15 patients having total brachial plexopahy/palsy. [109] This difference in brachial plexopathy can partially be explained by the mechanism of injury, as most of the mechanisms reported by Costa and Robbs are high energy injuries while this review have patients with more trivial injuries.

Concerning imaging modalities, conventional/digital subtracted angiography was the most utilized technique followed by CT angiography and standard contrast CT scan. There seems to be a comparative decrement in the use of conventional angiography to diagnose patients with Subclavian injury as the sensitivity of the modality improves. This is evidenced by Sturm *et al* where 14 of 15 patients underwent conventional diagnostic angiography before operative management was done. In addition, Costa and Robbs reported that all 11 patients for whom operative management was provided conventional angiography were performed. [108,109] Investigative modalities found that commonest vascular lesion was pseudoaneurysm. This was lower in Katras *et al,* where only 2 of 7 patients had Pseudoaneurysm of the Subclavian artery. [108]

Endovascular and hybrid methods of treatment in combination have contributed to 48% of the management for Subclavian artery injury, which certainly have shown a significant shift from the previous reports in the end of the past century where all of the three reports, Strum *et al,* Katras *et al,* and Costa and Robbs, reported only open repair in all the patients in each study. [107-109] Open repair group underwent more graft repair than primary/direct suture, which was similar to Costa and Robbs’ report [109]

Regarding the outcome of the patients, 6 of 46 patients in this review reported to have upper limb complication either by vascular or non vascular causes. This outcome was significantly lower compared to 7 out of 15 patients with limb complications in Costa and Robbs. [109] This may be explained by more significant mechanism of trauma by the later, better operative techniques and the advent of endovascular and hybrid techniques.

**Thoracic Aorta injury**

26(76.5%) of the patients were male and motor vehicle related injuries were reported among 82.3% of the patients. This corresponds to a larger study from Germany where 77.5% of the patients with blunt thoracic aorta injury were male and high speed motor vehicle accidents causing 78% of the injuries to thoracic aorta in blunt mechanism. [111]

Common clinical manifestations in this review were chest pain and hemodynamic instability (hypotension) which in combination represented 44% of the patients presenting with blunt aortic artery injury. Hemodynamic instability in German study was higher compared to this review, 35.6-70.1% depending on the vascular lesion in the former and 20.6% in the later. [111] This might be due to consistently faster response time in prehospital setting, but could also be explained by inconsistent case report/case series reporting. Polytrauma was reported in this review in 50% of patients and cervical and thoracic vertebral injuries were reported among 14%. This is a significant proportion of patients even though no prior data is there for the purpose of comparison.

Rib fracture is the most common chest wall trauma associated with Blunt thoracic aorta injury presenting in close to 38% of the patients. In addition, 38.2% of patients in this review had Traumatic brain injury. Autopsy report by Burkhart *et al* showed higher rates of rib fracture and Traumatic brain injury 69% and 68%, compared to this review. [112] This might be because of patients in the later group are all patients in autopsy, so there is an one may expect a more severe injury compared to the patients in this group. In addition 47% of the patients had one or more pulmonary injuries and 38.2% of patients had abdominal injuries, both being lower than Burkhart *et al* with possible explanation of more severe injury in patients who have already passed on than patients who arrived alive to a treating hospital [112]

Innominate artery injury was most commonly associated with Aortic injury, and although prior study linking Aortic and Innominate artery injury is not available, it could be regarded as logical as similar trauma mechanisms and anatomic proximity makes both vessels vulnerable simultaneously.

Regarding investigative modalities, CT scan was the diagnostic modality of choice in 47.1%. This was in line with the recommendation from Mirvis *et al,*  which showed that sensitivity and specificity of greater than 90% concluding that CT scan is a reasonable alternative for traumatic aortic injury diagnosis and this certainly has been the case in almost half of the patients involved in the review. [113] In fact additional 20.6% of patients underwent CT angiography decreasing the need for conventional/Digital subtracted angiography to less than 30%. Most patients, 52.9% had injury either at isthmus or descending aorta. This is slightly lower than other studies. For instance, Williams *et al* reported 65% in isthmus and descending aorta. [114] Regarding the type of vascular lesion, Pseudoaneurysm was the most common in this review occurring in 52.9% of the patients reviewed. Most blunt thoracic aortic injuries are in the Pseudoaneurysm lesion in other literatures. One instance is Starnes *et al,* where Pseudoaneurysm was reported among 71% of the study subjects. [115]

Concerning the treatment modalities, Endovascular repair was the largest in proportion among reviewed cases among 44.1%. With addition of hybrid method, 61.7% of patients have undergone one or more minimally invasive corrective procedure. This data is found to be correlation with Gombert *et al,* 62.8% of patients operated, undergoing an endovascular procedure. But compared to what Gombert and colleagues have reported, this review could not find patients whom underwent sole medical therapy with no surgical intervention. [111] Graft repair was the most common method of open repair.

Outcome and complications review showed 6% mortality rate which was significantly lower than large reports like Gombert *et al,* in which 40.8% total mortality was reported. [111] This level of staggering difference may be attributed to the fact that case reports and case series may focus on alive patients and success stories than mortalities.

**Innominate artery injury**

29 cases have been analyzed in this review with mean age of 36 years old which is quite similar to patients’ mean age of Aortic injury in this review. The high male predominance, 89.7% have been replicated in the older review done by Hirose and Gill which showed a predominance of 86.3%. 79.3% of patients had motor vehicle related injuries which is not further away from 88.9% reported by Hirose and Gill. Chest pain and blood pressure/pulse discrepancy were the two commonest manifestations with 24% and 20.7% rate respectively. Hirose and Gill reported 20 of 132 patients, 15.15% with reported blood pressure/pulse deficit. Chest pain hasn’t been evaluated in the later review. [90]

On the subject of associated injuries, this review found rib fracture in 45% of reported cases, polytrauma in 27.6% and 41.4% had at least one pulmonary injury. Hirose and Gill reported significantly lower rate of rib fractures, 16 of 132 cases (12.1%). Similarly only 28 of 132 patients were reported as having a pulmonary complication which is also significantly lower than the value in this review. The reason for these discrepancies could not be attained But head injury, at 13.8% in this review was comparable to the report from Hirose and Gill, where 15 of 132 patients (11.4%) reviewed had a traumatic brain injury [90] seat belt sign status was reported in 8 patients of which 6 had a seatbelt sign, which can partially explain the sudden deceleration injury which might have caused the Innominate artery injuries.

Even though 62% of patients in this review underwent diagnostic angiography, this invasive modality seems to be decreasing, as Hirose and Gill reported all cases reviewed with reported imaging modality underwent diagnostic conventional angiography, which made the authors conclude angiography as the gold standard modality. This shows a slow and yet a steady improvement in utilization of noninvasive diagnostic modalities, CT with contrast and CT angiography and one can deduce from experiences attained from Blunt thoracic aortic injury investigations, the change in the tide in the direction of non invasive modalities could not be far. Hirose and Gill couldn’t detect types of vascular injuries in the older literatures, but this review found pseudoaneurysm in more than 58% of the cases. This correlates well with similar review’s findings on Thoracic aorta and Subclavian artery injury lesions. [90]

Coming to the management of Innominate artery injury, when one compares it with Aortic and Subclavian artery repairs in this review; open repair has a significant lead with 82% in reviewed cases. Hirose and Gill didn’t report any endovascular procedure in the case reports reviewed prior to 2003. Although the progress might be slower with Innominate artery injury, there is still a growing confidence relative to the older series, in utilizing endovascular procedures in patients with Innominate artery injury. [90] Complications with cerebrovascular accidents have occurred in 10% of the patients, even if there are no studies to compare this finding to, one can conclude this rate is high. In this review, all complications occurred in open surgical repair group. But considering the vast majority of patients undergoing open repair, assumption that more complicated cases have more chance of being managed by the procedure with more experiences, it is impossible to incriminate the type of procedure for the rate of complication.

**Conclusion**

Subclavian artery injury due to blunt trauma is still not common among literatures. From experiences acquired from this review, considering Clavicular fracture as a trigger to look for arterial injuries especially in older patients with comparatively trivial mechanism of trauma. One can also conclude that blood pressure/pulse deficit was the best clinical manifestation followed by hemodynamic instability, which both can be evaluated in the emergency department for early diagnosis. Also investigations using any of the three methods, CT with contrast, CT angiography and conventional angiography, can be done and no preference of one over the other could be put forward. Open repair is still the most predominant modality but considering the fast growth of endovascular and hybrid techniques, it is wise to conclude, individualized management based on the centers’ and the patient’s circumstances have to be considered when making management decision. Considering the high rate of upper limb complications not attributed to the vascular lesions, it would be imperative to evaluate all patients with Subclavian artery injury, especially when occurring in association with Clavicular fracture, with upper limb neurologic examination.

Blunt thoracic aortic injuries are still common among high speed deceleration injuries, and as most literatures do, this review also concludes that, significant mechanism of trauma, motor vehicle related injuries and fall from a height should always induce higher vigilance in investigating for aortic injuries. One special consideration is to not overlook any type of chest pain in patients with significant mechanism of trauma as many patients’ primary presenting feature was chest pain. In addition most patients had polytrauma and significant number had traumatic brain injury which also should direct the investigations and management in both directions, towards diagnosing and treating aortic injury and other site injuries. Rib fracture also should trigger a suspicion for a blunt thoracic aortic trauma. Non invasive modality of investigation, CT with contrast should be the first investigation in patients suspected with aortic injury and in most cases in would suffice. One can conclude from this review that, endovascular procedure could be considered regardless of the type of vascular lesion.

Innominate artery injury is a predominantly motor vehicle related injury. Chest pain and blood pressure/pulse deficit are the most common clinical features. This shows triggers to investigate in search of Subclavian and Aortic injuries can also used to investigate for Innominate artery injuries. But suspected Innominate artery injuries may need conventional/digital subtracted angiography and the threshold for it should be lower compared to Aortic and Subclavian artery injuries. Still open surgical management is the procedure of choice and until further experience is attained there can be no recommendation in changing this time tested technique any time soon.

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Table 1: Blunt subclavian artery injury case report and case series

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study(year)** | **age** | **sex** | **Mechanism**  | **Main vascular presentation** | **Associated presentation** | **Cranial injury** | **Vertebral injury** | **Other Vascular injury** | **Chest wall injury** | **Lung injury** | **Facial injury** | **Limb injury** | **Abdominal injury** | **Seatbelt sign** | **Diagnostic modality** | **Type of injury** | **treatment** | **Type of open repair** | **Type of graft** | **Type of repair** | **Complications**  |
| **Fatime *et al(2010)*** | 20 | M | Pedestrian MVA | Upper limb pain | polytrauma |  |  |  |  |  | Yes  | Yes  |  |  | angiography | Dissection  | Open repair | Direct repair |  | E to E | None  |
| **Stefan’Czyk *et al(2010)*** | 10 | F |  | Bleeding |  |  |  |  |  | HPN |  |  |  |  | CTA and Doppler | PA | Endovascular  |  |  |  | None  |
| **Günday *et al* (2013)** | 31 | M | Other  | Chest pain | Shock |  |  |  | Rib fracture | PNT |  |  |  |  | Doppler and angio | Dissection  | Endovascular  |  |  |  | None  |
| **Sandiford *et al* (2001)** | 85 | F | Fall | Bp/pulse deficit | None |  |  |  |  |  |  | Yes |  |  | CTA and Doppler | PA  | Endovascular  |  |  |  | None  |
| **Fuduric *et al(2014)*** | 20 | M | MCI | Bp/pulse deficit | Polytrauma |  |  |  |  |  |  | Yes |  |  | CTA | Dissection  | Open repair | Graft repair | PPG |  | ULC |
| **Assenza *et al (2012)*** | 70 | M | Fall  | ASCS |  |  |  |  | Clavicle fracture |  |  |  |  |  | CT | Laceration  | Endovascular  |  |  |  | None  |
| **Queiroz *et al (2018)*** | 27 | M | Bicycle injury  | Shock |  |  |  |  |  | HTX |  |  |  |  | CT | PA | Open repair | NS |  |  | Dead |
| **Serrano *et al (2003)*** | 60 | F | Fall | PSCS |  |  |  |  | Clavicle fracture |  |  |  |  |  | Angiography  | PA  | Open repair | Graft repair | CAB |  | None  |
| **Derom *et al(2008)*** | 93 | F | Fall | PSCS |  |  |  |  | Clavicle fracture |  |  |  |  |  | CT | PA  | Endovascular  |  |  |  | ULC |
| **Nikolaos *et al(2009)*** | 70 | M |  | ?DAE |  |  |  |  | Clavicle fracture | HTX |  |  |  |  | CT | Rupture  | Endovascular  |  |  |  | None  |
| **Weber  *et al (2017)*** | 57 | M | MCI | Shock  | Polytrauma  | Yes | Yes |  |  | HPN |  |  | Yes |  | CT | Laceration  | Endovascular  |  |  |  | CVA |
| **Campfield *et al (2016)*** | 64 | F | Fall  | Shock | Brachial plexopathy |  |  |  | Clavicle fracture |  |  |  |  |  | CT | Laceration  | Open repair  | direct repair  |  | SSR | ULC\* |
| **Yonezawa *et al(2016)*** | 55 | M | MCI | Chest pain |  |  |  |  | Rib fracture | CHPN |  |  |  |  | Angiography  | Laceration  | Endovascular  |  |  |  | Dead  |
| **Cheema *et al(2008)*** | 43 | M | MVC | Shock  | Polytrauma | Yes |  |  | C&R fracture  | HPN |  |  |  |  |  | Rupture | Open repair | Direct repair |  | Ligation  | None  |
| **Diaz-Gutierrez  *et al(2016)*** | 20 | M | MVC | Shock  | Polytrauma  |  |  |  | Rib fracture  | CHPN  |  |  | Yes | No  | CT | PA  | Hybrid  |  |  |  | None  |
| **Elkbuli  *et al(2019)*** | 30 | M | MCI | Shock |  |  |  | SCV injury  |  | HPN |  |  |  |  | Angiography  | Rupture  | Open repair | Graft repair  | CAB |  | None  |
| **Enamorado-Enamorado  *et al(2011)*** | 24 | F | MVC | Shock | Polytrauma  |  |  |  |  |  |  | Yes |  |  | CTA | PA | Endovascular  |  |  |  | None  |
| **Nakada  *et al (2014)*** | 41 | M | MVC | Bp/pulse deficit |  |  |  |  | Clavicle fracture | PNT |  |  |  | No | Angiography  | Dissection  | Endovascular  |  |  |  | None  |
| **Gullo *et al(2012)*** | 53 | M | Fall | PSCS | Brachial prexopathy |  |  |  | Clavicle fracture  |  |  |  |  |  | Doppler | PA  | Hybrid |  |  |  | None  |
| **Hirose *et al(2005)*** | 30 | F | MVC | Bp/pulse deficit |  |  |  |  | C&R fracture | HTX |  |  |  | Yes | Angiography | PA  | Endovascular |  |  |  | None  |
| **Ipaktchi  *et al(2014)*** | 14 | M | Other | Bp/pulse deficit | None |  |  |  |  |  |  |  |  |  | CTA | Rupture | No treatment |  |  |  | - |
| **Continued**  |
| **Jaiswal  *et al(2018)*** | 74 | M | Fall  | PSCS | Brachial plexopathy |  |  |  |  | CHPN |  |  |  |  | CTA | PA  | Open repair | Direct repair  |  | SSR | None  |
| **Ostovan *et al(2017)*** | 21 | M | MVC | Bp/pulse deficit | ASCS |  |  |  |  |  |  | Yes  |  |  | Angiography | Dissection | Endovascular |  |  |  | None  |
| **Kapetanakis *et al(2006)*** | 51 | M | MVC | Chest pain | Polytrauma  |  |  |  | R&S fracture  | HPN |  | Yes | Yes | Yes | CT | Rupture | Open repair | Graft repair  | PPG |  | None  |
| **Karkos *et al(206)*** | 21 | M  | Pedestrian MVA |  | Poltyrauma |  |  |  |  |  |  | Yes  |  |  |  | Laceration  | Open repair  | Graft repair  | SBG |  | RI |
| **Noh  *et al(2018)*** | 33 | M | Other  | Shock  |  |  |  | SCV injury |  | HPN |  | Yes  |  |  | CT | Rupture | Open repair | Graft repair | PPG |  | None  |
| **Kluemper *et al(2017)*** | 18 | M | MVC | Bp/pulse deficit | Brachial plexopathy |  |  |  | C&R fracture | HPN |  |  |  |  | Doppler | Compression | Hybrid |  |  |  | ULC\* |
| **Knobloch *et al (2006)*** | 52 | M | MCI | Bp/pulse deficit |  |  |  |  | Clavicle dislocation |  |  | Yes |  |  | CTA | Dissection  | Open repair  | Graft repair  | CSB |  | None  |
| **Sabbagh  *et al(2016)*** | 45 | M | MVC | Bp/pulse discripancy | Polytrauma Brachial plexopathy  | Yes | Yes |  | Sternal fracture | PNT |  | Yes | Yes |  | CT | Rupture | Hybrid |  |  |  | ULC\* |
| **Mirza *et al(2018)*** | 83 | F |  | PSCS |  |  |  |  | Clavicle fracture  |  |  |  |  |  | CTA | PA  | Endovascular |  |  |  | None  |
| **Faisham *et al(2010)*** | 19 | M | MCI | Bp/pulse discripancy | Polytrauma |  |  |  | Clavicle fracture  | HPN | Yes | Yes |  |  | Angiography  | Spasm | Open repair | Graft repair  | SBG |  | None  |
| **Quinones-Baldrich(2009)** | 33 | M | Sport injury | PSCS | None |  |  |  |  |  |  |  |  |  | CTA | PA | Endovascular  |  |  |  | None  |
| **Gill *et al(2013)*** | 13 | M | Sport injury | ASCS | Brachial plexopathy  |  |  |  | Clavicle fracture |  |  |  |  |  | CTA | Compression  | Open repair  | Direct repair |  | CD | ULC\* |
| **Rodriguez-Merchan *et al*** | 46 | M |  | PSCS |  |  |  |  | Clavicle fracture |  |  |  |  |  | Angiography | PA  | Endovascular  |  |  |  | None  |
| **Scheffler *et al(2003)*** | 58 | F | Sports injury | Bp/pulse deficit | None |  |  |  |  |  |  |  |  |  | Doppler & angiography  | Dissection  | Medical/rTPA  |  |  |  | None  |
| **Sodhi *et al (2007)*** | 20 | M | MVC | Shock |  | Yes |  |  | C&R fracture | HTX |  |  |  |  | Angiography | Compression | Open repair | Graft repair | CSB |  | None  |
| **Zaharudin *et al(2016)*** | 53 | M | MVC |  |  |  |  |  | Sternum fracture | PC |  |  |  |  | Doppler | PA | Hybrid |  |  |  | None  |
| **Tachtsi *et al(2011)*** | 67 | F | MVC | UL pain  |  |  |  |  | Clavicle fracture |  |  |  |  |  | Angiography | PA  | Open repair | Direct repair |  | Ligation | None  |
| **Tennysona *et al(2018)*** | 48 | M | MVC | Shock |  |  |  |  | Rib fractures | CHPN | Yes |  |  | No | CXR | Laceration  | Open repair | Direct repair |  | PR | None  |
| **Mandal *et al(2004)*** | 55 | M | Sport injury | Bp/pulse deficit |  |  |  |  | Clavicle fracture |  |  |  |  |  | MRA | PA | Open repair | Graft repair | SBG |  | RI\*\* |
| **Schaik *et al(2015)*** | 52 | M | Bicycle accident  | Bp/pulse deficit |  |  |  |  | Clavicle fracture |  |  |  |  |  | CTA | Dissection  | Open repair | NS |  |  | None  |
| **Watanabe *et al(2005)*** | 72 | M | Fall | PSCS | Brachial plexopathy  |  |  |  | Clavicle fracture |  |  |  |  |  | Angiography | PA  | Open repair | Direct repair |  | E to E  | None  |
| **Zhang *et al(2015)*** | 50 | M | Engineering accident | Bp/pulse deficit | RLN palsy |  |  |  |  |  |  |  |  |  | CTA | PA | Endovascular  |  |  |  | None  |
| **Continued**  |
| **Butterworth *et al(2001)*** | 42 | M | Sports injury | Bp/pulse deficit |  |  |  | SCV injury | Clavicle fracture |  |  |  |  |  | Angiography  | Stenosis  | Observation  |  |  |  | None  |
| **Sladojevic *et al(2016)*** | 51 | M | MVC |  |  |  |  |  | Rib fracture |  |  |  |  |  | CTA | PA  | Open repair  | Graft repair  | ICSBG |  |  |
| **Bukhari *et al(2005)*** | 45 | M | MVC | Bp/pulse deficit |  | Yes |  |  | Clavicle fracture | PNT |  |  |  | Yes | CTA | PA  | Enodvascular  |  |  |  | None  |

ASCS: acute supraclavicular swelling, Bp: Blood pressure, C&R: clavicle and rib, CAB: carotid axillary bypass, CD: clavicle disimpaction, CHPN: contusion with hemopneumothorax, CSB: carotid subclavian bypass, CT: computed tomography, CTA: computed tomography angiography, CVA: cerebrovascular accident, CXR: Chest Xray, DAE: decreased air entry, E to E: end to end anastomosis, HPN: hemopneumothorax, HTX: Hemothorax, ISCBG: innominate subclavian carotid bypass graft, MCI: motor cycle injury, MRA: magnetic resonance angiography, MVA: motor vehicle accident, MVC: motor vehicle collision, NS: not specified, PC: pulmonary contusion, PNT: pneumothorax, PPG: prostathic interposition graft, PR: patch repair, PSCS: progressive supraclavicular swelling, R&S: rib and sternum, RI: repeat intervention, SBG: saphenous bypass graft, SCV: subclavian vein, SSR: simple suture repair, UL: upper limb, ULC: upper limb complications

\*not secondary to the vascular injury

\*\*failed endovascular repair and open repair afterwards

Table 3: Blunt thoracic aortic injury case report and case series

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study(year)** | **age** | **sex** | **Mechanism**  | **Main vascular presentation** | **Associated presentation** | **Cranial injury** | **Vertebral injury** | **Other Vascular injury** | **Chest wall injury** | **Lung injury** | **Facial injury** | **Limb injury** | **Abdominal injury** | **Seatbelt sign** | **Diagnostic modality** | **Location**  | **Type of injury** | **treatment** | **Type of open repair** | **Perfusion** | **Complication**  |
| **Matsumoto *et al(2005)*** | 69 | F | MVC | Chest pain |  |  |  |  |  | HTX |  |  |  |  | Angiography  | Arch | PA  | Open repair | Graft repair | PCPB | None |
| **Benedetto *et al(2008)***  | 19 | M | MVC | shock | Polytrauma  |  |  | Innominate Artery |  |  |  |  | Yes |  | CT | D&I aorta | Rupture | Hybrid |  |  | None |
| **Badmanaban *et al(2003)*** | 29 | F | MVC |  | Polytrauma |  |  |  | Rib fracture  | HTX | Yes |  | Yes | Yes | Angiography | D&I aorta | Rupture | Open repair | Graft repair | PCPB | Fetal loss  |
| **Boulate *et al(2018)*** | 41 | M | MVC |  | Polytrauma | Yes |  | Innominate artery  | Sternum fracture  | PNT |  |  |  |  | Angiography | Ascending  | Dissection  | Open repair | Patch repair  | CCPB | None  |
| **Boulate *et al(2018)*** | 23 | F | Animal injury |  |  |  |  |  | Sternum fracture |  |  |  |  |  | Angiography  | Ascending  | PA | Open repair | Graft repair  | CCPB | None |
| **Boulate *et al(2018)*** | 26 | F | Pedestrian MVA | Altered mentation  |  |  |  |  | Sternum fracture | HTX |  |  |  |  | CT | Arch | rupture | Open repair | Patch repair | CCPB | CVA |
| **Chock *et al(2014)*** | 25 | M | MCI |  | Paraplagia |  | Yes |  | Rib fracture  | PNT |  | Yes |  |  | CTA | D&I aorta | PA  | Endovascular  |  |  | Paraplagia  |
| **Coppi *et al(2012)*** | 24 | M | MCI | Altered mentation  | Polytrauma | Yes  |  |  |  |  |  |  |  |  | CT | D&I aorta | PA | Open repair | Graft repair | SCS | None  |
| **Eckhauser *et al(2013)*** | 12 | M | MCI | Shock |  | Yes |  | Innominate artery  | Rib fracture  | HPN | Yes |  |  |  | CTA | Ascending  | Rupture  | Open repair  | Patch repair  | CCPB | None |
| **Fraedrich *et al(2003)*** | 81 | M | MVC |  |  |  |  | LSC&I artery | R&S fracture  | PC |  | Yes |  |  | CT | Arch | Dissection  | Endovascular  |  |  | None  |
| **Ochoa *et al(2011)*** | 39 | M | MVC | Altered mentation  | Polytrauma  | Yes  |  |  | R&S fracture |  |  | Yes |  |  | CT | D&I aorta  | PA  | Endovascular  |  |  | None |
| **Gombert *et al(2016)*** | 15 | M | MVC | Chest pain  | Polytrauma  |  |  |  |  |  |  | Yes | Yes  |  | CT | D&I aorta | PA  | Hybrid  |  |  | None |
| **Ryu *et al(2010)*** | 73 | F | MVC | Chest pain  | Polytrauma  |  |  |  |  |  |  | Yes |  |  | CT | Arch  | PA  | Hybrid |  |  | None  |
| **Ktenidis *et al(2012)***  | 30 | M | MVC | Chest pain  |  |  |  |  |  |  |  | Yes |  |  | Angiography  | D&I aorta  | PA  | Hybrid  |  |  | None  |
| **Kovari *et al(2017)*** | 31 | F | Fall |  |  |  | Yes |  | Rib fracture  | HPN |  | Yes | Yes |  | CT | D&I aorta | PA  | Endovascular  |  |  | None  |
| **Kovari *et al(2017)*** | 32 | M | MVC | Shock  |  | Yes | Yes |  | Rib fracture  | CHPN  |  | Yes  | Yes  |  | CT | Arch  | PA  | Endovascular  |  |  | None  |
| **Mattison *et al(2001)*** | 21 | M | MVC | Shock  | Polytrauma  | Yes  |  |  | Rib fracture  | HPN |  | Yes | Yes |  | Angiography  | D&I aorta | Rupture  | Endovascular  |  |  | Dead |
| **Moore *et al(2001)*** | 23 | M | Workplace injury | Chest pain  |  |  | Yes  |  |  | HPN |  | Yes |  |  | Angiography  | D&I aorta | PA  | Hybrid  |  |  | None  |
| **Murphyv*et al(2009)*** | 26 | M | Animal injury | Chest pain |  |  |  |  | C&R fracture  |  |  |  |  |  | CTA | Arch  | Rupture  | Endovascular  |  |  | None  |
| **Piffaretti *et al(2015)*** | 64 | M | MVC | Jugular tightness  | Polytrauma  |  |  | RASCA injury | Rib fracture  | PNT |  |  | Yes |  | CTA | D&I aorta | PA  | Endovascular  |  |  | None  |
| **Piffaretti *et al(2015)*** | 47 | M | Fall  | Shock  |  | Yes |  |  | Rib fracture  | CHPN |  | Yes |  |  | CTA | Arch  | PA  | Endovascular  |  |  | None  |
| **Continued**  |
| **Patel *et al(2002)*** | 53 | M | MVC |  |  |  |  | Innominate artery |  |  |  |  |  |  | Angiography  | Arch  | PA  | Open repair  | Graft repair  | CCPB | None  |
| **Gandhi *et al(2003)*** | 12 | F  | MVC | Altered mentation  | Polytrauma  | Yes  |  |  |  |  | Yes | Yes | Yes  | No  | Angiography  | D&I aorta  | PA  | Open repair  | Graft repair  | PCPB | None  |
| **Bradley *et al(2006)*** | 40 | F | MVC | Chest pain  |  | yes | Yes  |  |  |  |  | Yes |  |  | CT | Arch  | Rupture  | Open repair  | Graft repair  | CCPB | None  |
| **Serna *et al(2006)*** | 28 | M | MVC | Bp/pulse deficit |  |  |  | LSCA injury | Rib fracture  |  |  |  |  | No | Angiography  | Arch  | Rupture  | Open repair  | Graft repair  | CCPB | None  |
| **Propper *et al(2009)*** | 32 | M | MVC |  | Polytrauma  |  |  |  |  | HPNT | Yes | Yes | Yes |  | CT | D&I aorta | Rupture  | Endovascular  |  |  | None  |
| **Reynolds *et al(2011)*** | 21 | F | MVC | Altered mentation  | Polytrauma  | Yes  |  |  |  |  | Yes  |  |  |  | CT | D&I aorta  | PA  | Endovascular  |  |  | CNS insult\* |
| **Reynolds *et al(2011)*** | 40 | M | MVC | Shock  | Polytrauma  | Yes  |  |  |  |  |  |  | Yes  |  | CTA | D&I aorta  | Rupture  | Endovascular  |  |  | Dead  |
| **Reynolds *et al(2011)*** | 47 | M | MVC |  | Polytrauma  |  |  |  |  |  |  | Yes  | Yes  |  | CTA | Arch  | Rupture  | Endovascular  |  |  | None  |
| **Siddiqi *et al(2015)*** | 21 | M | Pedestrian MVA | Shock  | Polytrauma  | Yes  |  | Innominate artery  |  | CHPN |  | Yes  | Yes  |  | CT | D&I aorta  | PA  | Open repair  | Graft repair  | SCS | CNS insult\* |
| **Thompson *et al(2006)*** | 46 | M | Fall  |  | Polytrauma  |  |  |  |  |  |  |  | Yes  |  | CT | D&I aorta  | PA  | Endovascular  |  |  | -  |
| **Turhan *et al(2004)*** | 31 | M | MVC | Bp/pulse discripancy |  |  |  |  |  |  |  |  |  |  | Echocardiography  | D&I aorta  | Dissection  | Open repair  | Graft repair  | NS | None  |
| **Waldenberger *et al(2003)*** | 81 | M | MVC |  | Polytrauma  |  |  | LSC&I artery | C&R fracture  | PC |  | Yes |  |  | CT | Arch  | Dissection  | Endovascular  |  |  | None  |
| **Yeo(2015)** | 20 | M | MVC | Chest pain  |  | Yes  |  |  |  |  |  |  |  |  |  | Arch  | Dissection  | Hybrid  |  |  | None  |

Bp: Blood pressure, C&R: clavicle and rib, CHPN: contusion with hemopneumothorax, CT: computed tomography, CTA: computed tomography angiography, CVA: cerebrovascular injury, D&I: descending and isthmus, HPN: hemopneumothorax, HTX: Hemothorax, LSC&I: left subclavian and innominate, LSCA: left subclavian artery, MCI: motor cycle injury, MVA: motor vehicle accident, MVC: motor vehicle collision, NS: not specified, PC: pulmonary contusion, PNT: pneumothorax, RASCA: right aberrant subclavian artery, R&S: rib and sternum, RI: repeat intervention, SCS: simple clamp and stitch, SCV: subclavian vein,

\*not secondary to the vascular injury

Table5: Blunt innominate artery injury case reports and case series

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study(year)** | **age** | **sex** | **Mechanism**  | **Main vascular presentation** | **Associated presentation** | **Cranial injury** | **Vertebral injury** | **Other Vascular injury** | **Chest wall injury** | **Lung injury** | **Facial injury** | **Limb injury** | **Abdominal injury** | **Seatbelt sign** | **Diagnostic modality** | **Type of injury** | **treatment** | **Type of open repair** | **Type of graft** | **Type of repair** | **Complication**  |
| **Al-khaldi *et al (2006)*** | 35 | M | MVC | DAE |  |  |  | RASCA injury | SCR fracture  | CHPN |  |  |  | Yes  | CTA | PA  | Open repair  | Graft repair  | PPG |  | None  |
| **Dhaliwal  *et al(2005)*** | 20  | M  | Fall | PSCS |  |  |  | SVC injury  |  |  |  |  |  |  | Angiography  | PA  | Open repair  | Primary repair |  | SLR | None  |
| **Knosalla *et al (2000)*** | 18 | M | MCI | Altered mentation  | Polytrauma  | Yes  |  |  |  | PC | Yes  |  |  |  | Angiography  | Dissection  | NS |  |  |  |  |
| **Hirose *et al(2004)*** | 46 | M | MVC | Bp/pulse discrepancy  |  |  |  |  |  |  |  |  |  |  | Angiography  | PA | Open repair  | Graft repair  | AIA G |  | None  |
| **Hirose *et al(2003)*** | 56 | M | MVC | Bp/pulse discrepancy  |  |  |  |  |  |  |  |  |  | No | Angiography  | Dissection  | Open repair  | Graft repair  | ACSG |  | None  |
| **Stover *et al(2001)*** | 37 | M | MVC | Chest pain  |  |  |  |  | R&S fracture  |  |  | Yes  |  | Yes  | Angiography  |  | Open repair  | Graft repair  | AIA G |  | NS |
| **Stover *et al(2001)*** | 30 | M | MVC | Chest pain  |  |  |  |  |  |  |  |  |  | Yes  | Angiography  | PA  | Open  | NS | NS |  | NS |
| **Axisa *et al (2000)***  | 21 | M | MVC |  | Polytrauma  |  |  |  | Rib fractures  | PNT  | Yes  | Yes  | Yes  |  | Angiography  | PA | Endovascular  |  |  |  | None  |
| **Omrane *et al(2014)*** | 48 | M | MVC | Bp/pulse deficit  | Polytrauma  | Yes  |  |  |  |  |  |  |  |  | CT | Dissection  | Open repair  | Graft repair  | NS |  | None  |
| **Bito *et al(2014)*** | 40 | F | Fall | Shock  |  | Yes  |  |  | Rib fractures  |  |  | Yes  |  |  | CT | Rupture  | Open repair  | Graft repair  | ASR |  | CVA |
| **Boutayeb *et al(2014)*** | 54 | M | MVC |  | Polytrauma  |  |  |  | Rib fracture  |  | Yes  |  |  |  | CT | PA | Open repair  | Graft repair  | AIA G |  | None  |
| **Watanabe *et al(2001)*** | 36 | M | Sport injury  | Bp/pulse deficit  | Altered mentation  |  |  |  |  |  |  |  |  |  | Angiography  | Rupture  | Open repair  | Graft repair  | PPG |  | CVA |
| **Davidović *et al(2010)*** | 55 | F | MVC | Shock  |  |  |  |  | R&S fractures |  |  |  |  |  | Angiography  | PA | Open repair  | Graft repair  | ACSG |  | None  |
| **Dias-Neto *et al(2018)*** | 41 | M | Fall  | Chest pain  |  | Yes  | Yes  |  | C&R fractures | HTX | Yes  | Yes  |  |  | Angiography  | Dissection  | Open repair  | Graft repair  | AIA G |  | None  |
| **Miles *et al(2003)*** | 29 | M | MVC |  |  | Yes  |  |  | Rib fractures  |  |  |  |  | Yes  | Angiography  | Rupture  | Endovascular  |  |  |  | NS |
| **Howe *et al(2017)*** | 50 | M | Fall | UL pain  |  |  |  | RSC&RCCA injury  | Rib fractures  | PNT |  |  |  |  | CTA | Dissection  | Open repair  | Graft repair  | IABG |  | None  |
| **Huang *et al(2008)*** | 36 | M | MVC | Chest pain  |  |  |  |  |  | HPNT | Yes  | Yes  |  |  | CT | PA | Endovascular  |  |  |  | None  |
| **Lee *et al(2015)*** | 55 | M | Fall | Chest pain  |  |  |  |  |  |  |  |  |  |  | CT | PA | Hybrid  |  |  |  | None  |
| **Mousa *et al (2010)*** | 51 | M | MVC | Chest pain  |  |  |  |  |  |  |  |  |  |  | CTA | PA | Open repair  | Graft repair  | AIA G |  | None  |
| **Ormazabal *et al(2012)*** | 21 | M | MVC |  |  |  |  |  | Sterna fracture  |  |  |  |  | Yes  | CT | Dissection  | Open repair  | NS  |  |  | NS |
| **Chu *et al(2006)*** | 19 | M | MVC | Altered mentation  | Polytrauma  |  |  | Aortic injury  | Clavicle fracture  | PC |  | Yes  | Yes  | Yes  | CT | Rupture  | Open repair  | Graft repair  | AIAG |  | None  |
| **Roberts *et al(2000)*** | 24 | F | MVC |  |  |  |  |  |  |  |  |  |  | No | Angiography  | Dissection  | Open repair  | Graft repair  | PPG |  | None |
| **Sladojevic *et al(2015)*** | 25 | M | MVC | Bp/pulse deficit  |  |  |  |  |  |  | Yes  | Yes  |  |  | Angiography  | PA | Open repair  | Graft repair  | ACSG |  | None  |
| **Sladojevic *et al(2015*** | 56 | M | MVC |  |  |  |  |  | R&S fractures  |  |  |  |  |  | Angiography  | PA | Open repair  | Graft repair  | ACCG |  | None |
| **Continued**  |
| **Symbas *et al (2005)*** | 32 | M | MCI | Shock | Polytrauma  |  | Yes  |  | Rib fracture  | CHPNT | Yes  |  | Yes  |  | CT | PA | Open repair | Graft repair  | AIAG |  | None  |
| **Symbas *et al (2005)*** | 32 | M | MCI | Chest pain | Polytrauma |  |  |  | Rib fracture | PC |  | Yes  |  |  | Angiography  | PA | Open repair | Graft repair | AIAG |  | None  |
| **Symbas *et al (2005)*** | 40 | M | MVA | Bp/pulse deficit |  |  |  |  | Rib fracture | CHPNT |  |  |  |  | Angiography  | PA | Open repair | Graft repair | AIAG |  | None  |
| **Boulate *et al(2018)*** | 18 | M | MCI |  | Polytrauma  |  |  |  | Rib fractures  | HPNT | Yes  |  |  |  | Angiography  | PA | Open repair  | Graft repair  | PPG |  | CVA |
| **Boulate *et al(2018)*** | 30 | M | MVA |  |  |  |  |  | R&S fractures | PNT |  |  |  |  | Angiography  | PA | Open repair  | Graft repair  | AIAG |  | RI |

ACSG: Aorto-right common carotid and right subclavian bifurcated graft, ACCG: ascending to common carotid bypass graft, AIAG: ascending to innominate artery graft repair, ASR: ascending to subclavian graft, Bp: Blood pressure, C&R: clavicle and rib, CHPN: contusion with hemopneumothorax, CT: computed tomography, CTA: computed tomography angiography, CVA: cerebrovascular accident, DAE: decreased air entry, E to E: end to end anastomosis, HPN: hemopneumothorax, HTX: Hemothorax, ISCBG: innominate subclavian carotid bypass graft, IABG: innominate axillary bypass graft, MCI: motor cycle injury, MVA: motor vehicle accident, MVC: motor vehicle collision, NS: not specified, PC: pulmonary contusion, PNT: pneumothorax, PPG: prostathic interposition graft, PR: patch repair, PSCS: progressive supraclavicular swelling, R&S: rib and sternum, RI: repeat intervention, RCCA: right common carotid artery, RSC&RCCA: right subclavian and right common carotid arteries, SCR: sternum, clavicular and rib fracture, SCV: subclavian vein, SLR: simple laceration repair, SSR: simple suture repair.

Table 2: Demographics, mechanism of injury and clinical manifestations of patients with Subclivian artery injury

|  |  |  |  |
| --- | --- | --- | --- |
| Category | Subcategory  | Number  | Percentage(%)  |
| Age category | 1-17 years | 3 | 6.5 |
|  | 18-44 years | 18 | 45.7 |
|  | 45 years and above | 25 | 54.3 |
| Sex | Male  | 36 | 78.3 |
|  | Female  | 10 | 21.7 |
| Mechanism of injury | Pedestrian motor vehicle accident | 2 | 4.3 |
|  | Motor vehicle collision | 15 | 32.6 |
|  | Motor cycle injury | 6 | 13.0 |
|  | Falling down accident  | 8 | 17.4 |
|  | Sports injury | 5 | 10.9 |
|  | Bicycle | 3 | 6.5 |
|  | Workplace injury | 2 | 4.3 |
|  | Other and non specified | 5 | 10.9 |
| Clinical presentation | Blood pressure or pulse deficit  | 16 | 34.8 |
|  | Hemodynamic instability | 10 | 21.7 |
|  | Progressive supraclavicular swelling | 8 | 17.4 |
|  | Decreased Air entry | 1 | 2.2 |
|  | Upper limb pain | 2 | 4.3 |
|  | Acute supraclavicular swelling  | 2 | 4.3 |
|  | Chest pain/dyspnea | 3 | 6.5 |
|  | External bleeding | 1 | 2.2 |
|  | Non-specified | 3 | 6.5 |
| Associated injuries |  |  |  |
| Chest wall injuries | Chest wall injury |  |  |
|  | Clavicle fracture alone | 19 | 41.3 |
|  | Rib fracture alone  | 5 | 10.9 |
|  | Sternum fracture alone  | 2 | 4.3 |
|  | Rib and clavicle fracture | 5 | 10.9 |
|  | Rib and sternum fracture  | 1 | 2.2 |
|  | None/not reported | 14 | 30.4 |
| Lung/intrathoracic injury | Lung parenchymal/intrathoracic injury |  |  |
|  | Pneumothorax alone  | 4 | 8.7 |
|  | Hemothorax alone  | 4 | 8.7 |
|  | Hemopneumothorax | 7 | 15.2 |
|  | Lung contusion alone  | 1 | 2.2 |
|  | Lung contusion with hemopneumothorax | 3 | 6.5 |
|  | None/Not reported | 27 | 58.7 |
| Other area injuries | Face injury | 3 | 6.5 |
|  | Subclavian vein injury | 1 | 2.2 |
|  | Extremity injury | 11 | 23.9 |
|  | Abdominal injury | 4 | 8.7 |
|  | Traumatic brain injury  | 5 | 10.9 |

Table 4: Demographics, mechanism of injury and clinical manifestations of patients with Aortic injury

|  |  |  |  |
| --- | --- | --- | --- |
| Category | Subcategory  | Number  | Percentage(%)  |
| Age category | 1-17 years | 3 | 8.8 |
|  | 18-44 years | 22 | 64.7 |
|  | 45 years and above | 9 | 26.5 |
| Sex | Male  | 26 | 76.5 |
|  | Female  | 8 | 23.5 |
| Mechanism of injury | Pedestrian motor vehicle accident | 2 | 5.9 |
|  | Motor vehicle collision | 23 | 67.6 |
|  | Motor cycle injury | 3 | 8.8 |
|  | Fall from height  | 3 | 8.8 |
|  | Animal related injury | 2 | 5.9 |
|  | Workplace injury | 1 | 2.9 |
| Clinical presentation  | Chest pain | 8 | 23.5 |
|  | Hemodynamic instability | 7 | 20.6 |
|  | Altered mentation | 5 | 14.7 |
|  | Blood pressure or pulse deficit | 2 | 5.9 |
|  | Other | 3 | 8.8 |
|  | Non-specified | 9 | 26.5 |
| Related complaint  | Polytrauma  | 17 | 50 |
| Chest wall injury | Rib fracture alone | 9 | 26.9 |
|  | Sternum fracture alone  | 3 | 8.8 |
|  | Sternum and rib fracture  | 3 | 8.8 |
|  | Rib and clavicle fracture | 1 | 2.9 |
|  | None/not reported | 18 | 52.9 |
| Lung parenchymal/ intrathoracic injury | Pneumothorax alone  | 3 | 8.8 |
|  | Hemothorax alone  | 3 | 8.8 |
|  | Hemopneumothorax | 5 | 14.7 |
|  | Lung contusion alone  | 2 | 5.9 |
|  | Lung contusion with hemopneumothorax | 3 | 8.8 |
|  | None/Not reported | 18 | 52.9 |
| Associated vascular injury | Innominate artery | 5 | 14.7 |
|  | Left subclavian with Innominate artery | 2 | 5.9 |
|  | Left common carotid artery  | 1 | 2.9 |
|  | Right aberrant subclavian artery | 1 | 2.9 |
|  | None/Not reported | 25 | 73.5 |
| Other area injuries  | Face injury | 5 | 14.7 |
|  | Extremity injury | 17 | 50 |
|  | Abdominal injury | 13 | 38.2 |
|  | Traumatic brain injury  | 13 | 38.2 |
|  | Vertebral injury | 5 | 14.7 |

Table 6: Demographics, mechanism of injury and clinical manifestations of patients with Aortic injury

|  |  |  |  |
| --- | --- | --- | --- |
| Category | Subcategory  | Number  | Percentage(%)  |
| Age category | 18-44 years | 20 | 69.0 |
|  | 45 years and above | 9 | 31.0 |
| Sex | Male  | 26 | 89.7 |
|  | Female  | 3 | 10.3 |
| Mechanism of injury | Motor vehicle collision | 19 | 65.5 |
|  | Motor cycle injury | 4 | 13.8 |
|  | Fall from height  | 5 | 17.2 |
|  |  Sports injury | 1 | 3.4 |
| Clinical manifestations  | Chest pain  | 7 | 24.1 |
|  | Blood pressure or pulse deficit | 6 | 20.7 |
|  | Altered mentation | 2 | 6.9 |
|  | Hemodynamic instability | 3 | 10.3 |
|  | Progressive supra-clavicular swelling | 1 | 3.5 |
|  | Ischemic limb pain  | 1 | 3.5 |
|  | Decreased air entry | 1 | 3.5 |
|  | Other | 1 | 3.5 |
|  | Non-specified | 7 | 24.1 |
| Related complaint | Polytrauma  | 8 | 27.6 |
| Chest wall injury | Rib fracture alone | 9 | 31.0 |
|  | Sternum fracture alone  | 1 | 3.4 |
|  | Clavicle fracture | 1 | 3.4 |
|  | Sternum and rib fracture  | 4 | 13.8 |
|  | Rib and clavicle fracture | 1 | 3.4 |
|  | Rib, clavicle and sternum fracture  | 1 | 3.4 |
|  | None/not reported | 12 | 41.4 |
| Lung parenchymal/intrathoracic injury | Pneumothorax alone  | 3 | 10.3 |
|  | Hemothorax alone  | 1 | 3.5 |
|  | Hemopneumothorax | 2 | 6.9 |
|  | Lung contusion alone  | 3 | 10.3 |
|  | Lung contusion with hemopneumothorax | 3 | 10.3 |
|  | None/Not reported | 17 | 58.6 |
| Associated vascular injury | Aorta  | 1 | 3.5 |
|  | Right subclavian and right common carotid artery | 1 | 3.5 |
|  | Right aberrant subclavian artery | 1 | 3.5 |
|  | Superior vena cava injury | 1 | 3.5 |
|  | None/Not reported | 25 | 86.2 |
| Other area injuries  | Face injury | 8 | 27.6 |
|  | Extremity injury | 8 | 27.6 |
|  | Abdominal injury | 3 | 10.3 |
|  | Traumatic brain injury  | 4 | 13.8 |
|  | Vertebral injury | 3 | 10.3 |
| Seatbelt sign | Yes | 6 | 20.7 |
|  | No | 3 | 6.9 |
|  | Not reported | 21 | 72.4 |