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# 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 among the rare causes for presentation at trauma centers. Most of the literature on these injuries is in the form of case reports and case series, with no significantly consolidated data available.

**Methods:** A systematic review of English language case reports and case series from 2000 to 2019 was carried out using the PubMed and Google Scholar search engines.

**Results:** The mean patient ages were 35.9, 36.4, and 44.3 years for thoracic aorta, innominate, and subclavian artery injuries, respectively. Of the innominate artery injury patients, 89.7% were male. Motor vehicle-related injuries contributed to 50.9% of thoracic aortic injuries. A blood pressure/pulse deficit was recorded in 34.8% and 20.7% of patients with subclavian and innominate artery injuries, respectively, and chest pain and hemodynamic instability were found in 23.5% and 20.5% of aortic injury patients, respectively. Clavicular fracture was the most common associated finding in subclavian artery injury patients at 42%. Computed tomography was performed in 21.7%, 47.1%, and 27.6% of patients with subclavian artery, thoracic aorta, and innominate artery injuries, respectively. An endovascular intervention was performed in 44.1% of patients with subclavian artery injuries.

**Conclusion:** Injury to the subclavian artery is relatively common among the older population. Blood pressure or pulse discrepancies could point to either subclavian or innominate artery injury. An endovascular intervention can be considered in all patients but must be individualized based on patient and facility factors.

**Keywords:** Aortic rupture; Clavicular fracture; Traumatic pseudoaneurysm; Endovascular repair; Cerebrovascular accident

## INTRODUCTION

Trauma is the most common cause of mortality in children and adults under 44 years of age [1]. Blunt trauma is the leading mechanism affecting patients in most civilian trauma centers [2, 3]. Furthermore, motor vehicle accidents are the principal cause of blunt trauma, accounting for 1.3 million deaths, 20s–50 million non-fatal injuries, and 29% of all trauma cases annually [4, 5]. The overall incidence of vascular trauma is 5%, with a larger fraction contributed by penetrating trauma mechanisms [6, 7]. In fact, trauma centers report that only 5% of vascular trauma cases are caused by blunt mechanisms [8]. However, this

may be an underestimation because many blunt trauma patients with major vascular injuries do not survive long enough to reach a healthcare facility. The findings of postmortem examinations of prehospital trauma deaths support this notion, placing blunt major vascular trauma as the second most common cause of death, after head injury [9, 10].

The paucity of blunt vascular injuries in trauma centers is reflected in the literature; most of the relevant publications are case reports and case series [11].

This review is intended to integrate the experiences of centers around the world through the analysis of case reports and case series concerning this issue and hopefully fill the knowledge gaps surrounding the epidemiological changes, investigative modality advancements, and management innovations for blunt vascular trauma.

## METHODS

### Data source and search strategy

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PubMed and Google Scholar were utilized to search for publications between January 2000 and September 2019 posing no language restrictions to the authors. The following key statements were utilized to initiate the search process: “case report/case series, subclavian artery injury,” “case report/case series, thoracic aorta injury,” and “case report/case series, innominate artery injury.”

### Inclusion criteria

All case reports and case series on subclavian, thoracic aorta, and innominate artery injuries arising from blunt mechanisms with no missing publication segments and published in English were included. Only publications from January 2000 to September 2019 were included.

### Exclusion criteria

The exclusion criteria were as follows: any blunt vascular injuries not involving the subclavian artery, thoracic aorta, or innominate artery. All reports of vascular injury with a penetrating mechanism of trauma were excluded. Publications that are primarily produced in a language other than English were excluded.

### Data extraction and handling

From each patient report, the following information was retrieved: year of reported case, age at presentation, 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, specific type of vascular injury for the main thoracic arterial injuries under question, diagnostic modality utilized, treatment provided, type of open surgical treatment provided, and outcome with specific complications pertaining to the vascular injury and mortality. No effort was made to communicate with authors concerning missing data from the publications.

### Data synthesis and analysis

The generated data was entered into SPSS version 23 in the categories mentioned above, and the accuracy of the data was evaluated and ascertained.

After the data entry and cleanup were complete, the data analysis was conducted using the same software: SPSS version 23.

## RESULTS

### Subclavian artery injury

The cases of a total of 46 patients with subclavian artery injuries were reviewed (Table 1). The mean age of the patients was  $44.33 \pm 21.11$  years, and 73.8% were male. Motor vehicle collisions were involved in

32.6% of the cases. Motor vehicle-related injuries were reported in 13 (65%) patients younger than 45 years of age. Patients older than 45 years of age presented due to a falling accident in 36.4% of the reported cases. Of the female patients with subclavian artery injuries, half presented due to a falling accident.

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 subclavian artery injuries were blood pressure/pulse deficit (9 patients, 45%) and hemodynamic instability (7 patients, 35%). Patients presenting with subclavian artery injury after falling accidents reported progressive supraclavicular swelling in 5 (63.5%) cases. Three out of the 5 patients presenting with sports-related injuries presented with a blood pressure/pulse deficit.

Concerning associated injuries, clavicular fracture was reported in 24 (52.2%) cases. Of the patients with subclavian artery injuries and clavicular fractures, 62.5% were 45 years of age or older. Four (8.7%) of the patients had reported traumatic brachial plexopathy, and 10 (21.7%) of the patients presented with polytrauma. Of the reviewed patients, 15 (32.6%) had a pneumothorax, hemothorax, or both at presentation (Table 2).

Regarding the diagnostic modalities utilized, 44 cases reported the use of 1 or more imaging techniques. Conventional/digital subtracted angiography was utilized in 13 (28.3%) of the reported cases, and doppler ultrasonography, contrast CT, and CT angiography were used in 3 (6.5%), 10 (21.7%), and 12 (26.1%) cases, respectively. One patient had a chest x-ray as the sole imaging modality for diagnosis. A combination of CT angiography and conventional angiography with Doppler ultrasonography was conducted in 2 (4.3%) patients.

The types of vascular injuries diagnosed using imaging modalities or with intra-operative findings were 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%), and 3 (6.5%) of the cases, respectively. One patient presented with a spasm of the subclavian artery.

The treatment modalities were specified in all 46 of the reviewed cases, with open surgical repair performed in 21 (45.7%) cases and endovascular and hybrid procedures performed in 17 (37%) and 5 (10.9%) cases, respectively. Three patients underwent conservative/medical therapy. Within the open surgical repair group, 11 (57%) underwent graft repair. Of the graft repair patients, 3 (27.3%), 2 (18.1%), and 2 (18.1%) underwent a prosthetic interposition graft, a prosthetic carotid-subclavian bypass, and a prosthetic carotid-axillary bypass graft, respectively. In addition,

**Table 1.** Blunt Subclavian 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	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				
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					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 discrepancy	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 discrepancy	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	Medial/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		Ligament	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
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	ICS BG		
Bukhari et al(2005)	45	M	MVC	Bp/pulse deficit		Yes			Clavicle fracture	PNT			Yes	CTA	PA	Endovascular				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: prosthetic 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 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	Complications
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
Badman 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	Work place injury	Chest pain		Yes			HPN	Yes		Angiography	D&I aorta	PA	Hybrid			None		
Murphyvet 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		
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 discrepancy										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

**Table 5.** 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	Complications
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										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									Yes	CT	Rupture	Open repair	Graft repair	ASR	CVA
Boutayeb et al(2014)	54	M	MVC		Polytrauma										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												Angiography	PA	Open repair	Graft repair	ACSG	None
Dias-Neto et al(2018)	41	M	Fall	Chest pain		Yes	Yes									Angiography	Dissection	Open repair	Graft repair	AIA G	None
Miles et al(2003)	29	M	MVC			Yes										Angiography	Rupture	Endovascular			NS
Howe et al(2017)	50	M	Fall	UL pain												CTA	Dissection	Open repair	Graft repair	IABG	None
Huang et al(2008)	36	M	MVC	Chest pain												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												Yes	CT	Dissection	Open repair	NS		NS
Chu et al(2006)	19	M	MVC	Altered mentation	Polytrauma										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	Angiography	PA	Open repair	Graft repair	ACSG	None
Sladojevic et al(2015)	56	M	MVC													Angiography	PA	Open repair	Graft repair	ACCG	None
Symbas et al(2005)	32	M	MCI	Shock	Polytrauma	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	CHP NT		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 fracture	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: prosthetic 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.

3 (27.3%) patients underwent a saphenous bypass graft, 8 (42.1% of the open repair cases) patients had direct repairs with end-to-end anastomosis, a simple suture and ligation were performed in 2 (25%) patients, and 1 patient underwent a patch repair.

The outcomes and complications were reported in 45 of the 46 cases, with 73.9% of patients experiencing total resolution and 6 (13%) experiencing upper limb complications, of which 4 were confirmed brachial plexopathy at presentation rather than vascular injury-related complications. Repeat intervention was needed in 2 (4.3%) patients, and 2 (4.3%) patients died. Furthermore, 1 patient was diagnosed with a cerebrovascular accident related to the subclavian artery injury.

### Thoracic Aorta injury

The data for a total of 34 aortic injury patients was retrieved from the literature between 2000 and 2019 (Table 3). The mean age of the patients with aortic injuries was 35.9±18.9 years, and 26 (76.5%) of the patients were male. Of the patients examined, 23 (67.6%) presented after a motor vehicle collision, and 28 (82.4%) had injuries related to motor vehicles (including pedestrian motor vehicle accidents and motorcycle injuries). Hemodynamic instability (hypotension) and chest pain were the chief clinical features in 7 (20.6%) and 8 (23.5%) of the cases, respectively. Polytrauma was reported in 17 (50%) of the patients. Twenty-one (84%) of the patients aged under 45 years had motor vehicle-related injuries, compared to 7 (77.7%) of the patients aged 45 years or older. Female patients presented after motor vehicle accidents in 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 overall and in 3 (8.8%) and 1 (2.9%) cases with sternum and clavicle fractures, respectively. Hemopneumothorax alone was reported in 5 (14.7%) patients, and with lung contusion in 3 (8.8%) patients. Five (14.7%) patients had an abdominal-associated innominate artery injury, and 13 (38.2%) patients had an associated traumatic brain injury (Table 4).

The most common imaging modalities utilized were contrast CT scanning and CT angiography, which were used in 16 (47.1%) and 7 (20.6%) cases, respectively, and conventional/digital subtracted angiography was used in 10 (29.4%) cases. The most common sites of injury were the isthmus and the descending aorta, accounting for 18 (52.9%) of the examined cases. The aortic arch and the ascending aorta were injured in 13 (38.2%) and 3 (8.8%) cases, respectively. A pseudoaneurysm was discovered in 18 (52.9%) of the patients using an imaging modality or intraoperative findings. Rupture was diagnosed in 11 (32.4%) cases and dissection with or without thrombosis in 5 (14.7%) cases.

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

In terms of the outcomes and complications in the aortic injury patients, 76.5% experienced complete resolution, with 2 deaths out of the 34 patients reported.

Three (9%) patients had chronic cerebral sequelae, with 2 of the 3 cases caused by traumatic brain injury.

### Innominate artery injury

The data of a total of 29 patients was retrieved from reports from 2000 to 2019 (Table 5). The mean age of the patients with innominate artery injuries was  $36.4 \pm 12.8$  years, and 26 (89.7%) of the patients were male. Motor vehicle collisions contributed to 19 (65.5%) of the innominate artery injury cases, with motor vehicle associated-injuries accounting for 79.3% of the cases. Regarding the clinical presentations of the innominate artery injury patients, chest pain and blood pressure/pulse deficit were reported in 7 (24.1%) and 6 (20.7%) cases, respectively. Polytrauma was reported in 8 (27.6%) cases.

Rib fracture alone was reported in 9 (31%) patients and with sternum fracture in 4 (13.8%) patients. Lung contusion alone was reported in 3 (10.3%) patients and with hemopneumothorax in another 3 (10.3%). Eight (27.6%) of the cases included facial injuries. Extremity injuries were reported in 8 of the 29 patients (27.6%), and 6 (20.7%) had a seatbelt sign (Table 6).

Regarding diagnostic imaging and treatment modalities, angiography (conventional/digital subtracted) was utilized in 18 (62.1%) cases. A contrast CT scan and CT angiography were performed in 8 (27.6%) and 3 (10.3%) cases, respectively. A pseudoaneurysm was identified using imaging modalities or intraoperative findings in 58.6% of the reported cases, whereas 24.1% of the cases had dissection with or without intravascular thrombosis, and rupture was present in 13.8% of the cases. In 1 case, the type of innominate injury was not further specified. Twenty-four (82.8%) patients underwent open surgical repair: 3 patients were treated with an endovascular technique, and 1 patient was treated with a hybrid method. Twenty-one of the 24 (87.5%) patients treated with open repair underwent a graft repair, and 1 patient was treated with a direct suture repair. Two cases did not specify the method of open repair used. Among the patients in the graft repair group, 10 (47.6%) had an ascending aorta to innominate artery bypass graft, whereas 3 (14.3%) had an aorto-right common carotid and right subclavian bifurcated bypass graft. An interposition graft was performed 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 performed in 1 patient each.

Among the patients with innominate artery injuries, 69% experienced complete resolution and were symptom free at follow-up, 10.3% of the patients had a cerebrovascular accident pertaining to the arterial injuries, and 1 patient required a repeat intervention.

## DISCUSSION

### Subclavian artery injury

Subclavian artery injuries were more common in males, corresponding with the results of a report by Sturm et al. in 1984, which included 80% (12 out of 15 patients) male patients [108]. The mean age of the patients examined in this review was relatively older than that of the report of 26.2 years by 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 of the reviewed cases as a mechanism of trauma, which is low compared to other studies [107–109]. Motor vehicle-related injuries were found to be more common among males than females in this review, corresponding to a significantly higher rate of motor vehicle-related fatalities among males than among females [110]. A point worth mentioning is the high proportion of fall-related subclavian artery injuries in older patients, which has never been previously reported in systematic reviews.

The most common clinical presenting signs and symptoms in the reviewed cases were blood pressure/pulse deficit and hemodynamic instability. This is certainly not an outlier in the context of blunt subclavian artery injuries. Katras et al. reported that 7 out of the 15 patient cases they reviewed included hypotension (unstable hemodynamic status), and 7 out of 15 included diminished or absent pulse [107]. Patients with subclavian artery injuries after a fall had a less dramatic, but more progressive presentation of progressive supraclavicular swelling, pointing toward the necessity for 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. This finding has been replicated by multiple reviews/articles published by other authors. [107–109]. Concerning imaging modalities, conventional/digital subtracted angiography was the most commonly utilized technique, followed by CT angiography and standard contrast CT scanning. In the present review, conventional angiography was used less frequently than in previous reviews. This is consistent with a review by Sturm et al., in which 14 of the 15 patients underwent conventional diagnostic angiography before operative management was performed. In addition, Costa and Robbs reported that conventional angiography was performed in all 11 patients for whom operative management was provided [108, 109]. Investigative modalities have found that most vascular lesions are pseudoaneurysms. However, this was not exhibited in a review by Katras et al., in which only 2 of the 7 patients had pseudoaneurysm of the subclavian artery [108].

Endovascular and hybrid methods of treatment together have contributed to managing 48%

of subclavian artery injuries, which certainly demonstrates a significant shift from the previous reports from the end of the past century. In all 3 of the reports examined from this period—those of Strum et al., Katras et al., and Costa and Robbs—only open repair was reported in all of the patients [107–109]. In the present review, the open repair group underwent more graft repairs than primary/direct sutures, which is similar to Costa and Robbs' report [109].

Regarding patient outcomes, 6 out of the 46 patients in this review experienced upper limb complications due to either vascular or non-vascular causes. This outcome was significantly rarer than in the 7 out of 15 patient cases with limb complications in Costa and Robbs' report [109]. This may be due to recent improvements in operative techniques and the advent of endovascular and hybrid techniques.

### **Thoracic aorta injury**

More than 3/4ths of the patients with blunt thoracic aortic injury in this review were male, with motor vehicle-related injuries being the most common mechanism. This corresponds to a larger study from Germany, in which 77.5% of the patients with blunt thoracic aorta injuries were male, and high-speed motor vehicle accidents caused 78% of the blunt thoracic aortic injuries [111].

The most common clinical manifestations in this review were chest pain and hemodynamic instability (hypotension). Hemodynamic instability was more common in a German study, appearing in 35.6% to 70.1% of cases depending on the vascular lesions in question [111]. Polytrauma was reported in the present review in half of patients, and cervical and thoracic vertebral injuries were reported in significant number of patients at, 14.7%, although no prior data is available for comparison.

Rib fracture is the most common chest wall trauma associated with blunt thoracic aorta injury. There is also a high rate of associated traumatic brain injury among blunt thoracic aorta injuries. An autopsy report by Burkhart et al. showed higher rates of rib fracture and traumatic brain injury (69% and 68%, respectively) than this review (26.9% and 38.2%, respectively) [112]. This may be because autopsy cases have an expected higher severity of injury than the patient cases examined in the present review. In addition, in the present review, nearly half of the patients had 1 or more pulmonary injuries. This high occurrence is still lower than that of the autopsy reports of patients with thoracic aorta injuries [112].

Innominate artery injuries were most commonly associated with aortic injuries, and although prior studies linking aortic and innominate artery injury are not available, this association is logical. Similar trauma mechanisms and anatomic proximity make both vessels vulnerable simultaneously.

CT scanning was the diagnostic modality of choice in

nearly half of the patient cases in the present review [113]. This is consistent with the recommendation from Mirvis et al., who argue that, given its sensitivity and specificity of greater than 90%, the CT scan is a good option for traumatic aortic injury diagnosis. In fact, an additional 1/5th of patients in the present review underwent CT angiography, further decreasing the need for conventional/digital subtracted angiography.

In the present review, most patients (52.9%) had injuries either at the isthmus or the descending aorta. This is slightly lower than in other studies. For instance, Williams et al. reported that 65% of the reviewed injuries occurred at the isthmus or the descending aorta [114]. Pseudoaneurysm was the most common vascular lesion in this review. This is similar to other findings in the literature, including those of Starnes et al., in which pseudoaneurysm was reported among 71% of the blunt aortic injury patients [115].

Endovascular repair was the most common modality of thoracic aorta repair in the present review. In fact, with the introduction of the hybrid method, close to 2/3rds of patients underwent a minimally invasive corrective procedure with either total endovascular or hybrid techniques. This data is similar to the findings of Gombert et al., in which 62.8% of patients underwent an endovascular procedure. However, contrary to what Gombert et al. reported, this review did not find patients who underwent conservative management with no surgical intervention [111]. Graft repair was the most common method of open repair in the present review.

The present review revealed a 6% mortality rate, which is significantly lower than the rates reported by large reviews, such as that by Gombert et al., in which a 40.8% rate of total mortality was reported [111]. This level of staggering difference may be attributed to the fact that the case reports and case series in the present review are those of living patients rather than fatalities.

### **Innominate artery injury**

The mean ages of the thoracic aorta and innominate artery injury patients are quite similar. The high male predominance (89.7%) identified in this review is consistent with the results of an older review by Hirose and Gill, which showed a male predominance of 86.3%. Motor vehicle related-accidents were the mechanism of injury in more than 80% of the patients in this review, which is similar to the 88.9% reported by Hirose and Gill. Chest pain and blood pressure/pulse discrepancies were the 2 dominant manifestations, occurring in almost half of the patients in the present review. Hirose and Gill reported that 20 out of 132 patients (15.15%) experienced blood pressure/pulse deficits even though they didn't report on Chest pain. [90].

**Table 2.** Demographics, mechanism of injury and clinical manifestations of patients with Subclavian artery injuries

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 Subclavian artery injuries

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	25.6
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
Other area injuries	None/Not reported	25	73.5
	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 Innominate artery injuries

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

On the subject of associated injuries, this review found rib fractures in almost half of the reported cases, polytrauma in 1/4th of the reports, and a significant number (41.4%) of instances of at least 1 pulmonary injury. Hirose and Gill reported a significantly lower rate of rib fractures (16 out of 132 cases, 12.1%). Similarly, Hirose and Gill reported only 28 out of 132 patients experiencing pulmonary complications, which is also significantly lower than the rate obtained in this review. The reason for these discrepancies is unknown. The rate of head injury, at 13.8% in this review, is comparable to that in the report from Hirose and Gill, in which 15 out of 132 patients (11.4%) experienced a traumatic brain injury [90]. The seatbelt sign status was reported in 8 patients in the present review, of which 6 had a seatbelt sign, which can indicate a sudden deceleration injury that may have caused the innominate artery injuries.

Although 62% of patients in this review underwent a diagnostic angiography, this invasive modality seems to be decreasing in popularity. Hirose and Gill reported that in all of their reviewed cases with a reported imaging modality, diagnostic conventional angiography was used, which caused the authors to conclude that angiography is the gold standard modality. This shows a slow yet steady increase in the utilization of noninvasive diagnostic modalities such as CT with contrast and CT angiography.

The present review found pseudoaneurysm in more than half of the cases. This correlates well with similar review findings on thoracic aorta and subclavian artery injuries [90].

In the innominate artery injury cases examined in the present review, open repair was the most common management modality (in contrast with the for aortic and subclavian artery repair, for which endovascular intervention was preferred more often). Hirose and Gill did not report any endovascular procedures in the case reports reviewed prior to 2003. Although the progress towards endovascular and hybrid techniques may be slower compared to aortic and subclavian artery injury repairs, more and more surgeons have been utilizing endovascular interventions in recent years [90].

In the present review, complications with cerebrovascular accidents occurred in 10% of the patient cases, and all of these complications occurred in the open surgical repair group and none in innominate artery injury patients treated with endovascular interventions. This could be due to selection bias because more stable patients may have been more likely to be managed with endovascular techniques than those undergoing open repairs.

## CONCLUSION

In subclavian artery injuries, clavicular fracture can

point to arterial injuries, especially in older patients. Blood pressure/pulse deficits were the most common clinical indicators of these injuries. Investigations using CT with contrast, CT angiography, or conventional angiography are typically performed in these cases, with no clear preference of any one over the others. Open repair is still the most common treatment modality, with an increasing use of endovascular techniques.

Blunt thoracic aortic injuries are common among high-speed deceleration injuries. Chest pain in a patient with a significant trauma mechanism is a good indicator that further investigation is needed, especially when associated with head trauma or polytrauma. A CT scan can be the first and even the modality of choice for this investigation. Endovascular procedures can 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 deficits are the most common clinical features of this injury. Suspected innominate artery injuries may need conventional/digital subtracted angiography, and the threshold for performing these tests should be lower. Open surgical management is still the procedure of choice, and until further knowledge is gained, there can be no recommendation to replace this time-tested technique.

## CONFLICTS OF INTERESTS

All authors declare that there are no conflicts of interest.

## REFERENCES

1. Heron, M. P. (2019). National Vital Statistics report: Deaths: leading causes for 2017 June 24 2019; 68(6) 1-77.
2. Moodley, N. B., Aldous, C., & Clarke, D. L. (2014). An audit of trauma-related mortality in a provincial capital in South Africa. *South African Journal of Surgery*, 52(4), 101-104.
3. Byun, C. S., Park, I. H., Oh, J. H., Bae, K. S., Lee, K. H., & Lee, E. (2015). Epidemiology of trauma patients and analysis of 268 mortality cases: trends of a single center in Korea. *Yonsei medical journal*, 56(1), 220-226.
4. World Health Organization. (2015). Global status report on road safety 2015. World Health Organization.
5. World Health Organization. Violence, Injury Prevention, & World Health Organization. (2013). Global status report on road safety 2013: supporting a decade of action. World Health Organization.
6. Baghi, I., Herfatkar, M. R., Shokrgozar, L., Poor-Rasuli, Z., & Aghajani, F. (2015). Assessment of vascular injuries and reconstruction. *Trauma monthly*, 20(4).
7. Perkins, Z. B., De'Ath, H. D., Aylwin, C., Brohi, K., Walsh, M., & Tai, N. R. M. (2012). Epidemiology and outcome of vascular trauma at a British Major Trauma Centre. *European journal of vascular and endovascular surgery*, 44(2), 203-209.

8. Mattox, K. L., Feliciano, D. V., Burch, J., Beall Jr, A. C., Jordan Jr, G. L., & De Bakey, M. E. (1989). Five thousand seven hundred sixty cardiovascular injuries in 4459 patients. Epidemiologic evolution 1958 to 1987. *Annals of surgery*, 209(6), 698.
9. Baker, C. C., Oppenheimer, L., Stephens, B., Lewis, F. R., & Trunkey, D. D. (1980). Epidemiology of trauma deaths. *The American Journal of Surgery*, 140(1), 144-150.
10. Sobrino, J., & Shafi, S. (2013, April). Timing and causes of death after injuries. In *Baylor University Medical Center Proceedings* (Vol. 26, No. 2, pp. 120-123). Taylor & Francis.
11. O'Connor JV, Byrne C, Scalea TM, Griffith BP, Neschis DG. (2019). Vascular injuries after blunt chest trauma: diagnosis and management. *Scand J Trauma Resusc Emerg Med*, 17: 1-10.
12. Fatimi, S. H., Anees, A., Muzaffar, M., & Hanif, H. M. (2010). Acute traumatic subclavian artery thrombosis and its successful repair via resection and end-to-end anastomosis. *Chinese Journal of Traumatology (English Edition)*, 13(4), 255-256.
13. Stefańczyk, L., Czczotka, J., Elgalal, M., Sapielha, M., & Rowiński, O. (2011). A large posttraumatic subclavian artery aneurysm complicated by artery occlusion and arteriobronchial fistula successfully treated using a covered stent. *Cardiovascular and interventional radiology*, 34(2), 146-149.
14. Günday, M., Özülkü, M., Yıldırım, E., Güven, A., & Çiftçi, Ö. (2013). Successful endovascular treatment of subclavian artery dissection after compression trauma. *The American journal of emergency medicine*, 31(2), 457-e1.
15. Sandiford, N., Tsitskaris, K., & Erritty, M. (2010). Delayed presentation of a pseudoaneurysm of the subclavian and axillary artery—the importance of vigilance. *Journal of the Royal Society of Medicine*, 103(2), 67-69.
16. Fudurić, J., Erdeljac, Ž., Frketić, I., Miletić, M., Šoštarić Zadro, A., Bačić, I., ... & Missoni, E. (2014). Blunt Trauma of Thorax with Subclavian and Axillary Artery Lesion-Case Report. *Collegium antropologicum*, 38(3), 1055-1057.
17. Assenza, M., Centonze, L., Valesini, L., Campana, G., Corona, M., & Modini, C. (2012). Traumatic subclavian arterial rupture: a case report and review of literature. *World Journal of Emergency Surgery*, 7(1), 18.
18. Queiroz, R. M., Santana, D. B. F. D., Roque, D., Bernardes Filho, F., Febrônio, E. M., & Valentin, M. V. N. (2018). Blunt thoracic trauma with the formation of pseudoaneurysm with the junction of the right subclavian artery. *Revista da Associação Médica Brasileira*, 64(11), 987-989.
19. Serrano, J. A., Rodriguez, P., Castro, L., Serrano, P., & Carpintero, P. (2003). Acute subclavian artery pseudoaneurysm after closed fracture of the clavicle. *Acta orthopaedica belgica*, 69(6), 555-557.
20. Derom, A., Ottenheim, S., Raat, H., & van Kleef, J. (2008). Endovascular treatment of acute subclavian pseudoaneurysm after fracture of the clavicle. *Acta Chirurgica Belgica*, 108(4), 441-443.
21. Baikoussis, N. G., Siminelakis, S. N., Matsagas, M., & Michalis, L. K. (2010). Massive haemothorax due to subclavian artery rupture: Emergency thoracotomy or primary stent-grafting?. *Heart, Lung and Circulation*, 19(7), 431.
22. Weber, C. D., Kobbe, P., Herren, C., Mahnken, A. H., Hildebrand, F., & Pape, H. C. (2017). Endovascular management of a combined subclavian and vertebral artery injury in an unstable polytrauma patient: case report and literature review. *Bulletin of emergency and trauma*, 5(1), 53-57.
23. Campfield, B., & Barzideh, O. S. (2016). Clavicular Fracture Associated with Life-Threatening Hemorrhage: A Case Report. *JBJS case connector*, 6(2), e31.
24. Yonezawa, N., Nakayama, Y., Takei, T., Toh, M., Asano, M., Imamura, T., & Ito, T. (2017). Fatal delayed rupture of the subclavian artery in a patient with first-rib fracture caused by blunt trauma. *Clinical case reports*, 5(3), 260.
25. Cheema, M., Kirton, O. C., Lukose, B., & Gallagher, J. (2008). Ligation of the subclavian artery after blunt trauma presenting as massive hemothorax. *Journal of Trauma and Acute Care Surgery*, 64(4), 1126-1130.
26. Diaz-Gutierrez, I., Rana, M. A., Ali, B., Marek, J. M., & Langsfeld, M. (2017). Hybrid Repair of Complex Left Subclavian Artery Injury with Partial Transection and Complete Thrombosis in an Unstable Patient following Blunt Trauma. *Annals of vascular surgery*, 40, 298-e11.
27. Elkbuli, A., Shaikh, S., McKenney, M., & Boneva, D. (2019). Subclavian artery avulsion following blunt trauma: A case report and literature review. *International journal of surgery case reports*, 61, 157-160.
28. Enamorado-Enamorado, J., Egea-Guerrero, J. J., Revuelto-Rey, J., Gordillo-Escobar, E., & Herrera-Melero, C. (2011). Left subclavian artery pseudoaneurysm after a traffic accident: a case report. *Case reports in critical care*, 2011.
29. Nakada, T. A., Idoguchi, K., Fukuma, H., Ono, H., Nakao, S., & Matsuoka, T. (2014). Case report: urgent endovascular treatment of subclavian artery injury after blunt trauma. *F1000Research*, 3.
30. Gullo, J., Singletary, E. M., & Larese, S. (2013). Emergency bedside sonographic diagnosis of subclavian artery pseudoaneurysm with brachial plexopathy after clavicle fracture. *Annals of emergency medicine*, 61(2), 204-206.
31. Hirose, H., & Temes, R. T. (2005, December). Acute subclavian artery occlusion by blunt trauma: a case report. In *HEART SURGERY FORUM* (Vol. 8, No. 6, p. 360). FORUM MULTIMEDIA PUBLISHING.
32. Ipaktchi, R., Dettmer, S., Vogt, P. M., & Knobloch, K. (2010). Subclavian artery and jugular vein rupture after a blunt thoracic trauma due to a BMX handlebar. *European journal of cardio-thoracic surgery*, 12(1), 235.
33. Jaiswal, L. S., Prasad, J. N., Maharjan, R., & Pandit, N. (2018). Giant pseudoaneurysm of subclavian artery after blunt chest trauma. *Journal of vascular surgery cases and innovative techniques*, 4(3), 220-222.
34. Ostovan, M. A., Kojuri, J., & Dehghani, P. (2017). Endovascular Repair of the Traumatic Dissection of the Subclavian-Axillary Artery: Report of Four Cases. *The Journal of Tehran University Heart Center*, 12(2), 88.
35. Kapetanakis, E. I., Sears-Rogan, P., Young, R. S., Kanda, L. T., & Ellis, J. L. (2006). Traumatic partial avulsion of a single right subclavian artery from the aortic arch and definitive

- repair. *The Annals of thoracic surgery*, 81(1), 348-350.
36. Karkos, C. D., Mair, R., Markose, G., Fishwick, G., London, N. J., & Naylor, A. R. (2007). Hybrid procedures combining open and endovascular surgical techniques for the management of subclavian artery injuries. *Journal of Trauma and Acute Care Surgery*, 63(5), E107-E110.
37. Noh, D., Lee, C. K., Hwang, J. J., & Cho, H. M. (2018). Concomitant avulsion injury of the subclavian vessels and the main bronchus caused by blunt trauma. *The Korean journal of thoracic and cardiovascular surgery*, 51(2), 153.
38. Kluemper, C., Koestner, T., Cowart, J., & Higgins, M. (2018). Intercostal Entrapment of Clavicle Fracture Causing a Pulseless, Flaccid Upper Extremity. *The Journal of hand surgery*, 43(12), 1143-e1.
39. Knobloch, K., von Falck, C., Teebken, O., & Krettek, C. (2006). Scapulothoracic dissociation with subclavian artery dissection following a severe motorbike accident. *European journal of cardio-thoracic surgery*, 30(4), 671-671.
40. Sabbagh, C. N., Chowdhury, M. M., Durrani, A., Van Rensburg, L., Koo, B., & Coughlin, P. A. (2016). A Novel Combined Hybrid Approach to Enable Revascularisation of a Trauma-Induced Subclavian Artery Injury. *EJVES short reports*, 32, 18-20.
41. Mirza, W. R., & Shiraev, T. P. (2018). Endovascular Management of a Left Subclavian Artery Pseudoaneurysm Secondary to Clavicular Fracture. *European Journal of Vascular and Endovascular Surgery*, 55(5), 624.
42. Wan Ismail Faisham, P. M., Juhara, H., Munirah, N. M., Shamsulkamaruljan, H., & Ziyadi, G. M. (2011). Clavicle fracture and subclavian vessels disruption with massive haemothorax mimic intrathoracic injury. *The Malaysian journal of medical sciences: MJMS*, 18(2), 74.
43. Quinones-Baldrich, W. J. (2010). Right subclavian pseudoaneurysm secondary to blunt trauma in an arteriovenous malformation. *Journal of vascular surgery*, 51(1), 228-229.
44. Gill, I., Quayle, J., & Fox, M. (2013). A low energy paediatric clavicle fracture associated with acute brachial plexus injury and subclavian artery compression. *The Annals of The Royal College of Surgeons of England*, 95(2), e6-e9.
45. Rodriguez-Merchan, E. C., & Gomez-Cardero, P. (2010). Delayed union of a fracture of the middle third of the clavicle presenting with a late subclavian pseudoaneurysm. *Musculoskeletal surgery*, 94(2), 89-92.
46. Scheffler, P., Uder, M., Gross, J., & Pindur, G. (2003). Dissection of the proximal subclavian artery with consecutive thrombosis and embolic occlusion of the hand arteries after playing golf. *The American journal of sports medicine*, 31(1), 137-140.
47. Sodhi, K. S., Arora, J., & Khandelwal, N. (2007). Post-traumatic occlusion of subclavian artery with clavicle fracture. *Journal of Emergency Medicine*, 33(4), 419-420.
48. Zaharudin, I., Azizi, Z. A., & Govindarajanthran, N. (2016). Traumatic right proximal subclavian artery pseudoaneurysm treated with a hybrid procedure: a case report. *Med J Malaysia*, 71(4), 221.
49. Tachtsi, M. D., Pitoulias, G. A., Fycatas, P., Kalogirou, T., & Papadimitriou, D. K. (2011). Subclavian artery aneurysm due to clavicle fracture. *Annals of vascular surgery*, 25(7), 984-e5.
50. Tennyson, C., Karunaratne, D., McLaughlin, K. E., Hasan, R., & Grant, S. W. (2018). Delayed subclavian artery rupture secondary to a traumatic first rib fracture. *Trauma case reports*, 16, 1.
51. Mandal, A. K. J., Jordaan, J., & Missouriis, C. G. (2004). Fractured clavicle and vascular complications. *Emergency medicine journal*, 21(5), 648-648.
52. Van Schaik, P. M., de Borst, G. J., Moll, F. L., & Toorop, R. J. (2015). Late onset acute occlusion of the subclavian artery after clavicle fracture. *Vascular*, 23(6), 661-662.
53. Watanabe, K., & Matsumura, T. (2005). Late-onset brachial plexus paresis caused by subclavian pseudoaneurysm formation after clavicular fracture. *Journal of Trauma and Acute Care Surgery*, 58(5), 1073-1074.
54. Zhang, M., Yuan, Y., Hu, Y., Zhao, Y., Liu, H., & Lu, H. (2015). Urgent endovascular treatment of proximal right subclavian artery pseudoaneurysm using kissing technique. *Annals of vascular surgery*, 29(6), 1319-e1.
55. Butterworth, S. A., Ng, A. K., Janusz, M. T., & Simons, R. K. (2001). Great vessel injury after hockey-related trauma: two case reports and a literature review. *Journal of Trauma and Acute Care Surgery*, 51(4), 796-799.
56. Sladojevic, M., Markovic, M., Ilic, N., Pejlic, S., Banzic, I., Djoric, P., ... & Davidovic, L. (2016). Open Treatment of Blunt Injuries of Supra-Aortic Branches: Case Series. *Annals of vascular surgery*, 31, 205-e5.
57. Bukhari, H. A., Saadia, R., & Hardy, B. W. (2007). Urgent endovascular stenting of subclavian artery pseudoaneurysm caused by seatbelt injury. *Canadian journal of surgery*, 50(4), 303.
58. Matsumoto, M., Tanemoto, K., Inagaki, E., Hamanaka, S., Masaki, H., Nakata, M., ... & Tabuchi, A. (2006). Traumatic rupture of a right aortic arch in a patient with an aberrant left subclavian artery. *The Journal of thoracic and cardiovascular surgery*, 131(2), 464-465.
59. Benedetto, F., La Spada, M., Stilo, F., De Caridi, G., Cotroneo, A., Passari, G., & Spinelli, F. (2008). Endovascular repair in atypical traumatic rupture of thoracic aorta. *Il Giornale di chirurgia*, 29(10), 427-428.
60. Badmanaban, B., Diver, A., Ali, N., Graham, A. N., McGuigan, J., & MacGowan, S. (2003). Traumatic aortic rupture during pregnancy. *Journal of cardiac surgery*, 18(6), 557-561.
61. Boulate, D., Fabre, D., Langer, N. B., & Fadel, E. (2018). Ascending aorta, aortic arch and supra-aortic vessels rupture in blunt thoracic trauma. *Interactive cardiovascular and thoracic surgery*, 27(2), 304-306.
62. Chock, M. M., Aho, J., Naik, N., Clarke, M., Heller, S., & Oderich, G. S. (2015). Endovascular treatment of distal thoracic aortic transection associated with severe thoracolumbar spinal fracture. *Vascular*, 23(5), 550-552.
63. Coppi, G., Tshomba, Y., Psacharopulo, D., Marone, E. M., & Chiesa, R. (2012). Aberrant right subclavian artery in blunt aortic injury: implication for treatment and review of the literature. *Annals of vascular surgery*, 26(6), 861-e1.
64. Eckhauser, A. W., Hannon, D., Molitor, M., Scaife, E., &



- Gruber, P. J. (2013). Repair of traumatic aortoinnominate disruption using CorMatrix. *The Annals of thoracic surgery*, 95(4), e99-e101.
65. Waldenberger, P., Fraedrich, G., Mallouhi, A., Jaschke, W. R., Perkmann, R., Jung, T., & Czermak, B. V. (2003). Emergency endovascular treatment of traumatic aortic arch rupture with multiple arch vessel involvement. *Journal of Endovascular Therapy*, 10(4), 728-732.
66. Gilani, R., Ochoa, L., Wall Jr, M. J., Tsai, P. I., & Mattox, K. L. (2011). Endovascular repair of traumatic aortic injury using a custom fenestrated endograft to preserve the left subclavian artery. *Vascular and endovascular surgery*, 45(6), 549-552.
67. Gombert, A., Barbati, M. E., Grommes, J., Jalaie, H., Schleimer, K., Jacobs, M. J., & Kalder, J. (2016). Blunt thoracic aortic injury in case of a 15-year-old boy: difficulties and possibilities of the endovascular approach. *Annals of vascular surgery*, 33, 228-e15.
68. Ryu, Y. G., Choo, S. J., Lim, J. Y., Yoon, H. K., & Chung, C. H. (2010). Hybrid procedure for a traumatic aortic rupture consisting of endovascular repair and minimally invasive arch vessel transposition without sternotomy. *Journal of Korean medical science*, 25(1), 142.
69. Ktenidis, K., Lioupis, A., Giannopoulos, A., Ginis, G., & Kiskinis, D. (2012). Management of traumatic aortic isthmus rupture in case of aberrant right subclavian artery (arteria lusoria). *Annals of vascular surgery*, 26(3), 421-e1.
70. Kovari, V. Z., Pecs, F., Janvari, M. C., & Veres, R. (2017). Initial experience with the treatment of concomitant aortic pseudoaneurysm and thoracolumbar spinal fracture: Case report. *Trauma case reports*, 12, 48-53.
71. Mattison, R., Hamilton Jr, I. N., Ciraulo, D. L., & Richart, C. M. (2001). Stent-graft repair of acute traumatic thoracic aortic transection with intentional occlusion of the left subclavian artery: case report. *Journal of Trauma and Acute Care Surgery*, 51(2), 326-328.
72. Moore, R. D., & Brandschwei, F. (2001). Subclavian-to-carotid transposition and supracarotid endovascular stent graft placement for traumatic aortic disruption. *Annals of vascular surgery*, 15(5), 563-566.
73. Murphy, E. H., Dimaio, J. M., Dean, W., Jessen, M. E., & Arko, F. R. (2009). Endovascular repair of acute traumatic thoracic aortic transection with laser-assisted in-situ fenestration of a stent-graft covering the left subclavian artery. *Journal of Endovascular Therapy*, 16(4), 457-463.
74. Piffaretti, G., Carrafiello, G., Ierardi, A. M., Mariscalco, G., Macchi, E., Castelli, P., ... & Franchin, M. (2015). Thoracic endovascular aortic repair for blunt thoracic aortic injuries in complex aortic arch vessels anatomies. *Annals of vascular surgery*, 29(6), 1320-e11.
75. Patel, K., Allen, K., Hinrichs, C., Jihayel, A., & Donahoo, J. S. (2002). Traumatic aortic arch injury. *The Annals of thoracic surgery*, 73(2), 666.
76. Gandhi, S. K., Von Haag, D., Webber, S. A., & Pigula, F. A. (2003). Traumatic aortic transection in a child with an anomalous right subclavian artery. *The Annals of thoracic surgery*, 76(6), 2087-2089.
77. Leshnower, B. G., Litt, H. I., & Gleason, T. G. (2006). Anterior approach to traumatic mid aortic arch transection. *The Annals of thoracic surgery*, 81(1), 343-345.
78. Serna, D. L., Miller, J. S., & Chen, E. P. (2006). Aortic reconstruction after complex injury of the mid-transverse arch. *The Annals of thoracic surgery*, 81(3), 1112-1114.
79. Propper, B. W., Alley, J. B., Gifford, S. M., Burkhardt, G. E., & Rasmussen, T. E. (2009). Endovascular treatment of a blunt aortic injury in Iraq: extension of innovative endovascular capabilities to the modern battlefield. *Annals of vascular surgery*, 23(5), 687-e19.
80. Reynolds, T. S., Donayre, C. E., Somma, C. G., Poggio, W. G., Kim, K. M., Nguyen, T., & White, R. (2011). Endovascular management of blunt aortic injury with an associated aberrant right subclavian artery: a report of three cases. *Annals of vascular surgery*, 25(7), 979-e7.
81. Siddiqi, M. S., Sharma, A. K., & Sabti, H. A. (2015). Polytrauma to right diaphragm, descending thoracic aorta, and innominate artery. *Asian cardiovascular and thoracic annals*, 23(9), 1075-1078.
82. Thompson, J. K., Reed, A. B., & Giglia, J. S. (2006). Novel endovascular treatment of blunt thoracic aortic trauma with a self-expanding stent lined with aortic extender cuffs. *Annals of vascular surgery*, 20(2), 271.
83. Turhan, H., Topaloglu, S., Cagli, K., Sasmaz, H., & Kutuk, E. (2004). Traumatic type B aortic dissection causing near total occlusion of aortic lumen and diagnosed by transthoracic echocardiography: A case report. *Journal of the American Society of Echocardiography*, 17(1), 80-82.
84. Waldenberger, P., Fraedrich, G., Mallouhi, A., Jaschke, W. R., Perkmann, R., Jung, T., & Czermak, B. V. (2003). Emergency endovascular treatment of traumatic aortic arch rupture with multiple arch vessel involvement. *Journal of Endovascular Therapy*, 10(4), 728-732.
85. Yeo, D. L. T., Haider, S., & Zhen, C. A. C. (2015). Blunt traumatic aortic injury of right aortic arch in a patient with an aberrant left subclavian artery. *The Yale journal of biology and medicine*, 88(1), 93.
86. Al-khaldi, A., & Robbins, R. C. (2006). Successful repair of blunt injury of aortic arch branches in the setting of bovine arch. *Journal of vascular surgery*, 43(2), 396-398.
87. Dhaliwal, R. S., Luthra, S., Goyal, S., Behra, S., Krishna, R., & Ba, K. (2005). Traumatic giant pseudoaneurysm of innominate artery. *Asian Cardiovascular and Thoracic Annals*, 13(4), 369-371.
88. Knosalla, C., Pasic, M., & Hetzer, R. (2000). Traumatic dissection of the innominate artery. *European Journal of Cardio-Thoracic Surgery*, 18(3), 370-370.
89. Hirose, H., & Gill, I. S. (2004). Blunt injury of proximal innominate artery. *Annals of thoracic and cardiovascular surgery*, 10(2), 130-132.
90. Hirose, H., & Gill, I. S. (2004). Blunt injury of the innominate artery: a case report and review of literature. *Annals of thoracic and cardiovascular surgery*, 10(4), 218-223.
91. Stover, S., Holtzman, R. B., Lottenberg, L., & Bass, T. L. (2001). Blunt innominate artery injury. *The American surgeon*, 67(8), 757.
92. Axisa, B. M., Loftus, I. M., Fishwick, G., Spyt, T., & Bell, P. R.

- (2000). Endovascular repair of an innominate artery false aneurysm following blunt trauma. *Journal of Endovascular Therapy*, 7(3), 245-250.
93. Ben, S. O., Ben, M. H., Ben, M. M., Kaouel, K., Daoued, Z., & Khayati, A. (2014). Traumatic dissection of the innominate artery. A case report. *Journal des maladies vasculaires*, 39(1), 73-76.
  94. Bito, Y., Hirai, H., Sasaki, Y., Hosono, M., Nakahira, A., Suehiro, Y., ... & Suehiro, S. (2014). Successful surgical treatment of traumatic transection of the innominate artery: a case report. *Annals of vascular diseases*, 7(2), 165-168.
  95. Boutayeb, A., Porcu, P., Pirvu, A., & Chavanon, O. (2014). Post-traumatic injury of the brachiocephalic artery: on-pump beating heart repair. *Heart, Lung and Circulation*, 23(10), e226-e228.
  96. Davidović, L., Ilić, N., Cvetković, S., Koncar, I., Čolić, M., & Vjestica, M. (2011). Blunt injury of the innominate artery and left innominate vein. *Vascular*, 19(4), 223-225.
  97. Dias-Neto, M., Ramos, J. F., & Teixeira, J. F. (2018). Blunt Injury of the Innominate Artery: What Surprises to Expect? A Case Report. *Vascular and endovascular surgery*, 52(3), 226-232.
  98. Miles EJ, Blake A, Thompson W, Jones WG, Dunn EL. (2003). Endovascular repair of acute innominate artery injury due to blunt trauma. *Am Surg*, 68(2), 155-159.
  99. Howea KL, Guirgisa G, Woodmana G, Chub GF, Cooper MJ, Rapanosa T, Szalay D. (2017). Blunt innominate artery trauma requiring repair and carotid ligation. *Trauma Case Reports*, 12, 24-27.
  100. Huang C, Kao H. (2008). Endovascular Management of Post-Traumatic Innominate Artery Transection With Pseudo-Aneurysm Formation. *Catheterization and Cardiovascular Interventions*, 72, 569-572.
  101. Lee CW, Song S, Choi SU, Kim SH, Lee HC. (2015). Hybrid Repair for Anastomotic Pseudoaneurysm on the Innominate Artery Following Blunt Chest Trauma. *J Card Surg*, 30, 836-838.
  102. Mousa AY, Batsides GP, RV Todd. (2010). Delayed presentation of traumatic innominate artery injury. *J Vasc Surg*, 51, 1014.
  103. Ormazabal A, Muangman N, Eric J. (2012). Stern Manubrial Fracture with an Associated Innominate Artery Injury: *Curr Probl Diagn Radiol*, 41(4), 122-123.
  104. Chu MWA, Myers ML. (2006). Traumatic Innominate Artery Disruption and Aortic Valve Rupture. *Ann Thorac Surg*, 82:1095-7.
  105. Roberts CS, Sadoff JD, White DR. (2000). Innominate Arterial Rupture Distal to Anomalous Origin of Left Carotid Artery. *Ann Thorac Surg*, 69, 1263-4.
  106. Symbas JD, Halkos ME, Symbas PN. (2005). Rupture of the Innominate Artery from Blunt Trauma: Current Options for Management. *J Card Surg*, 20, 455-459.
  107. Sturm JT, Dorsey JS, Oslon FR, Perry JF. (1984). The management of Subclavian artery injuries following blunt thoracic trauma. *The annals of thoracic surgery*, 38(3), 188-191.
  108. Katras T, Baltazar U, Rush DS, Davis D, Bell TD, Browder IW, Compton RP, Stanton PE. (2001). Subclavian arterial injury associated with blunt trauma. *Vascular surgery*, 35, 43-50.
  109. Costa MC, Robbs JV. (1988). Non penetrating Subclavian artery trauma. *Journal of vascular surgery*, 8(1): 71-75.
  110. Road safety annual report 2018: International transport forum. [https://www.itf-oecd.org/sites/default/diles/docs/irtad-road-safety-annual-report-2018\\_2.pdf](https://www.itf-oecd.org/sites/default/diles/docs/irtad-road-safety-annual-report-2018_2.pdf)
  111. Gombert A, Barbati ME, Storck M, Kotelis D, Keschenau P, Pape H, Andruszkow H, Lefering R, Hilderbrand F, Greiner A, Jacobs MJ, Grommes J. (2017). Treatment of blunt thoracic aortic injury in Germany-Assessment of the TraumaRegister DGU, 12(3), 1-12.
  112. Burkhart HM, Gomez GA, Jacobson LE, Pless JE, Broadie TA. (2001). Fatal blunt aortic injuries: A review of 242 autopsy cases. *J Trauma*, 50, 113-115.
  113. Mirvis SE, Shanmuganathan K, Miller BH, White CS, Turney SZ. (1996). Traumatic aortic injury: Diagnosis with contrast-enhanced CT-Five year experience of a major trauma center. *Radiology*, 200(2), 413-422.
  114. Williams JS, Graff JA, Uku JM, Steining JP. (1995). Aortic injury in vehicular trauma. *Ann Thorac Surg*, 57, 726-730.
  115. Starnes BW, Lundgren RS, Gunn M, Quade S, Hatsukami TS, Tran NT, Mokadam N, Aldea G. (2012). A new classification scheme for treating blunt aortic injury. *J vasc surg*, 55(1), 47-54.

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