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Azygos Vein Laceration Due to Blunt Trauma

REFERENCE: Shkrum, M. J., Green, R. N., and Shum, D. T., **"Azygos Vein Laceration Due to Blunt Trauma,"** *Journal of Forensic Sciences*, JFSCA, Vol. 36, No. 2, March 1991, pp. 410–421.

ABSTRACT: The azygos vein ascends along the thoracic spine through the mediastinum and drains into the superior vena cava at the level of the fourth thoracic vertebra. Fracture-dislocation of the mid-thoracic spine, as a result of blunt thoracic trauma, can tear the azygos vein. Four such fatal cases (three motor vehicle accidents and one fall) were studied, only one of which was recognized prior to death. The vein can also be torn, in the absence of skeletal injuries, by horizontal acceleration/deceleration forces.

The pathologist must consider azygos vein laceration as a possible cause of either hemothorax or hemomediastinum or both in a victim of a blunt chest trauma, if that individual had persistent hypotension during the few hours before death and no identifiable source of hemorrhage can be found postmortem in sites such as the heart, great vessels, lung, and chest wall. A fracture-dislocation of the thoracic spine may not necessarily be present.

Azygos vein laceration seems to be an uncommon cause of hemothorax and hemomediastinum; however, this injury is probably more frequent than is implied by the few cases described in the medical literature.

KEYWORDS: pathology and biology, trauma, azygos vein, blunt trauma

Blunt trauma to the chest is common during motor vehicle accidents. Bleeding into the mediastinum and pleural cavities can occur from a variety of different sites. Azygos vein laceration is one possible source of hemorrhage and is associated with characteristic clinical, radiographic, and postmortem findings.

Anatomy

The anatomy of the azygos vein system (the azygos and hemiazygos veins) is variable [*1*].

The larger azygos vein originates from the union of a common trunk formed by the right subcostal and ascending lumbar veins with the lumbar azygos vein (Fig. 1). The azygos vein, from its origin at the level of the twelfth thoracic vertebra (T_{12}), ascends the anterior right side of the thoracic vertebrae through the posterior mediastinum. Along its course, the azygos vein drains the right posterior intercostal veins and is beside the

Presented at the 42nd Annual Meeting of the American Academy of Forensic Sciences, Cincinnati, OH, 19–24 Feb. 1990. Received for publication 28 March 1990; accepted for publication 16 May 1990.

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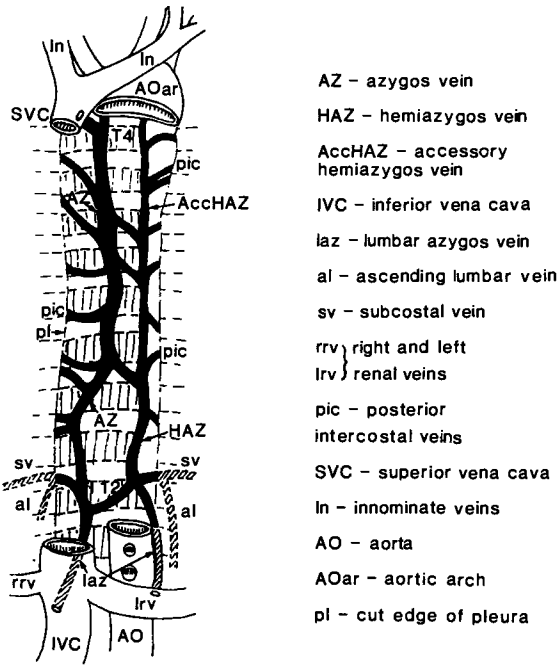

FIG. 1—*Anatomy of the azygos vein system.*

posterolateral descending thoracic aorta. Superiorly, the azygos vein arches forward over the right pulmonary hilum and joins the superior vena cava at the T_4 level.

The hemiazygos vein has a similar origin and course as the azygos vein. At the T_8 level, the hemiazygos vein crosses the midline behind the aorta to join the azygos vein. The accessory hemiazygos vein flows from the left innominate vein, descends to the T_7 level, and there joins the azygos vein. The hemiazygos and accessory hemiazygos veins can join, and the number of venous intercommunications between these veins and the azygos vein varies.

In over 95% of cases, a main right azygos vein and some form of hemiazygos vein are present. The latter can be either poorly developed or absent, in which case the left posterior intercostal veins drain into the azygos vein. The azygos vein can course across the midline to the left side of the thoracic spine.

Case Reports

Case 1

A 23-year-old construction worker, while placing safety rails on a scaffold, fell a total of five stories to a concrete foundation. His descent was partly interrupted by collision with the building two floors below the scaffold. He was found unconscious lying on his back.

On hospital admission, clinical assessment confirmed craniocerebral trauma. A computerized axial tomography (CAT) scan showed multiple skull fractures, diffuse subarachnoid hemorrhage, and cerebral edema. An initial chest radiograph revealed a left lung contusion but an apparently normal mediastinum. A chest CAT scan revealed thoracic vertebral fractures (Fig. 2). Despite drainage of bilateral hemothoraces (left,

FIG. 2—*Case 1: chest CAT scan showing fractures of the body and posterior elements of thoracic vertebra.*

1000 cc; right, 400 cc) and other resuscitative measures, the patient had uncontrollable hypotension (systolic pressure ranged from 40 to 80 mmHg) until his death, about 3½ h after the fall. A repeat chest radiograph, taken about 45 min after the initial film, had shown bilateral pulmonary contusions and a widened mediastinum (Fig. 3).

The autopsy confirmed severe craniocerebral trauma. There was no significant intraab-

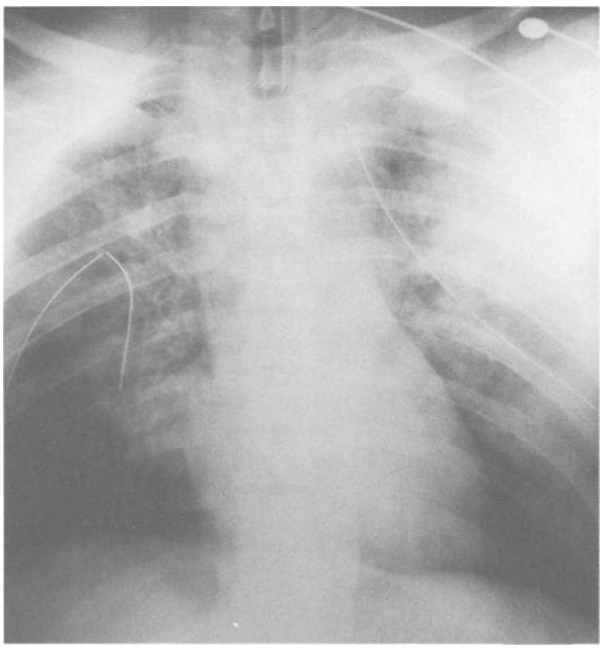

FIG. 3—*Case 1: second chest radiograph showing widened mediastinum.*

dominal trauma. Residual hemothoraces (right, 400 cc; left, 200 cc) and pulmonary contusions were present. The mediastinum contained an estimated 500 cc of blood. The aorta was intact. A lacerated azygos vein, associated with a fracture-dislocation of the T_5 vertebra, was discovered. Additional fractures of the T_6 through T_8 vertebrae and adjacent spinal cord transections were found.

Case 2

A 39-year-old female driver of a Plymouth Voyager minivan failed to negotiate a road curve. Her vehicle ran into a ditch and struck an earth embankment which covered a steel culvert. The front of the van was extensively crushed (up to 73 cm on the right side), and there was considerable intrusion of the front interior into the occupant space. Although the driver had worn a seat belt, it showed significant slack. It appears that at the time of impact, her chest hit and displaced the lower right portion of the steering wheel. Bruising of the right breast area and fractures of the right arm were noted.

On arrival at the hospital, the patient's level of consciousness declined and closed head injury was diagnosed. A systolic blood pressure of 70 mmHg was recorded. A widened mediastinum was seen on a chest radiograph. Decreased air entry in the left chest prompted insertion of a chest tube, which continuously drained sanguinous fluid until her death. The finding of abdominal distension led to a minilaparotomy, which revealed copious bleeding. Several litres of blood were removed at the laparotomy, and mesenteric and hepatic lacerations were repaired. Postoperatively, hypotension (systolic pressure ranging from 70 to 80 mmHg) persisted despite vigorous medical resuscitation. The patient had a cardiac arrest during which pericardiocentesis revealed no hemorrhage. She died 6½ h after the accident.

Postmortem examination confirmed severe craniocerebral trauma, including a basal skull fracture and multiple cerebral lacerations. There was a residual mesenteric hematoma (300 cc). A right hemothorax (3 L) was discovered. The only intrathoracic vascular injury was a transected azygos vein associated with a fracture-dislocation of the T_4 vertebral body and spinal cord transection.

Case 3

A 48-year-old female driver of a 1978 Chevrolet Malibu had reduced her speed to 10 km/h in order to make a left turn. The rear of the car was hit by a 1974 GMC pickup truck traveling at an unknown fast speed. There was extensive damage of the car's rear compartment, with intrusion into the front. Upon extrication from the damaged car ½ h later, the victim, who was wearing a lap/torso belt, was unconscious and hypotensive (systolic pressure 50 mmHg).

In the hospital, the patient began to vocalize following fluid resuscitation and a rise in her blood pressure (systolic pressure, 66 mmHg). A peritoneal tap produced negative results. A chest radiograph showed left rib fractures and a large right hemothorax. Insertion of a chest tube drained about 600 cc of blood. Continued fluid resuscitation restored the systolic pressure to 100 mmHg, but over the next 1½ h, hypotension (systolic blood pressure ranging from 55 to 75 mmHg) and a diminished level of consciousness recurred. A repeat chest radiograph revealed reaccumulation of the right hemothorax, and a second chest tube was inserted, draining 800 cc of blood. The systolic blood pressure continued to decline (40 mmHg) and the patient became bradycardic, requiring cardiac massage. A right thoracotomy showed a large hemothorax (700 cc), which persisted despite frequent suctioning. A pleural laceration was observed in the paravertebral area which, on exploration, revealed a torn azygos vein. An adjacent thoracic vertebral frac-

ture-dislocation was found (Fig. 4). Despite clamping of the bleeding site, cardiac output was inadequate, even with open-heart massage. There was no evidence of damage to the heart or its great vessels. The patient was pronounced dead 2½ h after the accident.

There was no evidence of craniocerebral trauma at autopsy. Several superficial hepatic and splenic lacerations were found, but there was only a small hemoperitoneum (200 cc). There were small bilateral hemothoraces (100 cc each). The left fourth to twelfth ribs were fractured, but pulmonary contusions were absent. There were fracture-dislocations of the T_5 to T_9 vertebrae. The only significant vascular injury was an azygos vein tear adjacent to an anterior fracture-dislocation of the sixth thoracic vertebra.

Case 4

A 24-year-old woman was the right front seat passenger of a 1978 Mazda driven by her husband. He had parked the car, after it ran out of gas, in the curb lane of a busy city street. He left his wife, who was restrained with a lap/torso belt, in the vehicle. The rear of the car was extensively crushed by a frontal impact from a 1972 Mercury which was traveling at an estimated 70 km/h (Fig. 5).

Shortly after the accident, the patient suffered a cardiac arrest. With resuscitation, her systolic blood pressure rose to 65 mmHg. A chest radiograph showed neither mediastinal widening, hemothoraces, nor rib fractures. An apparent bloody peritoneal tap prompted

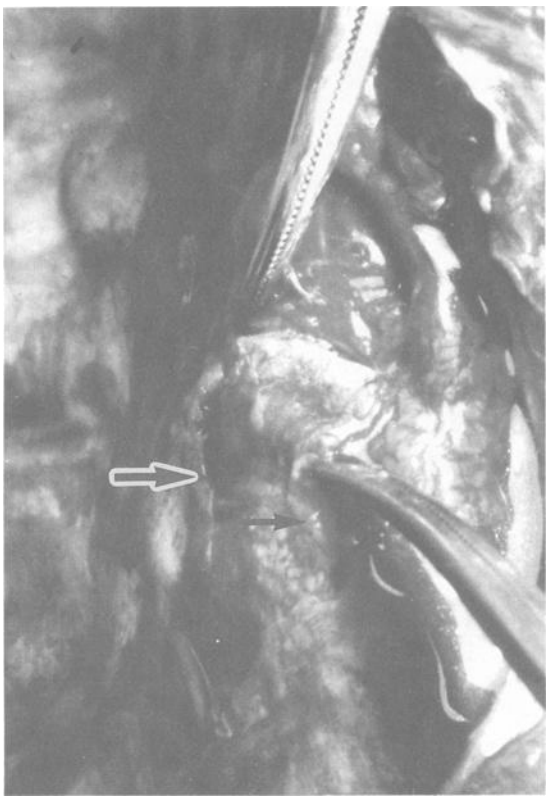

FIG. 4—*Case 3: fracture-dislocation of T_6 and pleural tear* (large arrow) *between lacerated ends (both clamped) of the azygos vein [ascending portion of the azygos vein* (small arrow)*].*

FIG. 5—*Case 4: extensive rear crushing of the victim's car.*

a laparotomy. Neither this nor a pericardial window located a source of hemorrhage. She remained hypotensive until her death 5 h after the accident.

Although autopsy revealed a hemoperitoneum (600 cc) and a pelvic hematoma related to an adjacent fracture, the most significant bleeding had occurred in the thorax. Bilateral hemothoraces (left, 1650 cc; right, 500 cc) and a mediastinal hematoma were found. The only major vascular injury was a lacerated azygos vein situated near an unstable fracture-dislocation of T_4 relative to T_5.

The salient clinical and pathological findings of each of these four cases are summarized in Table 1.

Discussion

Six cases of azygos vein laceration due to blunt thoracic trauma and previously reported in the medical literature have been reviewed (Table 2) [2–6].

These, as well as three cases (Cases 2 to 4) from this present study, occurred during motor vehicle accidents. The various authors provided, at best, brief details of the automobile collisions. Spagliardi and Palombo treated a front-seat unbelted passenger [2]. The patient of Sherani et al. was in a head-on car collision [5]. The patient of Coates and Hall was wearing a seat belt when she sustained her injuries [6]. In our study, there was either frontal (Case 2) or rear impact (Cases 3 and 4), with considerable intrusion of the damaged part of the vehicle into the passenger compartment. The one exception (Case 1) fell five stories but had part of his descent interrupted by collision with the side of the building.

The individuals, described in the literature, presented clinically with hypotension and had abnormal chest radiographs (a right hemothorax in five cases and a widened superior mediastinum in one case). All had a right thoracotomy, during which the azygos vein laceration was successfully repaired. In the case reported by Sherani et al., persistent hypotension despite surgical treatment of hepatic lacerations led to thoracotomy [5]. The location of the azygos vein tear was described as either at the junction of the azygos vein and the superior vena cava (four cases), in the arch (one case), or between the fourth and fifth intercostal spaces (one case). Only one case (Salizzoni et al. [3]) was associated with fracture-dislocation of the fifth thoracic vertebra. Other injuries mentioned included small hepatic tears which were surgically treated (Spagliardi and Palombo [2]), repaired pulmonary lacerations and bilateral rib fractures (Salizzoni et al. [3]), subclavian arterial laceration with resection of a consequent false aneurysm (Baldwin et al. [4]), closed head injury and repaired hepatic lacerations (Sherani et al. [5]), and multiple right rib fractures

TABLE 1—*Summary of cases of azygos vein laceration.*

Case	Age, years	Sex	Accident	Persistent Hypotension	Radiographic Findings	Azygos Vein Laceration	Thoracic Spine Fractures	Other Injuries	Survival Interval, h
1	23	M	fall	+	CXR[a]—wide mediastinum CAT scan—thoracic vertebral fractures	PMD[b]	T_5–T_8—PMC[c]	PMC—craniocerebral trauma, hemomediastinum and bilateral hemothoraces, pulmonary contusions	3½
2	39	F	MVA[d]—frontal collision, driver, belted	+	CXR—wide mediastinum	PMD	T_4—PMD	PMC—craniocerebral trauma, surgical repair of hepatic and mesenteric lacerations, PMD—right hemothorax	6½
3	48	F	MVA—rear colli-	+	CXR—(R) hemothorax	PMC [seen at (R) thora-	T_5–T_9—PMC	PMC—residual right hemothorax, left	2½

			sion, driver, belted			cotomy]		rib fractures PMD—small left hemothorax, superficial hepatic and splenic lacerations	
4	24	F	MVA—rear collision, passenger, belted	+	CXR—no findings	PMD	T_4—PMD	PMD—hemoperitoneum, pelvic hematoma, bilateral hemothoraces (L = 1650 cc; R = 500 cc), and hemomediastinum Laparotomy and pericardial window (antemortem)—no findings	5

[a]CXR = chest radiograph.
[b]PMD = postmortem diagnosis.
[c]PMC = postmortem confirmation of clinical diagnosis(es).
[d]MVA = motor vehicle accident.

TABLE 2—*Summary of literature review of azygos vein laceration due to blunt trauma.*

Authors	Age, years	Sex	Accident	Initial Hypotension	Radiographic Findings	Azygos Vein Laceration	Thoracic Spine Fractures	Other Injuries	Survived
Spagliardi and Palombo [2] (1978)	37		MVA,[a] Front-seat, unbelted passenger	+	CXR[b]—(R) hemothorax	CLD[c]—(R) thoracotomy Surgical repair of tear at SVC[d] junction	–	Surgical repair of small hepatic lacerations	+
Salizzoni et al. [3] (1980)	50	F	MVA	+	CXR—(R) hemothorax	CLD—(R) thoracotomy Surgical repair of torn arch and intercostal branches	–	Surgical repair of (R) lung lacerations	+
	41	M	MVA	+	CXR—(R) hemothorax	CLD—(R) thoracotomy Surgical repair of tear at SVC junction	+ CLD—T_5 anterior fracture-dislocation	Bilateral rib fractures	– (Died 35 days later of respiratory and renal failure)

Baldwin et al. [4] (1984)	28	F	MVA	+	CXR—wide superior mediastinum	CLD—(R) thoracotomy and sternotomy Surgical repair of tear at SVC junction	–	Hematoma on anterior chest Subclavian arterial intimal tear with false aneurysm	+
Sherani et al. [5] (1986)	25	M	MVA, frontal impact	+	CXR—(R) hemothorax	CLD—(R) thoracotomy following persistent hypotension despite surgical repair of hepatic lacerations Tear between 4th and 5th intercostal spaces	–	Closed head injury Surgical repair of hepatic lacerations	+
Coates and Hall [6] (1987)	63	F	MVA, belted	+	CXR—(R) hemothorax	CLD—(R) thoracotomy Surgical repair of tear at SVC junction	–	Multiple (R) rib fractures	+

[a]MVA = motor vehicle accident.
[b]CXR = chest radiograph.
[c]CLD = clinical diagnosis.
[d]SVC = superior vena cava.

(Coates and Hall [6]). Only one victim died as a result of medical complications about one month after the accident (Salizzoni et al. [3]).

All of our cases, on hospital admission, had hypotension, which persisted until death several hours later. A chest radiograph showed either a widened mediastinum (Cases 1 and 2) or right hemothorax (Case 3), but appeared normal in one case (Case 4). In this case, the chest radiograph may not have detected the early stages of venous hemorrhage into the mediastinum and pleural cavities, abnormalities found at autopsy. It is noteworthy that in Case 1, the enlarged mediastinum was not detected until the second chest radiograph was done about ¼ h after the first. Thoracotomy was performed in one case (Case 3). In the other three cases, the azygos vein tear was recognized postmortem. Two of these (Cases 1 and 2) were also dominated clinically by severe craniocerebral trauma. Also, mesenteric and hepatic lacerations were repaired in Case 2. A laparotomy and a pericardial window failed to find a bleeding source in Case 4. Without exception, the azygos vein laceration was situated adjacent to an upper mid-thoracic vertebral fracture (T_4 to T_6).

Salizonni et al. outlined the mechanisms of azygos vein laceration due to blunt thoracic trauma [3]. A fracture-dislocation, typically of the mid-thoracic spine, can directly tear the azygos vein. The four cases from this present study represent examples of such a mechanism. In the one literature case associated with fracture-dislocation of the fifth thoracic vertebra, the azygos vein tear was not adjacent to the fracture site but at the junction with the superior vena cava.

The arch of the azygos vein is relatively mobile compared with its ascending portion, which is bound to the spinal column by intercostal veins, and compared with its distal end, which empties into the superior vena cava, which is fixed by cervical fascia and the heart. This is analogous to the aortic arch and descending thoracic aorta. During a motor vehicle collision or fall, sudden horizontal acceleration or deceleration forces are applied to the thorax. As a result, shear stresses can be exerted along the arch of the azygos vein (Fig. 6). In addition, cardiac displacement can bend the arch over the right pulmonary hilum (bending stress), and the asymmetrical shape and position of the heart can cause a leftwise torsion (torsion stress). The other cases in the literature are probably due to

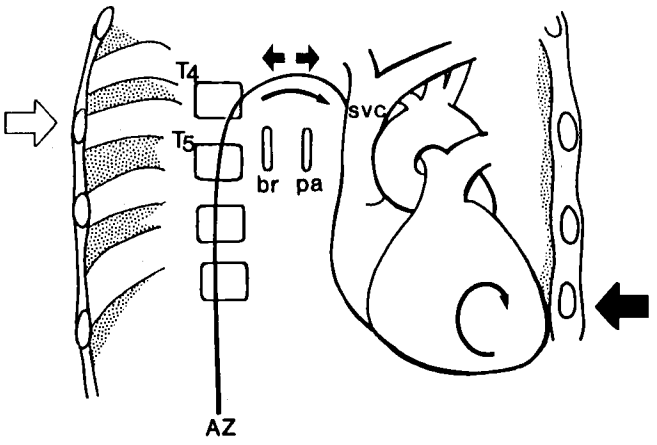

FIG. 6—*Mechanisms of azygos vein laceration due to blunt trauma: The azygos vein can be torn by adjacent fracture-dislocation of the thoracic spine, as can occur during rear impact* (large open arrow). *Sudden acceleration or deceleration during a motor vehicle impact or fall can cause shear forces* (small solid arrows) *on the azygos vein arch. These can be accentuated by bending* (curved arrow along arch) *and torsion stresses* (curved arrow on heart) *due to cardiac displacement. Chest compression* (large closed arrow) *can contribute.* Br = *bronchus;* pa = *pulmonary artery.*

these horizontal acceleration/deceleration forces. Spagliardi and Palombo emphasized that chest compression, as manifested, for example, by rib fractures, could accentuate these various stresses on the azygos vein arch [2]. Theoretically, the cumulative effects of repeated chest compressions (for example, cardiopulmonary resuscitation) could sufficiently stress the arch, resulting in a laceration. The mechanisms of horizontal acceleration/deceleration (with chest compression) and direct trauma from adjacent vertebral fracture-dislocation are probably not mutually exclusive; however, the former can cause isolated venous tears without arterial and skeletal injuries. Also, the impacts themselves may involve relatively low kinetic energy, and the use of seat belts may modify the inertial forces exerted on the major thoracic vessels.

Azygos vein laceration, although uncommon, is a potential cause of hemothorax or hemomediastinum or both in a victim who has sustained blunt thoracic trauma, particularly in the setting of a motor vehicle accident. A survival interval of several hours, during which hypotension has persisted despite vigorous resuscitation and even surgical repair of nonthoracic sources of hemorrhage, is an important clinical feature of this entity. A mid-thoracic spinal fracture may be present. It can either be the cause of the azygos vein rupture or, at least, represent the magnitude of force exerted along the vulnerable azygos vein arch. If an autopsy does not reveal a bleeding site in either the heart, its great vessels, lung, or chest wall that would adequately explain hemorrhage into the mediastinum and pleural cavity, then the possibility of azygos vein laceration must be considered.

Acknowledgments

The authors thank Judy Beck for assistance in preparing the manuscript, the Visual Services Department, Victoria Hospital, for preparing the figures, and M. Caruso for translating the scientific articles from the Italian medical literature.

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