Central Venous Injuries of the Subclavian–Jugular and Innominate–Caval Confluences

Injuries to the central venous system can result from penetrating trauma or iatrogenic causes. Injuries to major venous confluences can be particularly problematic, because the clavicle and sternum seriously limit exposure of the injury site. We report our institution's experience with central venous injuries of the subclavian–jugular and innominate–caval venous confluences. Significant injuries of the subclavian–jugular venous confluence frequently result from penetrating trauma, while injuries to the innominate–caval confluence are usually catheter-related. Median sternotomy provides adequate exposure of the innominate–caval confluence, while exposure of the subclavian–jugular venous confluence requires extension of the median sternotomy incision into the neck and resection of the clavicle. The literature is reviewed. (*Tex Heart Inst J 1999;26:177-81*)

Patients and Methods

We performed a retrospective review of patients who had been treated at our institution for vascular injuries of the central venous system between 1988 and 1997. For each patient identified, we analyzed the mechanism of the injury, the location of the injury, and the surgical approach used to resolve the injury.

Subclavian–Jugular Confluence Injuries (n=4)

**Patient 1.** An 18-year-old man with a gunshot wound to the base of the neck presented in respiratory distress. He underwent urgent orotracheal intubation and was taken to the operating room. The chest was entered via a median sternotomy, and a blowout injury of the trachea was found above the carina; the injury was stented by the endotracheal tube. A hemothorax was found in the right side of the chest, and the sternotomy was extended transversely to create a right anterolateral thoracotomy. An exsanguinating hemorrhage was discovered at the junction of the internal jugular vein and the subclavian vein. A hemitranssection of the proximal thoracic esophagus was also found. The patient died of exsanguination before vascular control could be achieved.

**Patient 2.** A 58-year-old woman underwent elective biopsy of a mass (ultimately found to be a benign lymph node) located very deep within the base of the right aspect of the neck. Scissors were used to probe deeply into the base of the neck, and an exsanguinating hemorrhage ensued. To obtain better access to the hemorrhage, the surgeon created an oblique neck incision to the suprasternal notch, and resected the head of the right clavicle. The limited exposure gained from this incision enabled the surgeon to perform tamponade of the hemorrhage, which was found to emanate from a laceration of the confluence of the right subclavian and jugular veins. A cardiothoracic surgeon was consulted, and the neck incision was extended...
to a full median sternotomy for improved exposure. A partial occlusion clamp was applied at the site of the laceration and a primary repair was performed. The patient recovered UNEVENTFULLY.

**Patient 3.** A 61-year-old man presented to the emergency room with a transmediastinal gunshot wound. He was hemodynamically stable, but arteriography revealed a pseudoaneurysm of the proximal left common carotid artery near the aortic arch, with an arteriovenous fistula to the left innominate vein. There was no evidence of neurologic compromise. Gastrografin swallow showed no evidence of esophageal injury.

The patient was taken to the operating room, and the chest was entered via a median sternotomy that was extended into the left aspect of the neck and the supraclavicular area. When the sternum was spread open, an exsanguinating arterial and venous hemorrhage was found to emanate from the supraclavicular notch. The surgeon exposed the aortic arch and achieved vascular control of the left common carotid artery, but torrential venous bleeding continued. The surgeon performed tamponade of the area and resected the medial portion of the left clavicle, tremendously improving the exposure and revealing multiple large lacerations of the internal jugular and innominate vein confluences. However, the application of several occlusion clamps did little to control the bleeding, and the patient suffered cardiac arrest. The aorta and the right atrium were cannulated, and cardiopulmonary bypass was begun. The hemorrhage was drained by means of pump suckers, and closer inspection revealed a 95% circumferential transection of the base of the left common carotid artery. This lesion was repaired by means of end-to-end anastomosis. The surgeon then found that the internal subclavian–jugular venous junction with the left innominate vein had been shattered, and the patient was hemorrhaging from all 3 veins. The venous junction was further dissected and vascular repair of the 3 veins was performed, while the patency of the confluence was maintained. The patient was weaned from cardiopulmonary bypass and, after several days of obtundation, slowly improved. After several weeks, the patient was discharged home in stable condition.

**Patient 4.** A 24-year-old man with a gunshot wound above the left clavicle presented in stable condition. Arteriography revealed a fistula from the left common carotid artery to the confluence of the left internal jugular and subclavian veins.

The patient was taken to the operating room where laryngoscopy, bronchoscopy, and pharyngoscopy were performed, revealing a penetrating injury to the cervical esophagus. A median sternotomy was performed, with an extension to the left aspect of the neck. The common carotid artery was repaired primarily and the internal jugular–subclavian venous confluence was ligated. The penetrating esophageal injury was repaired and buttressed with surrounding tissues, and the esophagus was then excluded with a heavy absorbable tie proximal to the repair. A gastrostomy and a feeding jejunostomy were performed, and chest tubes were placed. The patient had an uneventful recovery and resumed his diet by mouth when the esophageal exclusion suture spontaneously resorbed.

**Innominate–Caval Confluence Injuries (n=5)**

**Patient 5.** A 60-year-old man with gastric carcinoma underwent central venous catheter placement for total parenteral nutrition (TPN). The catheter was placed via the left subclavian vein, and initial chest radiography showed the catheter to be correctly positioned in the cephalic portion of the superior vena cava (SVC). After the catheter had been in place for several days, the patient developed marked dyspnea. Chest radiography revealed a large hydrothorax in the right side of the chest, and the catheter tip appeared to be nearly perpendicular to the SVC, at the confluence with the innominate veins (Fig. 1). A chest tube was placed and the TPN catheter was removed. The patient recovered with conservative treatment.

**Patient 6.** A 69-year-old woman underwent placement of a permanent catheter via the right subclavian vein for TPN. Her obesity made line placement difficult. Because there was some trouble drawing fluid back from the port, an intraoperative contrast study was performed to confirm the proper positioning of the catheter tip in the SVC before TPN was begun. Several weeks later, the patient developed respiratory distress and suffered a cardiac arrest. She could not be resuscitated and died. Autopsy revealed tension hydrothorax of the right side of the chest and perforation of the cephalic SVC by the catheter tip.

**Patient 7.** A 32-year-old man with osteomyelitis underwent an attempt at permanent catheter placement via the left subclavian vein. When the rigid dilator was passed over the guide wire, the patient suddenly developed acute hemodynamic decompensation. A cardiothoracic surgeon was consulted, and the chest was entered via a median sternotomy. Acute cardiac tamponade was found, as was a tear at the junction of the innominate artery and the SVC (Fig. 1). This tamponade was decompressed and the tear was repaired without further incident. The patient recovered uneventfully.

**Patient 8.** A 42-year-old man with renal failure underwent placement of a Shiley hemodialysis catheter via the right subclavian vein. When the
Adjacent to this was a ward for placement of vein perforation. The patient then suffered acute hemodynamic decompensation and cardiac arrest. A cardiothoracic surgeon was called, and the chest was entered via a median sternotomy. A large acute pericardial tamponade was decompressed, and the tip of the catheter was found within the right side of the pericardium, having perforated the junction of the right innominate vein and SVC. The patient could not be resuscitated and died on the operating table.

**Discussion**

Injury to the central venous system is most often the result of either penetrating trauma (e.g., gunshot wound) or iatrogenic causes (e.g., catheter placement). Penetrating injuries, particularly gunshot wounds, to the subclavian and innominate veins can result in rapid exsanguination and are associated with significant mortality. The clavicle and sternum act as bony barriers to surgical intervention and thus present a particular challenge to immediate vascular control within the central venous system. Of 4 patients with injuries at the subclavian–jugular venous confluence, 3 had sustained their injuries from gunshot wounds, and 1 of these died.

At the innominate–SVC confluence, central venous catheterization is a more common cause of injury and erosion than is penetrating trauma. However, such perforations of central veins represent a minority of catheter-based complications; the vast majority of catheter-based complications manifest as pneumothorax, infection, and intravascular thrombosis. The innominate–SVC confluence is adjacent to several structures and spaces—both pleural and pericardial—and perforation of this area may manifest clinically in a variety of ways. Localized central line perforation within the mediastinal pleura remains uncomplicated, for the most part, if the problem is identified early and the catheter promptly removed. At times, however, the perforation is delayed because it results from erosion of the innominate–caval junction and possible local infection. In this instance, the perforation usually communicates to the pleural space and results in a delayed hydrothorax, frequently on the opposite side of the chest from the line insertion, or it may be bilateral. Again, the simple intervention of line removal, combined with chest tube insertion, is usually therapeutic. In our series, 2 patients sustained their injuries from central venous catheterization, and 1 of these patients died from unrecognized tension hydrothorax.

The innominate–caval junction is adjacent to the pericardium, and acute central line perforation in this area may result in cardiac tamponade and in
sudden hemodynamic decompensation. In this instance, rapid surgical exposure, tamponade decompression, and vascular control are required to save the patient. In our series, 3 patients presented with acute tamponade, and 1 of them died.

The clinical profile of patients who sustain chronic catheter injury at the innominate–caval junction is often characteristic. These patients are often elderly women who are plagued with chronic disease, bedridden, and malnourished (as indicated by their albumin and protein levels). All of these factors result in poor overall tissue quality, and these patients are often predisposed to other complications.

Chronic catheter injuries that result from placement of a central line are usually associated with left-sided catheter insertion (73% on analysis of world literature), with the catheter tip eroding the cephalad portion of the SVC. Anatomically, when compared with the right innominate vein, the left innominate vein is more horizontal, and its junction with the SVC is almost a right angle. Tips of catheters that are inserted via the left approach are thus more likely to impinge on the right caval wall. This is particularly true when the length of the inserted catheter is insufficient. Unfavorable angulation of the catheter against the SVC wall, hyperosmolar irritation produced by the infused solution, and mechanical forces from catheter migration promote vascular perforation. Erosion may occur even when proper position of the catheter tip in the SVC has been confirmed radiographically. It is well documented that flexion and extension of the neck can cause a central venous catheter to migrate several centimeters, and this migration can unfavorably reposition the catheter tip. Although the most common result of delayed perforation is unilateral pleural effusion on the right side, the pleural effusion is bilateral in nearly one third of patients. Bilateral pleural effusion occurs when the infused solution tracks along mediastinal pleural planes to communicate with both pleural planes, in much the same way that a pneumomediastinum can result in bilateral pneumothorax.

The clavicle and sternum are bony shields to the central venous system (Fig. 2), and resection of the clavicular head, or sternotomy, or both are usually necessary to achieve vascular control. For injuries of the confluence of the internal jugular and subclavian veins, resection of the clavicular heads is required for adequate exposure. Although some subclavian venous injuries can be managed without median sternotomy—using clavicular division and disarticulation of the sternoclavicular joint—maximal exposure is achieved when median sternotomy is added. Thoracotomy does not provide good exposure of the subclavian–jugular junction; patient 1 in our series died from exsanguination before vascular control of the subclavian–jugular venous junction could be achieved by means of a thoracotomy. Ligation of venous injuries at the subclavian–jugular venous junction is recommended by some because of the difficulty of vascular reconstruction at venous confluences; however, in our series repair was possible in the majority of cases, and is preferable to ligation. In our 4 patients who sustained such injuries, the best exposure by far was achieved in those with median sternotomy and clavicular head resection. One patient required cardiopulmonary bypass because of simultaneous venous and arterial hemorrhage from the jugular–subclavian venous junction and the left carotid artery.

For injuries at the innominate–caval junction, a median sternotomy provides sufficient exposure; it is not necessary to extend the incision into the neck.

![Fig. 2](image_url)  
*Fig. 2. A* Anatomic position gives poor exposure of the subclavian–jugular and innominate–caval junctions. *B* Resection of the clavicular heads exposes the subclavian–jugular confluence, but gives poor access to the more central portions of the innominate veins. *C* The addition of a median sternotomy gives excellent exposure of both the innominate veins and their confluence with the superior vena cava.*

C=clavicle; R1=1st rib
or to resect the clavicle. The majority of chronic indwelling catheter erosion cases that result in hydrothorax require only drainage of the effusion and removal of the catheter; usually there is no need for surgical repair of the central venous injury. For acute injuries that result in tamponade, expeditious sternotomy is required.

Conclusions

We conclude that injuries of the innominate–caval junction are usually catheter-related, that they can occur from catheter insertions at either side, and that acute injuries frequently result in cardiac tamponade. Furthermore, significant subclavian–jugular venous injuries are usually caused by penetrating trauma such as gunshot wounds, and are not commonly catheter-related. For innominate–caval confluence exposure, median sternotomy alone is adequate; for subclavian–jugular exposure, extension of the incision into the neck and resection of the clavicle are necessary. Vascular control can be achieved by means of standard vascular clamps, ligation, or cardiopulmonary bypass. Most catheter-related central venous injuries that result in hydrothorax are best managed simply, by removing the catheter and draining the effusion.

References


