The variable anatomical relationship of phrenic nerve and subclavian vein: clinical implication for subclavian vein catheterization

G. K. Paraskevas*, A. Raikos, K. Chouliaras and B. Papaziogas

Department of Anatomy, Medical School of Aristotle University of Thessaloniki, PO Box 300, 54124 Thessaloniki, Greece

* Corresponding author. E-mail: g_paraskevas@yahoo.gr

Background. During subclavian vein catheterization, a potential, but rare, hazard is the phrenic nerve injury, which compromises respiratory function. We conducted a cadaver study focused on the possible anatomical relationships between the subclavian vein and the phrenic nerve.

Methods. Forty-two adult cadavers (84 heminecks) were dissected. Special attention was given to the topography of the phrenic nerve and subclavian vein.

Results. In all but three cases (81 of 84), normal topography was present, that is, the nerve was posterior to the vein. In two cases, the phrenic nerve crossed anterior to the subclavian vein and in one case traversed the anterior wall of the subclavian vein.

Conclusions. Variants of the relationship of the subclavian vein and the phrenic nerve should be familiar to anaesthesiologists during subclavian vein cannulation in order to achieve successful vein approach without causing phrenic nerve palsy.

Keywords: catheterization; phrenic nerve variations; subclavian vein

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diaphragm, and it also carries significant afferent fibres from the diaphragm, pericardium, pleura, and peritoneum. It arises principally from C4 root with occasional contributions from C3 and C5. It descends almost vertically on the anterior surface of the obliquely running anterior scalene muscle, behind the pre-vertebral fascia. Then, it crosses in front of the first portion of the subclavian artery posterior to the subclavian vein and enters the thorax by intersecting medially in front of the internal thoracic artery. Each nerve lies in the thorax in contact with the mediastinal pleura throughout its course towards the diaphragm.

Subclavian vein catheterization can cause complications in 4–35% of the cases including pneumothorax, hemothorax, mediastinal haematoma, brachial plexus injury, cannulation of the subclavian artery, thrombophlebitis, air embolism, injury to the recurrent laryngeal nerve, erosion of catheter, and phrenic nerve injury. Phrenic nerve palsy generally represents an immediate complication of subclavian venipuncture, but sometimes can be a late complication. Usually, patients with phrenic nerve palsy exhibit reduction in vital capacity along with symptoms of hypoxia and rarely pain on the right shoulder.

A number of mechanisms have been proposed to explain the injury of the phrenic nerve during subclavian and central venous catheterization. Direct nerve injury usually attributed to repeated attempts at venipuncture. Haemorrhagic compression of the phrenic nerve by a mediastinal haematoma or even compression of the phrenic nerve by the rigid tip of the venous catheter without perforating the subclavian vein can occur. Large needle size is a predominant factor for more severe nerve injury in the case of needle nerve perforation. Transient phrenic nerve paralysis due to local anaesthetic instilled at the beginning of the catheterization has been reported. Inflammation of the venous wall as a result of the catheter could lead to phrenic nerve compression. Moreover, inflammation could potentially induce damage to vasa nervorum of the phrenic nerve.

It is rare for the phrenic nerve to pass anterior to the subclavian vein. We found the variant in 2.38% of the cases; specifically we recorded two instances on the left side, in which the entire phrenic nerve crossed anterior to the subclavian vein in close proximity to the junction between the subclavian and internal jugular vein. Incidences of this aberrant location vary between: occasionally, and 9%. A recent case was documented by Prakash and colleagues.

Accessory phrenic nerves may cross anterior to the subclavian vein. An accessory phrenic nerve is present between 61.8% and 75% of people. The reported incidence of a pre-venous accessory phrenic nerve vary between 22%, 66%, and 84%. However, Loukas and colleagues commented that in 45% of the studied cases, the loop between the phrenic and accessory phrenic nerve involved the subclavian vein. If an accessory phrenic nerve exists, then damage of the main trunk of the phrenic nerve during catheterization will not produce complete paralysis of the corresponding half of the diaphragm due to motor fibre content.

Penetration of the subclavian vein by the phrenic nerve has been reported previously. Zeren reported one sole case among 900 dissections; Last and Anson only refer to it as ‘rarely found’. Talbot noticed in one specimen the presence of an accessory phrenic nerve passing through the subclavian vein and dividing it into two channels. Similarly, Codesido and Guerri-Gutenberg presented a case of accessory phrenic nerve passing through an annulus of the subclavian vein located 1 cm away from the jugulo-subclavian junction. In one of our cases, the right phrenic...

![Fig 1](https://academic.oup.com/bja/article-abstract/106/3/348/321861/16810)

**Fig 1.** Female cadaver, 74-yr-old, the left phrenic nerve (arrow) crossed anterior to the ipsilateral subclavian vein. It is positioned 0.5 cm away from the jugulo-subclavian junction instead of being located posterior to the subclavian vein (SV). IJV, internal jugular vein; SM, sternocleidomastoid muscle; BP, brachial plexus; CR, cranial; CA, caudal; L, lateral; M, medial.
nerve traversed the anterior wall of the right subclavian vein without dividing the vein into two distinct and separate venous channels. So, the cannulating needle could potentially damage the tethered phrenic nerve.

In summary, our results show that the anteriorly placed phrenic nerve may be situated in close proximity to the ipsilateral jugulo-subclavian junction. It is preferable for the anaesthetist to place the puncture site more laterally at the outermost portion of the subclavian vein. Furthermore, puncture sites higher in the neck or more laterally into the axillary vein may also minimize the risk of nerve impairment.
This study reinforces the need to appreciate anatomical variants during invasive practical procedures. The variants in the course of the phrenic nerve may make it more likely to be harmed during subclavian and jugular catheterization. Such variations are not apparent clinically or with ultrasound guidance. The risk of such damage at the time of needle puncture could be minimized by first-pass puncture of the vein and by real-time anatomical evaluation via ultrasound guidance and the assistance of various techniques for better topographical landmarks identification.

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Conflict of interest
None declared.

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