

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

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Editor's key points

- The phrenic nerve ordinarily enters the thoracic cavity posterior to the subclavian vein.
- The nerve can rarely cross anterior or penetrate the subclavian vein.
- The phrenic nerve, crossed anterior and inside subclavian vein wall in 2 and 1 of 84 cases, respectively.
- The lateral outermost segment of the subclavian vein should be preferred during its catheterization.

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

Accepted for publication: 13 August 2010

The topographical relationship between the phrenic nerve and the subclavian vein is of clinical interest since the phrenic nerve may be damaged during subclavian vein catheterization.^{1 2} The phrenic nerve ordinarily enters the thoracic cavity posterior to the subclavian vein,^{3 4} less commonly anterior to it, and rarely may penetrate it.^{5 6} The terminal branches pierce the diaphragm and spread on the abdominal surface of the diaphragm supplying the parietal peritoneum through connections with branches of celiac plexus.⁷ Further knowledge of analogous variable relationships are helpful to explain and prevent damage to the phrenic nerve during the subclavian vein catheterization.

Methods

During routine dissections of 42 Caucasian formalin-embalmed adult cadavers (25 males and 17 females, mean age 72 yr), we recorded the topographical relationship of the subclavian vein and the phrenic nerve at the thoracic outlet. The root of the neck was carefully dissected after removal of the clavicle to expose this topography. The medical history of the cadavers did not suggest an abnormal relationship between the phrenic nerve and the subclavian vein in any case. There were no surgical scars or gross anatomical and morphological abnormalities and the cause of death was not due to vascular or

neurological disease. Measurements and photographs were taken and schematic drawings were prepared during the course of the anatomical dissections.

Results

In 81 of the 84 studied supraclavicular regions, the phrenic nerve was found posterior to the subclavian vein, in two cases (2.38%) anterior to the subclavian vein [95% confidence interval (CI), 2.6–2.36%], and in one case (1.19%) traversing through the anterior wall of the subclavian vein (95% CI, 1.3–1.08%). In these two cases (female, 74 yr; male, 86 yr, both on the left side), the phrenic nerve crossed anterior to the subclavian vein ~0.5 and 0.3 cm, respectively, lateral to the jugulo-subclavian junction (Figs 1 and 2, respectively). In the third case (male, 83 yr), the right phrenic nerve traversed the anterior wall of the right subclavian vein, just 1.4 cm lateral to the jugulo-subclavian junction. It penetrated the anterior wall 0.2 and 0.3 cm from the superior and inferior border of the subclavian vein, respectively (Fig. 3).

Discussion

The phrenic nerve is of clinical importance because it is the sole motor supply to the corresponding half of the

diaphragm, and it also carries significant afferent fibres from the diaphragm, pericardium, pleura, and peritoneum.⁵ 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, haemothorax, 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.⁸ Phrenic nerve palsy generally represents an immediate complication of subclavian venipuncture,^{1,9} but sometimes can be a late complication.^{2,10} Usually, patients with phrenic nerve palsy exhibit reduction in vital capacity along with symptoms of hypoxia^{11,12} and rarely pain on the right shoulder.¹⁰

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.⁹ 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.¹ Large needle size is a predominant factor for more severe nerve injury in the case of needle nerve perforation.¹³ Transient phrenic nerve paralysis due to local anaesthetic instilled at the beginning of the catheterization has been reported.¹⁴ Inflammation of the venous wall as a

result of the catheter could lead to phrenic nerve compression.² Moreover, inflammation could potentially induce damage to vasa nervorum of the phrenic nerve.¹⁰

It is rare for the phrenic nerve to pass anterior to the subclavian vein.^{15,16} 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,^{6,11,17} 7.25%¹⁸ and 9%.¹¹ A recent case was documented by Prakash and colleagues.¹⁹

Accessory phrenic nerves may cross anterior to the subclavian vein. An accessory phrenic nerve is present between 61.8%²⁰ and 75%²¹ of people. The reported incidence of a pre-venous accessory phrenic nerve vary between 22%, 66%, and 84%.^{11,20} However, Loukas and colleagues²⁰ 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.^{3,20}

Penetration of the subclavian vein by the phrenic nerve has been reported previously. Zeren²² reported one sole case among 900 dissections; Last¹⁵ and Anson²³ only refer to it as 'rarely found'. Talbot¹¹ 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-Gutenberg²⁴ 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

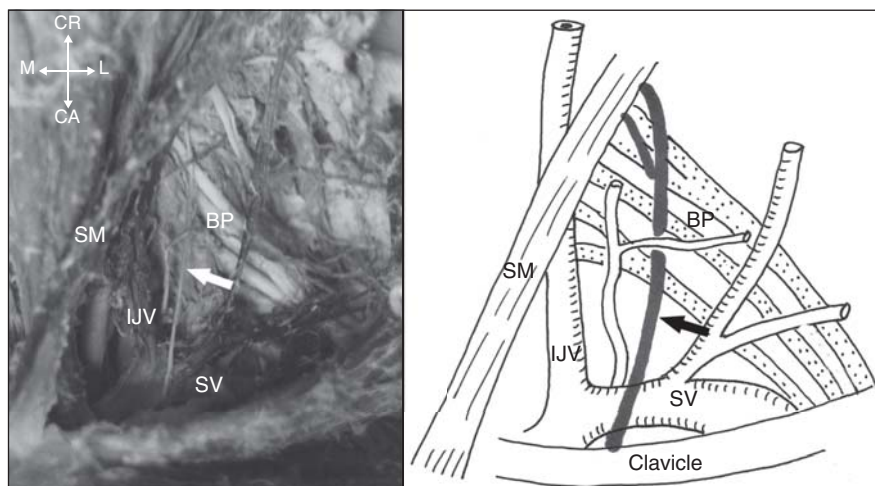


Fig 1 Female cadaver, 74-yr-old, the left phrenic nerve (arrow) crossed anterior to the ipsilateral subclavian vein. It is positioned 0.5 cm away from the jugulo-subclavian junction instead of being located posterior to the subclavian vein (SV). IJV, internal jugular vein; SM, sternocleidomastoid muscle; BP, brachial plexus; CR, cranial; CA, caudal; L, lateral; M, medial.

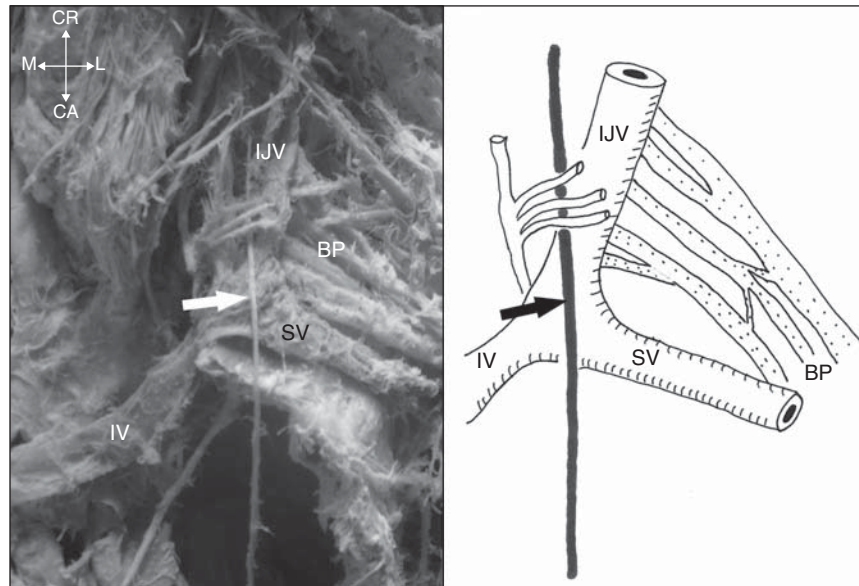


Fig 2 Male cadaver, 86-yr-old, the left phrenic nerve (arrow) directed obliquely in front of the left subclavian vein (SV) just 0.3 cm lateral to the ipsilateral jugulo-subclavian junction. IJV, internal jugular vein; IV, innominate vein; BP, brachial plexus; CR, cranial; CA, caudal; L, lateral; M, medial.

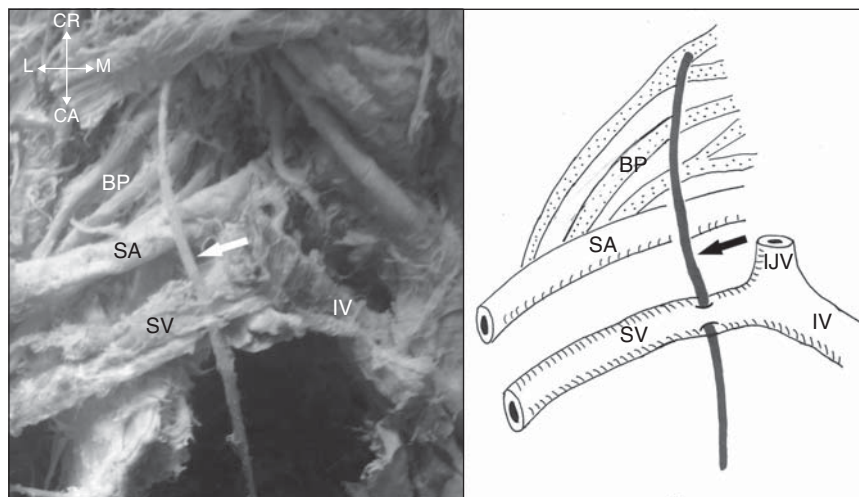


Fig 3 Male cadaver, 83-yr-old, the right phrenic nerve (arrow) was running obliquely traversing the anterior wall of the right subclavian vein (SV) just 1.4 cm lateral to the ipsilateral jugulo-subclavian junction. The penetration points were located 0.2 cm from the superior and 0.3 cm from the inferior border of the subclavian vein. SA, subclavian artery; IJV, internal jugular vein; IV, innominate vein; 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.²⁵ 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.²⁶

Acknowledgement

The authors would like to acknowledge Abdulatif Al Haj, MSc, for his excellent support in statistical analysis of our data.

Conflict of interest

None declared.

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