Anatomical Variations of the Posterior Intercostal Arteries and the Thoracic Vertebral Artery

L KOCBEK 1, I KRAJNC 2 AND F ANDERHUBER 3

1Institute of Anatomy, Histology and Embryology, and 2Department of Internal Medicine, Faculty of Medicine, University of Maribor, Maribor, Slovenia; 3Institute of Anatomy, Medical University of Graz, Graz, Austria

This study evaluated the occurrence and frequency of the anatomical variations of the origin and course of the posterior intercostal arteries (PIA) in 44 human cadavers. During a classical anatomical dissection of each cadaver an anomalous course of the PIA, defined as a thoracic vertebral artery, was found in six (14%) individuals. Every dorsally coursing PIA was taken into account, regardless of its origin, and their different origins and course were described. A specific dorsal course for the PIA was found in nine cases, which was bilateral in two cases. The variations that were found and that have been schematically presented will provide new information about the anatomical variations of the PIA. Consideration of the potential for anatomical variation of the PIA is important in vascular and thoracic surgery and in diagnostic and interventional radiology such as spinal angiography.

KEY WORDS: POSTERIOR INTERCOSTAL ARTERIES; THORACIC VERTEBRAL ARTERIES; ANATOMICAL VARIATION; THORACIC AORTA

Introduction

There are 12 pairs of posterior intercostal arteries (PIA). The first two pairs originate via the supreme intercostal artery from the costocervical trunk of the subclavian artery and the lower nine (excluding the subcostal artery) are segmental dorsal branches of the descending aorta. Each artery gives off a number of branches for vascularization of the spinal cord, nerve roots, intercostal, pectoral and serratus muscles, mammary glands and skin.1–4 Normally, the PIA run vertically to the ribs but sometimes they run dorsally between the ribs and the transverse processes, through the costotransverse foramina, like the vertebral arteries.5 Regardless of origin, all arteries that run through the costotransverse foramina of the upper thoracic region are named after Krassnig6 as the thoracic vertebral arteries (synonyms: arteria vertebralis thoracalis, arteria vertebralis dorsi, arteria vertebralis dorsi and arteria vertebralis descendens), despite the fact that the real thoracic vertebral artery originates from the vertebral artery or comes as the highest of the PIA direct from the thoracic aorta. The presence of the thoracic vertebral artery known in mammals is temporary in human embryos and its presence is connected to elongation of
the cervical canal.6,7 The investigation by Krassnig6 was centred on the thoracic vertebral arteries originating from the supreme intercostal artery, but little is known about the dorsal course of the PIA as direct branches of the thoracic aorta. There are also limited data defining the dorsal course of each PIA regarding their relationships with the neighbouring arteries, their origins and the course that they take to reach the corresponding intercostal space.

Subjects and methods

SUBJECTS AND PROTOCOL

Cadavers of individuals who donated themselves for scientific research and who had no macroscopic pathological and atherosclerotic lesions were selected for study. No selection criteria were used regarding gender, age or cause of death. The study was carried out at the Institute of Anatomy, Histology and Embryology, Faculty of Medicine, University of Maribor, Slovenia and at the Institute of Anatomy, Medical University of Graz, Graz, Austria. The study protocol was approved by The National Medical Ethics Committee of the Republic of Slovenia (NMEC), University Institute of Clinical Neurophysiology, Medical Centre Ljubljana, Ljubljana, Slovenia.

ANATOMICAL DISSECTION

Classic anatomical macrodissection using standard anatomical pincettes and scalpels was performed. The cadavers were fixed using the method of Thiel8,9 and the arteries were injected with a mass consisting of dextrin, latex and lead tetroxide, which provided the ideal firmness for dissection. The chest was opened by a midline thoracotomy, the ribs were cut at the mid-axillary line, and the heart and lungs were removed to visualize the aorta. The external and internal intercostal muscles in the intercostal spaces were removed and fine preparation of the arteries of interest was undertaken.

Results

A total of 44 cadavers were examined and a specific dorsal course for the PIA was found in nine cases, which was bilateral in two (5%) cases. An anomalous course of the PIA, defined as a thoracic vertebral artery, was found in six (14%) individuals. Five (6%) out of 88 paired arteries from the 44 specimens originated via the supreme intercostal artery from the costocervical trunk of the subclavian artery: three on the left and two on the right. The course pattern of the PIA was different regarding the number of intercostal arteries originating either from the supreme intercostal artery or the thoracic aorta. In one case the first and second PIA originated from the supreme intercostal artery but only the second PIA was found to be running dorsally to the second rib (Fig. 1A). In another case the first and second PIA originated from the supreme intercostal artery and both were running dorsally to the first and second rib (Fig. 1B). In one case, all three PIA originated from the supreme intercostal artery but only the third one was running dorsally to the third rib (Fig. 1C) and, in one case, all of the first three PIA were running dorsally to the first, second and third ribs (Fig. 1D). Four of the 88 arteries (5%) were direct branches of the thoracic aorta, with two on each side. All dorsally coursing PIA derived from the thoracic aorta formed a common trunk with the artery above or below: in one case, with regard to the second and third PIA, the second PIA went upwards and dorsally to the third rib (Fig. 1E); and, in three cases, with regard to the fourth and the fifth PIA, the fourth artery ran upwards and dorsally to the fifth rib (Fig. 1F; Fig. 2 – see arrow). There was no evidence of dorsally coursing PIA in the lower
Variable anatomy of the posterior intercostal arteries

In two individuals, a bilateral pattern of the thoracic vertebral artery was found. In one, the first and second PIA originated from the supreme intercostal artery, but only the second PIA ran dorsally to the second rib (Fig. 1A). In another individual, the fourth and the fifth PIA originated from the thoracic aorta via a common trunk. After branching from the fifth PIA, the fourth PIA ran perpendicular over the dorsal side of the fifth rib into the fourth intercostal space (Fig. 1F; Fig. 2 – see arrow) and continued its common course in the intercostal space between the intercostal vein and nerve.

Discussion

Many variations are known to occur relating to the site of the orifice, size, number of branches, supply area and other variables affecting the PIA or an entire arterial segment. The anomalous dorsal course of the PIA of different origins is rare and it has been investigated by only two other groups. Lippert and Pabst reported a frequency of 5% for dorsally coursing PIA from the supreme intercostal artery and the third PIA originating from the thoracic aorta has been reported in 4% of cases. In contrast, in the present study, every dorsally coursing artery was taken into account regardless of its origin, rather than just the first two or three PIA. The dorsal course of the fourth PIA has never been described before, but it was found to originate as a common trunk with the fifth PIA from the thoracic aorta, even bilaterally. All dorsal PIA from the thoracic aorta were found to originate

FIGURE 1: Variations of the dorsal course of the posterior intercostal arteries (PIA) originating via the supreme intercostal artery of the costocervical trunk from the subclavian artery (A, B, C, D) and from the thoracic aorta (E, F)
Variable anatomy of the posterior intercostal arteries

FIGURE 2: Dorsal course of the fourth posterior intercostal artery (PIA) going upwards behind the fifth rib (arrow) and originating from the thoracic aorta forming a common trunk with the fifth PIA

via a common trunk with the artery above or below. During embryonic development the cephalic folding, growth of the forebrain and elongation of the neck push the heart from the level of cervical flexure into the thoracic cavity and is responsible for the formation of a common trunk between two neighbouring PIA, which is formed by the proximal end of either one or other artery, by which it causes the more cranial intercostal arteries to take an upward course. The close physical origins, therefore, explain the occurrence of trunk formations involving two or more arteries.5

The side on which the arteries were positioned dorsally occurred almost equally on the left and right in the present study, compared with Adachi13 who found the dorsal supreme intercostal artery more frequently on the right side and the dorsal artery from the thoracic aorta more frequently on the left side. The dorsal course of the supreme intercostal artery or those of thoracic aortal origin are usually an incidental finding without any reported contribution to the patient's symptoms. Knowledge of anatomical variations in the
course of the PIA is important in vascular and thoracic surgery, in diagnostic and interventional radiology, especially in spinal angiography.4,15 – 18 During spinal angiographic imaging the radiologist should take into consideration any possible variation of the origin and course of the PIA because of its importance in angiography in this area.

In conclusion, the present study has reported some anatomical variations of the dorsally coursing PIA that have not been described previously. These variations, which might be due to pathological conditions such as atherosclerosis, elongation of the aorta, fracture of the spinal cord or ribs or as a result of an abnormal alignment of the spinal column, should be taken into consideration in clinical practice.

Conflicts of interest
The authors had no conflicts of interest to declare in relation to this article.

• Received for publication 17 January 2011 • Accepted subject to revision 7 February 2011 • Revised accepted 5 April 2011

References


Author’s address for correspondence
Dr Lidija Kocbek
Institute of Anatomy, Histology and Embryology, Faculty of Medicine, University of Maribor, Slomškov trg 15, SI-2000 Maribor, Slovenia.
E-mail: lidija.kocbek@gmail.com