Incidental findings of vascular anatomic variants on computed tomography

Alejandro Rodriguez, Ricardo Cobeñas, Juan Cruz Gallo, Alejandra Salamida, Nebil Larrañaga, Shigeru Kozima

Resumen
Introducción. El hallazgo de variantes anatómicas vasculares en estudios de tomografía computada (TC) puede generar confusiones, diagnósticos incorrectos e incluso la solicitud de nuevos estudios complementarios más invasivos.
El conocimiento de estas variantes, además, es importante porque pueden estar asociadas a otras anomalías, como cardiopatías, poliesplenia o síntomas como disfagia o disnea.
Objetivo. El objetivo de esta publicación es describir las variantes anatómicas vasculares halladas incidentalmente en estudios de tomografía computada.
Materiales y Métodos. Se revisaron 3586 estudios, realizados desde junio de 2010 hasta junio de 2011, con tomografía computada multicorte de 16 y 64 detectores. Entre los estudios analizados, se encontraron: arco aórtico derecho (AAD), subclavia derecha aberrante, vena cava superior izquierda, vena subclavia izquierda aberrante, vena cava inferior (VCI) izquierda, vena renal izquierda doble, vena renal circumaórtica, vena renal izquierda retroaórtica, subhepática e interrupción de la vena cava inferior con continuación en ácigos/hemiácigos.
Conclusión. Las variantes anatómicas vasculares son hallazgos que se encuentran con relativa frecuencia en forma incidental en estudios solicitados por otras razones. Su conocimiento puede evitar confusiones y la realización de estudios complementarios innecesarios, así como también nos obliga a analizar la presencia de otras anomalías que podrían estar asociadas.
Palabras clave. Tomografía computada multidetector. Variantes anatómicas vasculares. Tomografía computada.

Abstract
Incidental findings of vascular anatomic variants on computed tomography.
Introduction. Incidental findings of vascular anatomic variants on computed tomography scans (CT) may cause confusion, misdiagnosis and lead to even more invasive complementary exams.
The knowledge of these variants is also important because they can be associated with other anomalies such as heart diseases or polyosplenia, and symptoms like dysphagia or dyspnea.
Purpose. The aim of this study is to describe the vascular anatomical variants incidentally found on computed tomography imaging.
Materials and Methods. A total of 3586 scans were performed between June 2010 and June 2011 with 16-row and a 64-row Multidetector CT scanners. Findings included: right aortic arch, aberrant right subclavian artery, aberrant left subclavian vein, left superior vena cava, left inferior vena cava, double inferior vena cava, circumaortic renal vein, retroaortic left renal vein, subhepatic vein and azygos continuation of the inferior vena cava.
Conclusion. Vascular anatomical variants are found with relative frequency on CT scans requested for other reasons. To be familiar with these anomalies may prevent confusions, diagnostic errors and unnecessary complementary exams and forces us to search for other associated anomalies.

INTRODUCTION

Given the extended use of computed tomography (CT) for the evaluation of the most varied symptoms and/or pathologies, and the use of intravenous contrast in these studies, the evaluation of the different vascular anatomic variants has become routine for radiologists.

A proper analysis of a CT scan requires knowledge of the vascular anatomy of the scanned area. Furthermore, it is important to check the correct arrangement of vessels and their filling defects in the case of intravenous contrast-enhanced CT scans, both for future surgery planning and to account for symptoms reported by the patient.

At the time of interpretation of CT findings, it is not only necessary to consider the various anatomic variants that may occur, but also to have the knowledge of their different classifications, relationship with different symptoms and their association with other anomalies.

Ignorance of these vascular variants may lead to serious problems for the patient and it may even have medical and legal implications.

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Recibido: enero 2012; aceptado: septiembre 2012
Received: january 2012; accepted: september 2012
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doi: 10.7811/rav77n1a03
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MATERIALS AND METHODS

A total of 3586 scans performed from June 2010 to June 2011 with 16-row and 64-row multidetector CT scanners were reviewed. The age of patients involved ranged from 2 to 93 years old, with a mean age of 68 years. Males were 2110, with an age range between 4 and 90 years and a mean age of 65 years, while females were 1476, with an age range between 2 and 93 years and a mean age of 68 years. Indications were varied; some of the most common included abdominal pain, tumor staging and follow-up, evaluation of renal and hepatic cysts, arterial and venous thrombosis, CT-urography, CT enterography (CTE) and ultrasounds that were difficult to read because of overlapping bowel gas.

Intravenous contrast was administered at a dose of 1.5 ml/kg of body weight, by infusion pump at an approximate rate of 2.5 to 4 ml per second. A triphasic protocol was used, with series at 30 seconds, 70 seconds and 5 minutes for visualization of the branches of the celiac trunk and superior mesenteric artery, and of the origin of the hepatic, splenic, left gastric and gastroduodenal arteries.

Furthermore, for studying abdominal conditions, 2066 patients received an oral intake of 1000 ml of water mixed with 30 ml of iodinated contrast an hour prior to the scan, for better visualization of the digestive tract.

Patients were required to fast for at least 6 hours prior to the scan in order to prevent gastrointestinal complications from intravenous contrast injection.

Oral or intravenous contrast was not administered in patients who had a previous history of atopy.

RESULTS

Out of 3586 patients evaluated, 23 had vascular anomalies; i.e., 0.64% (Table 1).

We founded a total of five thoracic and eighteen abdominal vascular anomalies: Thoracic: 1 right aortic arch (RAA), 2 aberrant right subclavian arteries, 1 left inferior vena cava (IVC) and 1 aberrant left subclavian vein. Abdominal: 4 left inferior vena cava (IVC), 3 double renal veins, 3 circumaortic left renal veins, 4 retroaortic left renal veins, 1 double IVC, 1 accessory suprahepatic vein and 2 interruption of the inferior vena cava with direct continuation towards the azygos/hemiaicigos vein.

DISCUSSION

Vascular anatomic variants are abnormalities in the usual arrangement of vessels, which are found with relative frequency on contrast CT imaging for reasons unrelated to these abnormalities.

Right aortic arch

RAA is a rare and asymptomatic entity that is usually diagnosed incidentally. On plain chest radiograph (X-ray), it may be confused with widening of the anterior and superior mediastinum and usually diagnosed after a chest CT scan (Fig. 1). Symptoms associated with this congenital anomaly arise from compression of the airway and, less frequently, of the upper digestive tract, resulting in recurrent respiratory tract infections, dry cough and dyspnea. This is a congenital malformation occurring during embryologic development as a consequence of a complete obliteration of the left 4th aortic arch and of the left dorsal aorta.

Table 1: Number and percentages of thoracic and abdominal vascular variants found.

<table>
<thead>
<tr>
<th>Vascular anatomical variants</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAA</td>
<td>1</td>
<td>4.5%</td>
</tr>
<tr>
<td>Aberrant right subclavian artery</td>
<td>2</td>
<td>9%</td>
</tr>
<tr>
<td>Aberrant left subclavian artery</td>
<td>1</td>
<td>4.5%</td>
</tr>
<tr>
<td>Left SVC</td>
<td>1</td>
<td>4.5%</td>
</tr>
<tr>
<td>Abdominal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left IVC</td>
<td>4</td>
<td>17%</td>
</tr>
<tr>
<td>Double renal vein</td>
<td>3</td>
<td>13%</td>
</tr>
<tr>
<td>Circumaortic renal vein</td>
<td>4</td>
<td>17%</td>
</tr>
<tr>
<td>Retroaortic renal vein</td>
<td>4</td>
<td>17%</td>
</tr>
<tr>
<td>Accessory suprahepatic vein</td>
<td>1</td>
<td>4.5%</td>
</tr>
<tr>
<td>IVC with azygos</td>
<td>1</td>
<td>4.5%</td>
</tr>
<tr>
<td>Double IVC</td>
<td>1</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

RAA: right aortic arch; SVC: superior vena cava; IVC: inferior vena cava.

![Fig. 1: Chest CT scan without IV contrast showing the aorta on the right (arrow).](image-url)
Aberrant right subclavian artery

Aberrant right subclavian artery is a malformation of the aortic arch, with an incidence of 0.5 % to 1.8 %. It is a distal branch arising from an otherwise normal aortic arch. It courses behind the trachea and esophagus, crossing the mediastinum obliquely from left to right (Fig. 2) [1,3,7].

Aortic arch with aberrant left subclavian artery

This is a rare anomaly, which is associated with a right aortic arch. It has an aortic diverticulum at its origin, the so-called Kommerell’s diverticulum. It may be associated with the tetralogy of Fallot, approximately in 3 % of cases [1,3,5].

Isolated left vertebral artery

The isolated left vertebral artery originates directly from the aortic arch. It is one of the most common aortic arch branch anomalies, occurring in about 4% of the general population [1,8].

Anomalous course of the right brachiocephalic vein trunk

Tortuosity and low position of the brachiocephalic vein relative to the aortic arch, in elderly patients, may simulate a mediastinal mass [1].

Persistent left SVC

It rarely occurs in the general population and it is associated with congenital cardiac malformations. The left subclavian and jugular veins directly drain into this abnormal SVC. It passes lateral to the aortic arch and main pulmonary artery, draining close to the right atrium, into the coronary sinus, posterior to the right ventricle [1,3] (Fig. 3).

Accessory left gastric artery

The accessory left gastric artery arises from the left hepatic artery and is a variant gastric artery that supplies the cardias and fundus of the stomach. The incidence of this variant has been reported to be 3-14 % in angiographic studies [3,5].
Incidental findings of vascular anatomic variants

Fig. 3: (a) Chest CT scan without IV contrast showing persistent left SVC. Catheter present inside (arrow). (b) 3D reconstruction showing left superior vena cava (arrow) to the left of the aortic arch, draining into the right atrium. (c) MIP (Maximum Intensity Projection) coronal reconstruction showing left superior vena cava (arrow), descending to the left of the aortic arch.

Fig. 4: (a) Axial view of the abdomen with presence of a retroaortic left renal vein (arrow). (b) Coronal view of the abdomen showing the retroaortic left renal vein (arrow).

Common hepatic artery not arising from the celiac trunk

The presence of a common hepatic artery supplying the entire liver parenchyma and not originating from the celiac trunk has been reported with an incidence of 2% to 5%. The most common anatomical variations in hepatic artery are an accessory left hepatic artery arising from the left gastric artery in 3.0% and an accessory right hepatic artery branching off the superior mesenteric artery in 12% of cases.\textsuperscript{3,9,11}
Variations of celiac trunk

Variations in one of the three arteries of the celiac trunk are associated with another vascular anatomical variation in the rest of the body in 61-64% of cases.

The rate of vascular variations findings in this region ranges between 30% and 47% according to various reviews (9,10).

Renal vessels anomalies

The anatomy of left renal vessels is very important because it is the preferred side for resection in kidney transplantation donors.

One variant is the retroaortic left renal vein (Fig. 4), which passes behind the aorta and drains into the IVC. It can be seen either at the same level as a normal left renal vein or as low as the confluence of iliac veins to form the IVC (1,12-14).

Multiple renal veins are the most common variant, occurring in 15-30% of individuals (Fig. 5).

The most common left renal vein variant is the circumaortic vein (Fig. 6). It is a vascular ring around the aorta. Generally, the additional retroaortic vein connects to the IVC one to two vertebrae below the level of the preaortic vein.

Left inferior vena cava

Left inferior vena cava results from persistence of the left supracardinal vein with regression of the right supracardinal vein. The infrarenal inferior vena cava...
Incidental findings of vascular anatomic variants

is located to the left of the aorta. Over the left renal vein, it crosses anterior to the aorta joining to the right renal vein to form a normal IVC to the right and upwards, until draining into the right atrium.

A direct association has been reported between the presence of this vascular anomaly and an increased incidence of deep venous thrombosis \(^{(1,14-18)}\).

**Double inferior vena cava**

Both IVC can be equal in diameter or either of them may be dominant, and therefore have a larger caliber. In general the union of both IVCs occurs at the level of renal veins and it can be clearly seen both in axial and coronal planes (Fig. 7) \(^{(1,14-18)}\).

**Azygos continuation of the inferior vena cava**

When the subcardinal vein fails to join the hepatic veins during the sixth week of fetal life, blood returns to the heart from the postrenal segment via the azygos or hemiazygos system, and hepatic veins drain into the right atrium. This finding is usually associated with other abnormalities, such as asplenia or polysplenia \(^{(1,3,14-18)}\).

The retrohepatic segment of the IVC, usually located anterior to the right diaphragmatic crus and posterior to the hepatic caudal segment, is absent \(^{(1,3,14-18)}\).

The widened azygos vein is usually seen on one side of the aorta (Fig. 8) and the hemiazygos vein on the other.

Thus, knowledge of any variation in vascular anatomy becomes essential in the preoperative evaluation of potential candidates for abdominal or endovascular surgical procedures.

**Accessory subhepatic or suprahepatic vein**

This is an hepatic vein draining directly into the IVC, beneath the usual termination of suprahepatic veins. From the surgical viewpoint, this finding is important in cases of partial hepatectomy, as ligation of these vessels is necessary when performing resection of segments drained by such accessory veins \(^{(19)}\).

**CONCLUSION**

Vascular anatomic variants are incidentally found with relative frequency on imaging studies requested for other reasons.

Knowledge of these anomalies may prevent confusions and unnecessary complementary exams, and also lead us to search for other associated anomalies.

**References**


The authors declare no conflicts of interests.