

# Multiple variations of the abdominal aorta in a single cadaver

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## ABSTRACT

Numerous variations of the abdominal aorta were observed during a routine dissection of the abdominal region in a 60-year-old male cadaver in the Department of Anatomy, Meram Faculty of Medicine, Selçuk University, Turkey. In the present case, a common inferior phrenic trunk arose from the abdominal aorta and then divided into two branches. The left gastric artery arose from the front of the abdominal aorta, with an accessory right hepatic artery arising from the superior mesenteric artery. Although the single right renal artery originated from the abdominal aorta, double left renal arteries were found to originate from the abdominal aorta. Knowledge of these variations could help surgeons to identify and protect the abdominal aorta during surgery.

**Keywords:** abdominal aorta, anatomy, variation

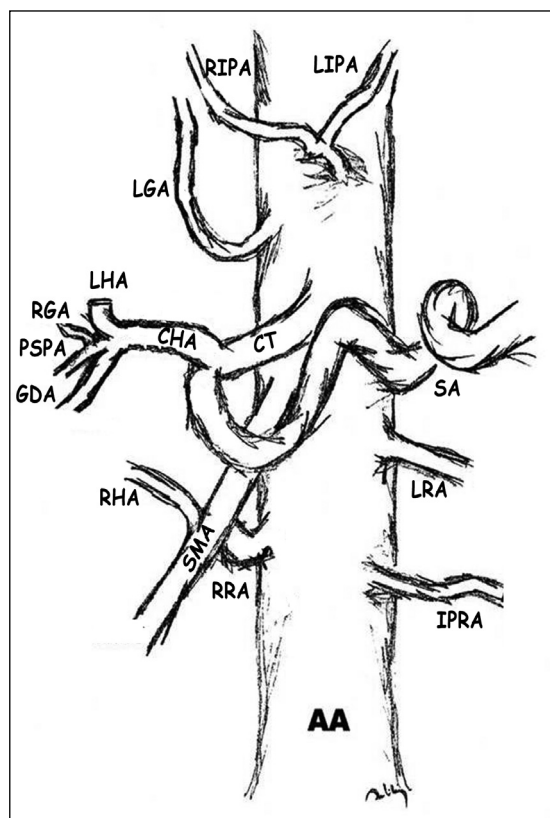
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## INTRODUCTION

The aorta, which is the main artery for circulation, is divided into three segments, according to its course: the aorta ascendans, arcus aorta and aorta descendens. Passing through the aortic hiatus underside the face of the thoracic 12 aorta lies the pars abdominalis aortae (abdominal aorta), which is 13 cm long and ends at the underside of lumbar 4. The branches of the abdominal aorta can be classified as single-double or visceral-parietal. The double visceral branches are the middle suprarenal, renal and testicular (ovarian artery) arteries, while the single visceral branches are the coeliac trunk, superior mesenteric and inferior mesenteric arteries. The double parietal branches are the inferior phrenic artery and arteriae lumbales, and the single parietal branch is the median sacral artery.<sup>(1)</sup> There have been many studies reporting the prevalence of variations in the branches of the abdominal aorta.<sup>(2-30)</sup>

## CASE REPORT

Variations in the branches of the abdominal aorta were observed during a routine abdominal region dissection



**Fig. 1** Illustration shows a description of the different types of arteries arising from the abdominal aorta.

RIPA: right inferior phrenic artery; LIPA: left inferior phrenic artery; LGA: left gastric artery; CT: coeliac trunk; CHA: common hepatic artery; LHA: left hepatic artery; PSPA: posterior superior pancreaticoduodenal artery; RGA: right gastric artery; GDA: gastroduodenal artery; SA: splenic artery; SMA: superior mesenteric artery; RHA: right hepatic artery; RRA: right renal artery; LRA: left renal artery; IPRA: inferior polar renal artery; AA: abdominal aorta

of a 60-year-old male cadaver at the Department of Anatomy of the Meram Faculty of Medicine at Selçuk University, Turkey. The inferior phrenic artery arose from a single rooted aorta just under the inferior phrenic artery diaphragm, and then bifurcated after 10.4 mm. The left hepatic artery arose from the abdominal aorta on the right side of the inferior phrenic artery. The coeliac trunk parted from the front side of the abdominal aorta, 11.5 mm from the aortic hiatus, and divided the common hepatic artery and splenic artery branches. The coeliac trunk was 6.6 mm thick and 33 mm away from the bifurcation, and its distance from the aortic bifurcation

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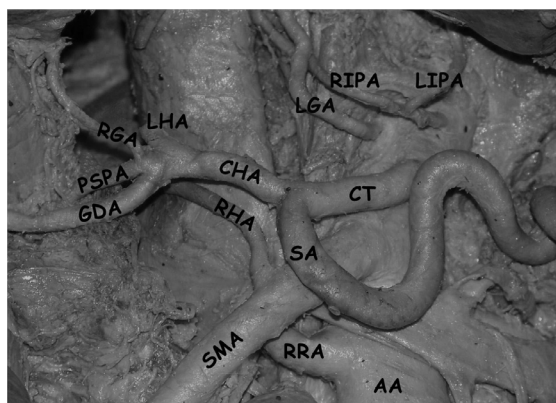
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**Fig. 2** Photograph shows sections of the different types of arteries arising from the abdominal aorta.

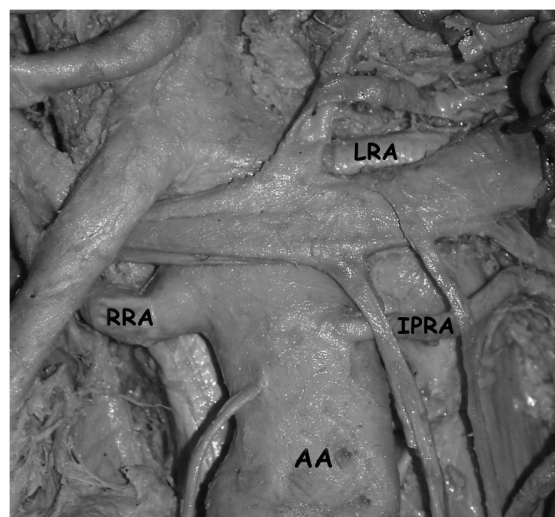
RIPA: right inferior phrenic artery; LIPA: left inferior phrenic artery; LGA: left gastric artery; CT: coeliac trunk; CHA: common hepatic artery; LHA: left hepatic artery; PSPA: posterior superior pancreaticoduodenal artery; RGA: right gastric artery; GDA: gastroduodenal artery; SA: splenic artery; SMA: superior mesenteric artery; RHA: right hepatic artery; RRA: right renal artery; LRA: left renal artery; IPRA: inferior polar renal artery; AA: abdominal aorta

was 126.3 mm. The superior mesenteric artery separated from the abdominal aorta 14 mm from the coeliac trunk and formed the right hepatic artery after 22.1 mm. The left hepatic artery and the gastroduodenal artery parted from the common hepatic artery, and the right gastric artery diverted from the gastroduodenal artery together with the posterior superior pancreaticoduodenal artery (Figs. 1 & 2).

The right renal artery arose from the right edge of the abdominal aorta at 13.2 mm from the diversion of the superior mesenteric artery, and its width at the base was 9 mm. Two renal arteries at a distance of 22 mm from each other were observed on the left side. The upper artery was evaluated as the left renal artery and the lower artery as the inferior polar renal artery. The thickness of the left renal artery and the inferior polar renal artery was 4.0 mm and 6.3 mm, respectively (Figs. 1 & 3).

## DISCUSSION

The inferior phrenic arteries are a pair of arteries on both sides of the diaphragm, and they have a highly variable origin. They arise separately from the front side of the aorta, just above the coeliac trunk.<sup>(1)</sup> However, it is known that they sometimes emerge as a single root. In a study conducted on 330 cadavers, Loukas et al classified the inferior phrenic artery into five groups according to its origin: from the coeliac trunk (Type A), from the aorta (Type B), from the renal artery (Type C), from the left gastric artery (Type D) and from the hepatic artery proper (Type E). In addition, they studied the origin of the left and right inferior phrenic arteries as a single rooted



**Fig. 3** Photograph shows the left renal artery (LRA), right renal artery (RRA) and inferior polar renal artery (IPRA) parting from the abdominal aorta (AA).

artery or separately, and determined that it originated from the coeliac trunk or the aorta as a single root.<sup>(2)</sup> Piao et al reported that the inferior phrenic artery arose as a single root from the abdominal aorta in 11 of the 68 cadavers that they dissected.<sup>(3)</sup> The inferior phrenic artery in the present case was a single root arising from the abdominal aorta, an observation that concurs with the cases encountered more often (31%) by Loukas et al.<sup>(2)</sup> Saeed et al found in a study conducted on 52 cadavers that in five cases (9.6%), the inferior phrenic artery diverted from the coeliac trunk either as a joint root or as single branches, and recorded their common root length as 5 mm.<sup>(4)</sup> In the present case, after having arisen from the abdominal aorta as a single root, the inferior phrenic artery bifurcated into the left and right inferior phrenic artery at a distance of 10.4 mm. This distance is nearly twice as much as the previously reported distances.

The left gastric artery is the initial branch of the coeliac trunk. Previous studies have reported that the left gastric artery parted directly from the abdominal aorta.<sup>(5-7)</sup> Ishigami et al encountered the accessory left gastric artery in 25% of the 118 cases in their study.<sup>(8)</sup> Saga et al demonstrated that the left gastric artery, 3 mm in its outer diameter, was rooted at the abdominal aorta, toward the right edge and at the mid-half section of the front wall.<sup>(9)</sup> The left gastric artery in our case arose from the right front side of the abdominal aorta, and its outer diameter was 3.9 mm, as reported by Saga et al.<sup>(9)</sup>

The coeliac trunk is a visceral branch of the abdominal aorta with a 7–20 mm thickness and 12.5 mm length, which splits just under the aortic hiatus at the level of the thoracic 12. Cavdar et al reported the distance between the coeliac trunk and the aortic hiatus

**Table I. The prevalence (%) of right hepatic artery variations in various studies.**<sup>(19,25-30)</sup>

Study	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Hiatt et al <sup>(9)</sup> (n = 1000)	75.7	9.7	10.6	2.3	1.5	0.2
Michels <sup>(25)</sup> (n = 200)	55.0	18.0	18.0	4.0	2.5	0.5
Rong and Sindelar <sup>(26)</sup> (n = 120)	51.0	12.0	21.0	-	5.0	11.0
Kemeny et al <sup>(27)</sup> (n = 100)	59.0	17.0	18.0	2.0	3.0	1.0
Rygaard et al <sup>(28)</sup> (n = 216)	75.5	4.6	13.4	1.9	1.4	3.2
Daly et al <sup>(29)</sup> (n = 200)	76.0	7.7	12.0	-	6.0	-
Niederhuber and Ensminger <sup>(30)</sup> (n = 111)	73.0	10.0	11.0	2.0	5.0	-

The types of right hepatic artery variations are based on Hiatt et al's classifications.<sup>(9)</sup>

as 12.5 mm;<sup>(10)</sup> however, the distance was 11.5 mm in our study. In another study, Yahel and Arensburg reported that the mean distance of the coeliac trunk from the aortic bifurcation in males was 127 mm,<sup>(11)</sup> whereas the distance was 123.6 mm in our study. The left gastric, splenic and common hepatic arteries all arise from the coeliac trunk.<sup>(1)</sup> Apart from this normal branching of the coeliac trunk, many more branching variations have been reported in the literature.<sup>(6,12-17)</sup> Vandamme and Bonte performed an angiographic study and demonstrated that trifurcation of the coeliac trunk was observed in 86% of the cases, while bifurcation was observed in 12%.<sup>(16)</sup> In our case, fewer bifurcations of the coeliac trunk were encountered (the common hepatic artery and splenic artery parted). Uva et al encountered the bifurcation of the coeliac trunk in one case, where a parting of the common hepatic artery from the left gastric artery was observed.<sup>(15)</sup> Koops et al, in an angiographic study performed on 604 cases, found that the splitting of the left hepatic artery from the left gastric artery was observed in 3% and the splitting of the right hepatic artery from the superior mesenteric artery in 11.9% of the cases.<sup>(18)</sup>

Hiatt et al<sup>(19)</sup> studied approximately 1,000 cases and classified the hepatic artery into six types. These include Type 1: common hepatic artery arising from the coeliac trunk (75.7%), Type 2: an accessory left hepatic artery existence splitting from the left hepatic artery (9.7%), Type 3: right hepatic artery splitting from the superior mesenteric artery (10.6%), Type 4: the existence of two common hepatic arteries, i.e. the right common hepatic artery rooted from the superior mesenteric artery and the left common hepatic artery rooted from the left hepatic artery (2.3%), Type 5: common hepatic artery arising from the branches of the superior mesenteric artery (1.5%), and Type 6: common hepatic artery arising directly from the aorta (0.2%).

Table I presents Hiatt et al's classifications, which were then compared with those of six other studies. According to Hiatt et al's definition, the probability of the occurrence of Types 4, 5 and 6 was low (Table I).

In the present case, unlike the instances in the above types, the right hepatic artery arose from the superior mesenteric artery and the left hepatic artery arose from the common hepatic artery.

The renal artery is a thick artery that is separated at a right angle from the lateral aorta, just under the superior mesenteric artery and at the level of the intervertebral disc between lumbar 1 and 2. Since the renal artery lies on the left side of the aorta, it is anatomically placed slightly higher than the right renal artery.<sup>(1)</sup> However, some studies have reported the origin of both the arteries to be from the same level.<sup>(20-22)</sup> One or two accessory renal arteries may exist mostly on the left side with a ratio of 23%.<sup>(1)</sup> Bordei et al found an accessory renal artery in 54 out of the 272 kidneys they examined, and reported that the accessory renal artery was located unilaterally in 42 of them. In 25 of the cases with a unilateral location, the accessory renal artery was reported on the left side.<sup>(23)</sup> Beregi et al measured the mean distance of the right renal artery from the superior mesenteric artery as 14.5 mm (2–35 mm) in an arteriography of 100 cases.<sup>(20)</sup> In our case, the mean distance was 11.5 mm.

Çiçekcibaşı et al reported a bilateral accessory inferior polar artery variation of 10.5% in their study on 90 fetuses (45 male, 45 female). On evaluating the role of gender and prevalence, they reported that it was greater in males and more prevalent on the right side.<sup>(21)</sup> Satyapal et al studied a total of 440 kidneys, 130 of which had undergone donor angiography, and found that the mean unilateral accessory renal artery variation was 23.2%. They also found that the variation was greater in males,<sup>(24)</sup> a finding that was similar to that reported by Çiçekcibaşı et al,<sup>(21)</sup> except that the variation was on the left side (27.6%). In our study, while the renal artery parted from the aorta under the superior mesenteric artery on the right side, the left renal artery and inferior polar renal artery were detected on the left side. Kosiński stated in his study that the mean distance of the right renal artery from the superior mesenteric artery was 14 mm.<sup>(22)</sup> It was 15.56 mm in our case.

In conclusion, the inferior phrenic artery, coeliac trunk, right gastric artery and exit variations from the renal arteries were established in our case, unlike in previously reported cases with single variations from the abdominal aorta. Hence, many observed variations, partitions and extensions can result in unnoticed haematoma as a result of cutting of the vessel, or ischaemia caused by the ligation of a vessel during surgery. We believe that awareness of these variations is important for surgeons who are interested in this field, so as to be able to detect and protect these arteries during surgery.

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