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Typology of Abdominal Arteries, with Special Reference to Inferior Phrenic Arteries and their Esophageal Branches

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Abstract

Origins and distribution of the human inferior phrenic arteries were studied by dissecting 68 Japanese adult cadavers. The inferior phrenic arteries were usually observed as paired (left and right) vessels. Their origins were summarized as follows: a) the aorta itself (85/138 cases, 61.6%), b) the ventro-visceral arteries (celiaco-mesenteric system of the aorta) including the celiac trunk (39/138 cases, 28.2%) and the left gastric artery (4/138 cases, 2.9%), and c) the latero-visceral arteries (adreno-renal system of the aorta) including the middle adrenal artery (4/138 cases, 2.9%) and the renal artery (6/138 cases, 4.3%). The left and right arteries occasionally originated in common trunk from the aorta, celiaco-mesenteric system or adreno-renal system (22/138 cases, 15.9%). A typological diagram explaining these variations is given. The inferior phrenic arteries, especially the left ones, sometimes issued visceral or esophageal branches. This fact indicates that the inferior phrenic arteries are homologous with the celiac trunk and mesenteric arteries. It is further discussed that the celiac trunk and mesenteric arteries are originally paired vessels, through introduction of our previous typological diagram of the abdominal arteries.

KEYWORDS: inferior phrenic artery, esophageal branch, typology of abdominal arteries

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Typology of Abdominal Arteries, with Special Reference to Inferior Phrenic Arteries and their Esophageal Branches

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Origins and distribution of the human inferior phrenic arteries were studied by dissecting 68 Japanese adult cadavers. The inferior phrenic arteries were usually observed as paired (left and right) vessels. Their origins were summarized as follows: a) the aorta itself (85/138 cases, 61.6%), b) the ventro-visceral arteries (celiacomesenteric system of the aorta) including the celiac trunk (39/138 cases, 28.2%) and the left gastric artery (4/138 cases, 2.9%), and c) the latero-visceral arteries (adreno-renal system of the aorta) including the middle adrenal artery (4/138 cases, 2.9%) and the renal artery (6/138 cases, 4.3%). The left and right arteries occasionally originated in common trunk from the aorta, celiacomesenteric system or adreno-renal system (22/138 cases, 15.9%). A typological diagram explaining these variations is given. The inferior phrenic arteries, especially the left ones, sometimes issued visceral or esophageal branches. This fact indicates that the inferior phrenic arteries are homologous with the celiac trunk and mesenteric arteries. It is further discussed that the celiac trunk and mesenteric arteries are originally paired vessels, through introduction of our previous typological diagram of the abdominal arteries (Murakami et al., 1995).

Key words: inferior phrenic artery, esophageal branch, typology of abdominal arteries

Origins and distribution of the mesenteric arteries, including the celiac trunk, vary widely (1-16). We previously studied mesenteric arteries on 944 Japanese cadavers and proposed a typological diagram which is useful to explain the variations of the mesenteric

arteries (17). The present study reinvestigates 68 adult Japanese cadavers and proposes a similar diagram of the inferior phrenic arteries. It also shows that the inferior phrenic arteries occasionally issue some esophageal branches.

Materials and Methods

Sixty-eight Japanese adult cadavers (males: 36, females: 32; 52-92 years old) were dissected with the help of medical students at Okayama University Medical School in 1995. The cadavers had been fixed by arterial perfusion with 10% formalin through the right or left radial artery, dehydrated with 50% ethanol, and stored six months or longer in the body preservation locker (Katoman, Tokyo, Japan).

Results

Origins of the inferior phrenic arteries varied widely. They are summarized in Table 1 and schematically or typologically diagrammed in Fig. 1.

The inferior phrenic arteries usually appeared as paired (left and right) vessels (55 cadavers). In these cadavers, the inferior phrenic arteries arose from the abdominal aorta (85 cases: 43 cases in the left side and 42 cases in the right side) (Fig. 2), celiac trunk (39 cases: 21 cases in the left side and 18 cases in the right side) (Fig. 3) or left gastric artery (4 cases: 3 cases in the left side and 1 case in the right side) (Figs. 4 and 7). The inferior phrenic artery rarely arose from the middle adrenal artery (4 cases: 3 cases in the left side and 1 case in the right side) (Fig. 5) or renal artery (6 cases in the right side).

In some instances, the left and right inferior phrenic

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arteries arose in a common trunk. This common trunk arose from the abdominal aorta (6 cadavers), the celiac trunk (4 cadavers) the left gastric artery (1 cadaver), or the left middle adrenal artery (1 cadaver). It was further observed in 2 cadavers that three inferior phrenic arteries had issued. More precisely, in one cadaver, one (left inferior phrenic artery) arose from the left middle adrenal artery, and two (right and accessory left inferior phrenic artery) originated in the aorta (Fig. 6). In another cadaver, they (right, left and accessory left inferior phrenic arteries) had a common origin in the left gastric artery (Fig. 7).

Regardless of their origins, the left and right inferior phrenic arteries constantly branched off into ascending, superior adrenal and descending arteries. The ascending artery divided into the sternal, costal and inferior branches. The costal branches of the left and right inferior phrenic arteries usually anastomosed with each other in front of the inferior vena cava (Figs. 3A-6A). The superior adrenal arteries supplied adrenal glands from the superior aspect. The descending artery supplied the crus of the diaphragm. In addition to these branches, the inferior phrenic arteries or their ascending arteries occasionally issued some esophageal branches which ascended along the abdominal esophagus and supplied it with blood.

The esophageal branches of the inferior phrenic arteries were encountered in 8 cases. More precisely, the left esophageal branches were observed in 7 cadavers (Figs. 2A, 3A, 5A, 6A and 7A) and the right esophageal branches in 1 cadaver (Fig. 4A). In the former 7 cases, the esophageal branches of the splenic artery were poorly

developed. In the latter case, the esophageal branches of the left gastric artery were not identified. These esophageal branches of the inferior phrenic arteries are described below:

Cases 1-3 (Fig. 2A). Cases 1-3 showed a similar pattern. In these cases, the left esophageal branch arose from the ascending artery of the left inferior phrenic artery with the usual origin in the abdominal aorta and also with the usual distribution pattern. The right inferior phrenic artery also arose from the abdominal aorta and also issued the superior adrenal artery.

Case 4 (Fig. 3A). The left esophageal branch arose from the ascending artery of the left inferior phrenic artery, which originated from the celiac trunk. The right inferior phrenic artery arose from the right renal artery.

Case 5 (Fig. 4A). The right esophageal branch arose from the aberrant left inferior phrenic artery. This phrenic artery arose from the left gastric artery and ascended in front of the stomach. In this case, the left superior adrenal artery originated in the abdominal aorta.

Case 6 (Fig. 5A). The left esophageal branch arose from the aberrant left inferior phrenic artery, which gave off the left middle adrenal artery. In this unusual case, the left superior adrenal artery arose from the right inferior phrenic artery.

Case 7 (Fig. 6A). The left esophageal branch arose from the ascending artery of the left accessory inferior phrenic artery with direct origin in the aorta and issued the left middle adrenal artery. In this case, the left inferior phrenic artery originated in the aorta and issued the left superior adrenal artery.

Table 1 Origins of the inferior phrenic arteries as dissected in 68 Japanese cadavers

	Common origin of the left and right inferior phrenic arteries (11 cadavers)	Separate origins of the inferior phrenic arteries (55 cadavers)		Three inferior phrenic arteries (2 cadavers)			Total cases (%)
		Left side	Right side	Left	Right	Accessory left	
Abdominal aorta	6 (× 2)	36	35	1	1	-	85 (61.6)
Ventro-visceral arterial system							
Celiac trunk	4 (× 2)	17	14	-	-	-	39 (28.2)
Left gastric artery	-	1	-	1	1	1	4 (2.9)
Proper hepatic artery	-	-	-	-	-	-	-
Splenic artery	-	-	-	-	-	-	-
Latero-visceral arterial system							
Middle adrenal artery	1 (× 2)	1	-	-	-	1	4 (2.9)
Renal artery	-	-	6	-	-	-	6 (4.3)
Total cases	11 (× 2)	55	55	2	2	2	138

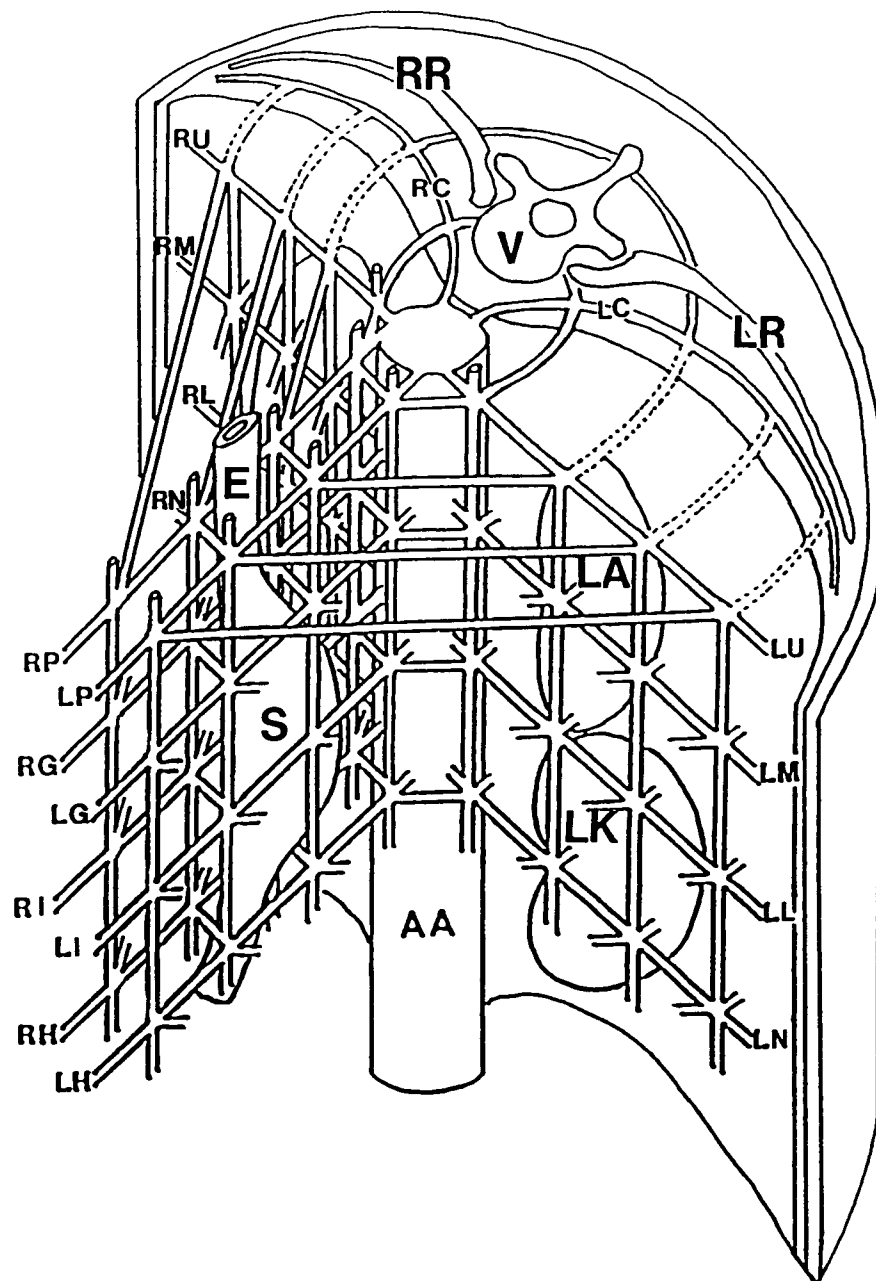


Fig. 1 Typological diagram showing the arterial system in the upper abdomen viewed from the left side. The arterial system of the upper abdomen consists of the antero-visceral (mesenteric) groups (LP, LG, LI, LH, RP, RG, RI, RH) supplying the mesenteric organs such as stomach and liver; the latero-visceral groups (LU, LM, LL, LN, RU, RM, RL, RN) supplying kidneys and adrenal glands; and the parietal groups (LC, RC) supplying the varietal walls of the body. The mesenteric groups, like the latero-visceral and parietal groups, are of paired vessels (left and right) formed by the left and right. AA: Abdominal aorta; E: Esophagus; LA: Left adrenal gland; LC and RC: Left and right intercostal arteries; LG and RG: Left and right upper gastric arteries; LH and RH: Left and right lower gastric arteries; LI and RI: Left and right middle gastric arteries; LK: Left kidney; LU and RU: Left superior adrenal arteries; LL and RL: Left and right inferior adrenal arteries; LM and RM: Left and right middle adrenal arteries; LN and RN: Left and right renal arteries; LP and RP: Left and right inferior phrenic arteries; LR and RR: Left and right ribs; S: Stomach; V: Vertebra.

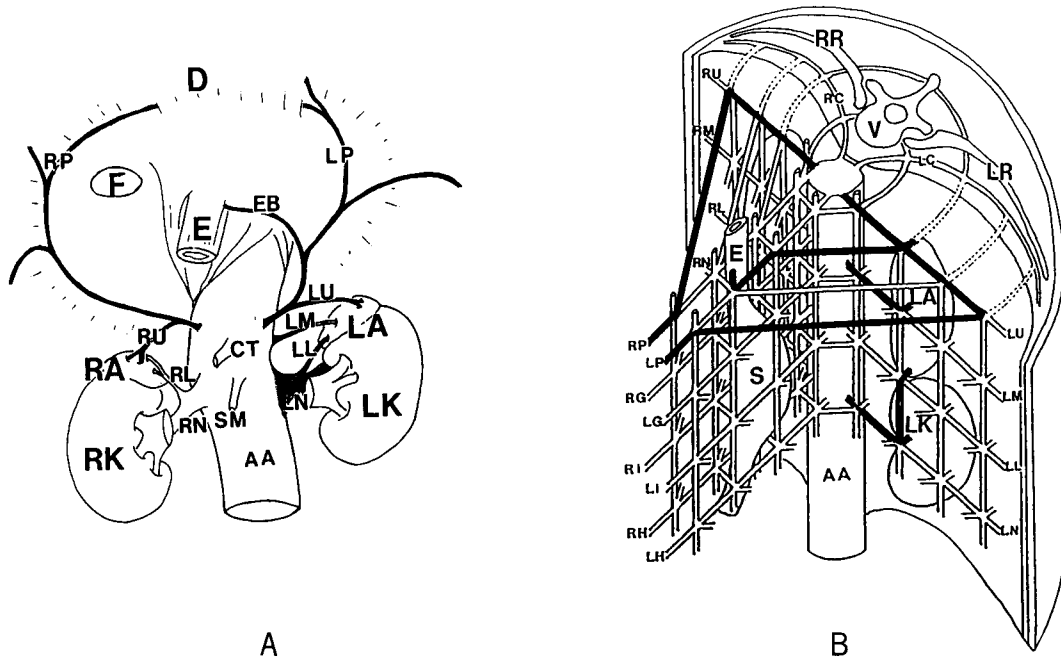


Fig. 2 Case 1. **A:** The left esophageal branch (EB) arises from the left inferior phrenic artery (LP) with usual origin in the abdominal aorta (AA). **B:** A typologic demonstration of case 1 as shown in Fig. 2A. CT: Celiac trunk; D: Diaphragm; RA: Right adrenal gland; RK: Right kidney; F: Foramen for the inferior vena cava; SM: Superior mesenteric artery. See legend to Fig. 1.

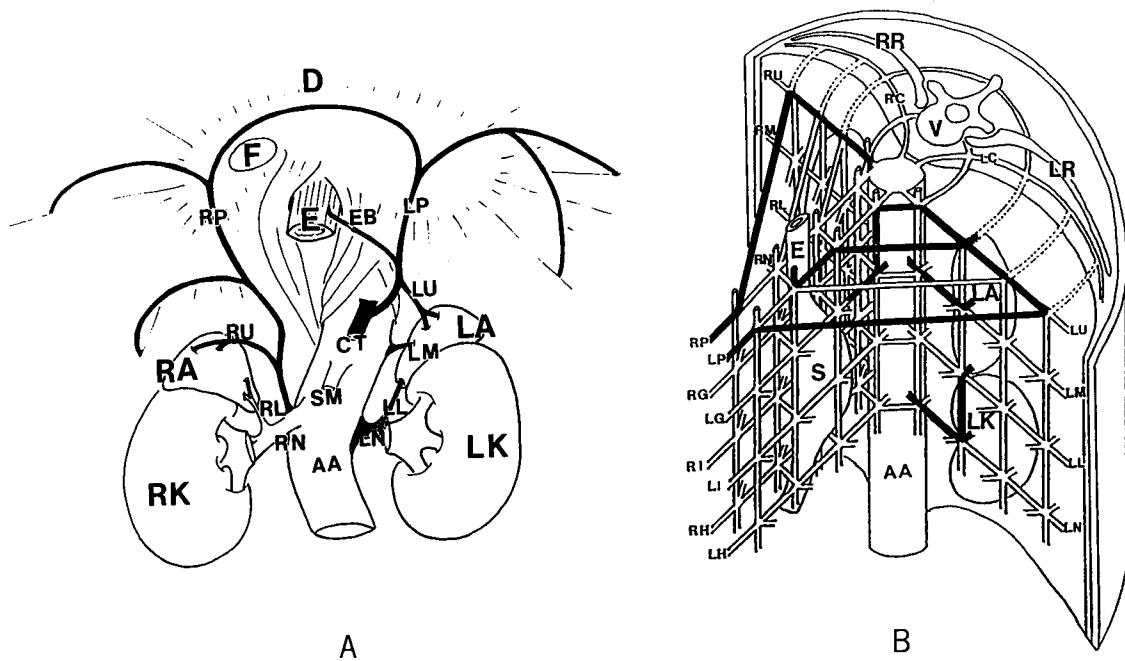


Fig. 3 Case 4. **A:** The left esophageal branch (EB) arises from the left inferior phrenic artery (LP) with unusual origin in the celiac trunk (CT). **B:** A typologic demonstration of case 4 as shown in Fig. 3A. See legends to Figs. 1 and 2.

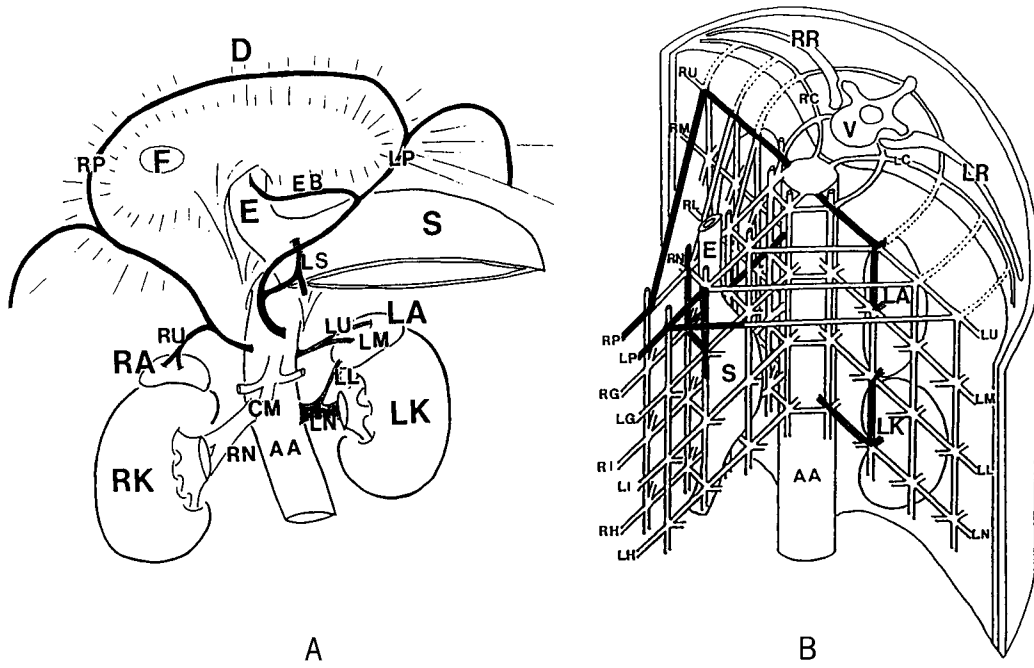


Fig. 4 Case 5. **A:** The right esophageal branch (EB) arises, together with the aberrant left inferior phrenic artery (LP), from the left gastric artery (LS). **B:** A typologic demonstration of case 5 as shown in Fig. 4A. CM: Celiac-mesenteric trunk. See legends to Figs. 1 and 2.

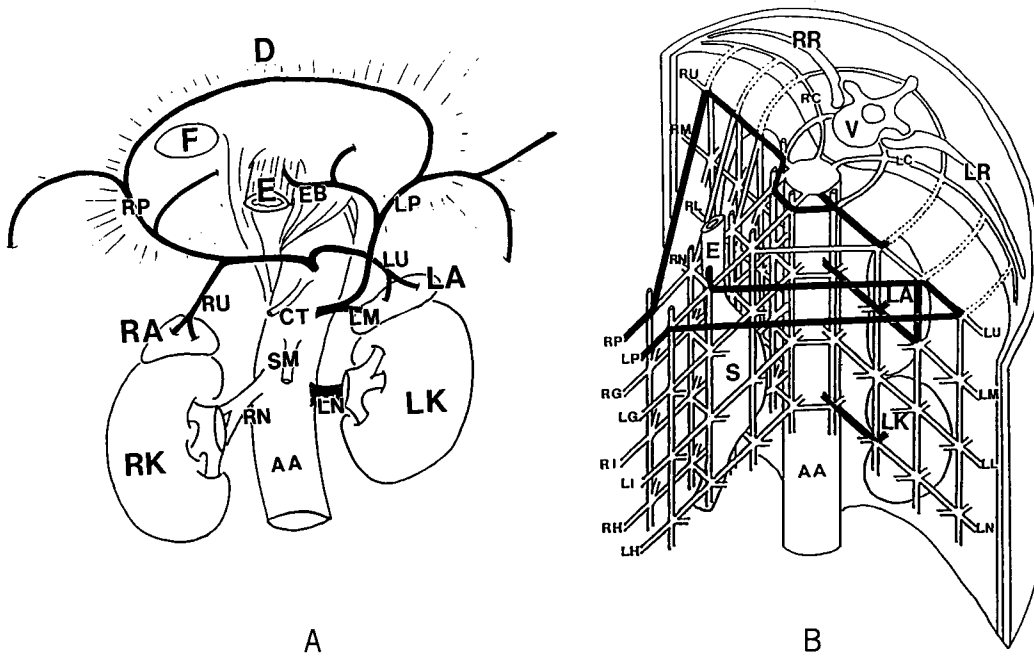


Fig. 5 Case 6. **A:** The esophageal branch (EB) arises from an aberrant left inferior phrenic artery (LP) originating in the left middle adrenal artery (LM). **B:** A typologic demonstration of case 6 as shown in Fig. 5A. See legends to Figs. 1 and 2.

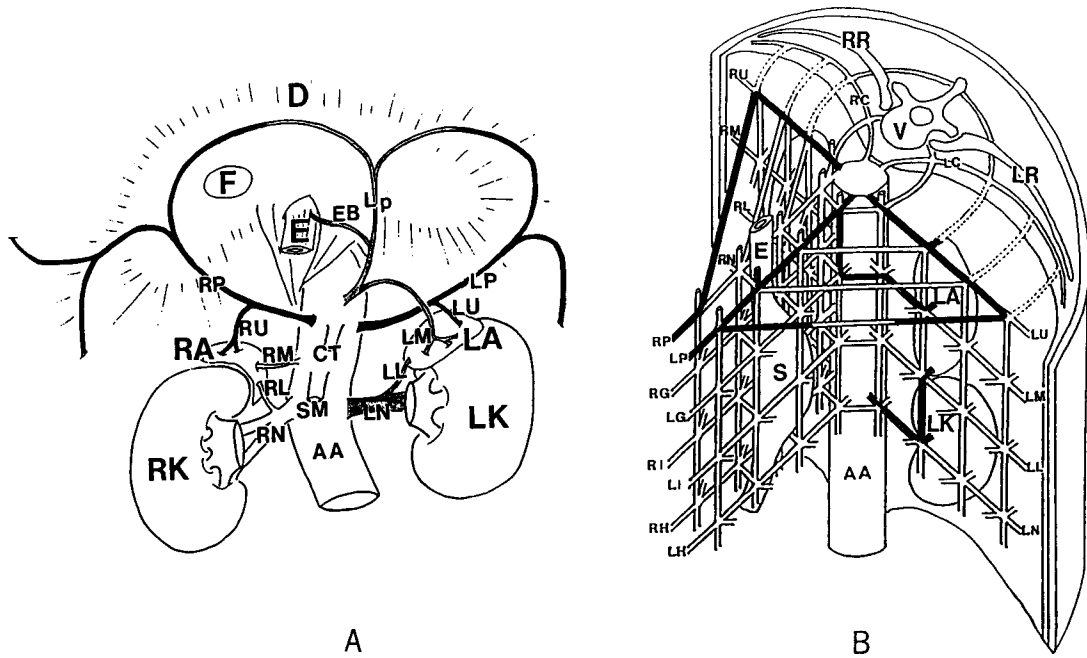


Fig. 6 Case 7. **A:** The left esophageal branch (EB) arises from the left accessory inferior phrenic artery (Lp). The left inferior phrenic artery (LP) with usual origin in the abdominal aorta (AA) and the left superior adrenal artery (LU). **B:** A topologic demonstration of case 7 as shown in Fig. 6A. See legends to Figs. 1 and 2.

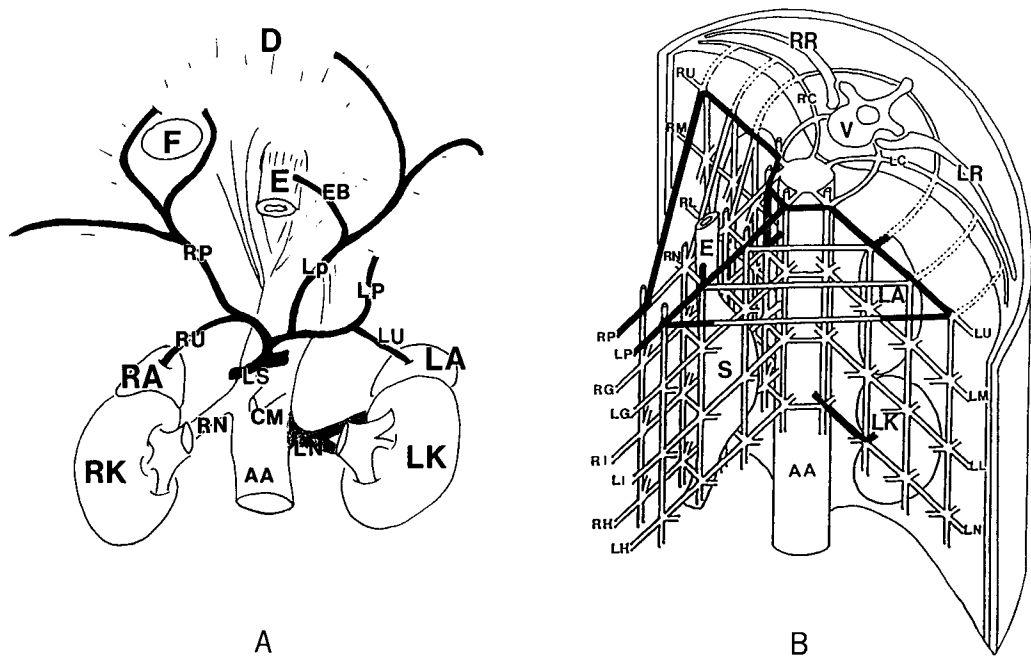


Fig. 7 Case 8. **A:** The left esophageal branch (EB) diverges from the left accessory inferior phrenic artery (Lp) which arises commonly with the left (LP) and right (RP) inferior phrenic arteries and the left gastric artery (LS) from the abdominal aorta (AA). **B:** A topologic demonstration of case 8 as shown in Fig. 7A. See legends to Figs. 1 and 2.

Case 8 (Fig. 7A). The left esophageal branch diverged from the ascending artery of the left accessory inferior phrenic artery which arose from the left inferior phrenic artery. The left inferior phrenic arteries arose commonly with the right inferior phrenic artery and the left gastric arteries. In this case, the left inferior phrenic artery also issued the left superior adrenal artery.

Discussion

It is well known that the abdominal aorta issues the inferior phrenic arteries, celiac trunk, superior mesenteric artery and inferior mesenteric artery from its anterior aspect. The celiac trunk, superior mesenteric artery and inferior mesenteric artery have been intensely studied by many authors since they supplied the mesenteric organs (gut and its associated organs such as liver, pancreas and spleen) (1-16). However, the inferior phrenic arteries have been scarcely studied since they were regarded as the muscular vessels to the diaphragm (1, 5).

The present study, together with other research (1, 5), confirms that the inferior phrenic arteries usually appear as paired vessels (left and right). The left and right inferior phrenic arteries consistently branched off into the ascending, descending and superior adrenal arteries. The present paper also proves that some visceral branches to the abdominal esophagus occasionally branch off from the inferior phrenic arteries. The occurrence of these visceral branches, which have not been reported by previous authors (1-16), indicates that the inferior phrenic arteries are homologous with the celiac trunk, superior mesenteric artery, inferior mesenteric artery and middle rectal artery which supply the gut and associated organs.

The present study, together with some early studies (1, 5), demonstrates that the left and right inferior phrenic arteries originate in various forms from the aorta, celiac trunk, left gastric artery, middle adrenal artery and renal artery. The inferior phrenic arteries can arise even from the intercostal arteries (1). These facts, as diagramed in Fig. 1, indicate that the inferior phrenic arteries originally possess some anastomoses with the renal and intercostal arteries and also with the mesenteric arteries, including the celiac trunk.

Tandler (18) and Felix (19), especially Felix, described that the mesenteric arteries in the human fetus developed as meshworks (or as some paired vessels with transverse and longitudinal anastomoses among them). A remnant of the longitudinal anastomosis has been reported

as an aberrant anastomosis between the celiac trunk and superior mesenteric arteries (20, 21). Thus, various patterns of the inferior phrenic arteries can be explained by Fig. 1 or as the results of the alterations caused by the high development of some arteries and the atrophy of other. Figs. 2B-7B demonstrate possible alterations (developments and reductions) of the vessels, each of which may explain the variations as shown in Figs. 2A-7A, respectively.

Our previous study based on a typological analysis of 944 Japanese adult cadavers indicated that the main abdominal vessels consist of five paired groups: left and right gastric; left and right splenic; left and right (common) hepatic; left and right superior mesenteric; left and right inferior mesenteric arteries (17). The gastric, splenic and hepatic arteries correspond to the upper gastric, middle gastric and lower gastric arteries in Fig. 1, respectively. Our previous study also suggests that the anticlockwise rotation of the intestinal loops at the embryonic or fetal stages causes the development of the left-sided vessels at the levels of the splenic and also inferior mesenteric arteries. This rotation also causes the development of the right-sided vessels at the levels of the gastric, common hepatic and superior mesenteric arteries (or retards the development of the right splenic, right inferior mesenteric, left gastric, left hepatic and left superior mesenteric arteries) (17). Thus, we believe that the celiac trunk is not an independent vessel but represents a modified form or proximal segment (part) of the gastric, splenic or hepatic arteries (17).

The present paper also shows that the esophageal branches of the inferior phrenic arteries develop only when the esophageal branches of the left gastric or splenic artery are absent or poorly developed. The preferential remnant of the left esophageal branches may also be caused by the anticlockwise rotation of the intestinal loops at the embryonic stage.

It has been confirmed that the bronchial and esophageal arteries usually arise from the thoracic aorta and run along the left-side of the esophagus and that they sometimes arise from the right intercostal artery and run along the right-side of the esophagus (22-24). These facts indicate that even in the thorax, the visceral vessels basically consist of paired vessels (left and right). The uppermost vessels in the thorax may be the left and right internal thoracic arteries which descend along the sternum (25).

References

1. Adachi B: Aorta abdominalis; in *Das Arteriensystem der Japaner II*, Maruzen, Kyoto and Tokyo (1928) pp11-129 (in German).
2. Morita S: Reports and conception of three anomalous cases of the celiac and superior mesenteric arteries. *Igaku Kenkyu* (1935) **9**, 1993-2006.
3. Anson J and McVAY B: The topographical positions and the mutual relations of the visceral branches of the abdominal aorta. A study of 100 consecutive cadavers. *Anat Rec* (1936) **67**, 7-15.
4. Endo M and Mori Y: Topographische Untersuchung über die Abgangsstelle der grossen Baucharterien bei den japanischen Feten. *Okajimas Folia Anat Jpn* (1938) **78**, 413-427.
5. Pick JW and Anson BJ: The inferior phrenic artery: Origin and suprarenal branches. *Anat Rec* (1940) **78**, 413-427.
6. Michels NA: Blood supply and anatomy of the upper abdominal organs, with descriptive atlas. Lippincott Company, JB Philadelphia and Montreal (1955) pp3-459.
7. Outi H, Kato N, Tajiri S and Murakami T: Variations of the celiac axis found in the last six years, especially on the left accessory gastric and the right and left accessory hepatic arteries. *Acta Anat Nippon* (1965) **40**, 35 (Japanese abstract).
8. Leithner C, Sinzinger H, Hohennecker J, Wicke L, Olbert F and Feigl W: Radiologic anatomy of the abdominal aorta and their large branches. *Okajimas Folia Anat Jpn* (1975) **52**, 119-150.
9. Katsume Y, Kanamura E, Sakai K, Yoshizawa M, Hirotsu A and Ishibashi K: The statistical report about thirteen anomalous cases on the branches of the coeliac trunk. *Kurume Igakkai Zasshi* (1978) **41**, 266-272 (in Japanese with English abstract).
10. Kikuta A, Ohtsuka A, Taguchi T, Ohtani O and Murakami T: A case of absence of the coeliac trunk: The left gastric, the splenic, the common hepatic, and the superior mesenteric arteries arising independently from the abdominal aorta. *Acta Anat Nippon* (1983) **58**, 406 (Japanese abstract).
11. Ohtsuka A, Kikuta A and Murakami T: Common hepatic artery ascending on the anterior surface of the pancreas and left renal vein running beneath the diaphragm. *Okajimas Folia Anat* (1984) **60**, 427-434.
12. Higashi N and Sone C: Two anomalous cases of truncus coeliacus. *Acta Anat Nippon* (1986) **61**, 709-715 (in Japanese with English abstract).
13. Kato S: Blood supply to the upper abdominal organs in the Japanese fetuses. *Tokyo Jikeikai Med J* (1987) **102**, 893-904 (in Japanese with English abstract).
14. Kitamura S, Nishiguchi T, Sakai A and Kumamoto K: Rare case of the inferior mesenteric artery arising from the superior mesenteric artery. *Anat Rec* (1987) **217**, 99-102.
15. Nelson TM, Pollak R, Jonasson O and Abcarian H: Anatomic variants of the celiac, superior mesenteric, and inferior mesenteric arteries and their clinical relevance. *Clin Anat* (1988) **1**, 75-91.
16. Başar R, Öndroğlu S, Cumhur T, Yüksel M and Ölcer T: Agenesis of the celiac trunk: An angiographic case. *Acta Anat Nippon* (1995) **70**, 180-182.
17. Murakami T, Ohtsuka A and Piao DX: Typology of the human coeliac, left gastric, splenic, hepatic, superior mesenteric, inferior mesenteric and inferior phrenic arteries. *Okayama Igakkai Zasshi* (1995) **107**, 219-226 (in Japanese with English abstract).
18. Tandler J: Über Varietäten der Arteria coeliaca und deren Entwicklung. *Anat Hefte* (1904) **25**, 473-500 (in German).
19. Felix W: Zur Entwicklungsgeschichte der Rumpfartern des menschlichen Embryo. *Gegenbaurs Morphol Jahrb* (1910) **41**, 577-614.
20. Zwerina H and Poisel S: Über eine Anastomose zwischen dem Truncus coeliacus, der Arteria mesenterica superior und der Arteria mesenterica inferior mit anderen Varietäten der unpaarigen und paarigen Äste der Baucharteria bei einem Individuum. *Anat Anz* (1966) **119**, 427-435 (in German).
21. Feigl W, Fibras W, Sinzinger H and Wicke L: Variabilität des Truncus coeliacus und seiner Anastomosen mit der Arteria mesenterica superior. *Acta Anat* (1975) **92**, 272-284 (in German).
22. Kasai T: Bronchial arteries and their typology. *Nippon Iji Shinpo* (1983) **3080**, 128-129 (in Japanese).
23. Takahashi D: Macroscopic anatomy of the bronchial artery with reference to its clinical considerations. *Hirosaki Med J* (1990) **42**, 230-242 (in Japanese with English abstract).
24. Ipponsugi H: Ueber die Vaskularisation der menschlichen Oesophagus (Japanisch Sprache mit Deutschen Zusammenfassung). *Kurume Igakkai Zasshi* (1955) **18**, 1172-1182.
25. Adachi B: A mammaria interna; in *Das Arteriensystem der Japaner I*, Maruzen, Kyoto and Tokyo (1928) pp156-160 (in German).

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