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Color Doppler ultrasonography of the abdominal aorta

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Abstract Alterations of the abdominal aorta are relatively common, particularly in older people. Technological advances in the fields of ultrasonography, computed tomography, angiography, and magnetic resonance imaging have greatly increased the imaging options for the assessment of these lesions. Because it can be done rapidly and is also non-invasive, ultrasonography plays a major role in the exploration of the abdominal aorta, from its emergence from the diaphragm to its bifurcation. It is indicated for the diagnosis and follow-up of various aortic diseases, especially aneurysms. It can be used to define the shape, size, and location of these lesions, the absence or presence of thrombi and their characteristics. It is also useful for monitoring the evolution of the lesion and for postoperative follow-up. However, its value is limited in surgical planning and in emergency situations.

Sommario La patologia dell'aorta addominale è relativamente frequente, in particolare nelle persone di età avanzata. Le innovazioni tecnologiche introdotte nel campo dell'ecografia, della tomografia computerizzata, dell'angiografia e della risonanza magnetica, hanno ampliato notevolmente il ventaglio di opzioni dell'imaging vascolare. In particolare l'ecografia ha un ruolo di primaria importanza per la possibilità di valutare l'aorta addominale dall'emergenza diaframmatica fino alla biforcazione, per la rapidità di esecuzione e la non invasività. Risulta pertanto indicata per la diagnosi e il follow-up delle varie malattie, in particolare degli aneurismi, dei quali può definire forma, dimensioni, topografia, assenza o presenza di trombi e loro caratteristiche, così come nel monitoraggio e nel follow-up post-operatorio. I limiti dell'indagine sono rappresentati dalla pianificazione dell'intervento chirurgico e dalle situazioni di emergenza.

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Introduction

Technological innovations in the field of ultrasound, computed tomography, angiography, and magnetic resonance imaging (MRI) have expanded the options for vascular imaging and modified diagnostic protocols in terms of the available technologies, diagnostic problems, and treatment solutions that involve the use of radiological methods to guide and monitor interventional procedures [1,2].

Ultrasonography is the first-line imaging study for the diagnosis and the postoperative evaluation and follow-up of patients with diseases of the abdominal great vessels [3].

The combination of velocimetry with ultrasound and color methods (color Doppler ultrasound) substantially increased the possibilities for ultrasound in the diagnosis of disorders involving the deep vessels. It stimulated the acquisition of functional data, which were often unobtainable with other methods, and significantly increased the space occupied by ultrasound methods in diagnostic imaging [4,5].

Anatomy

The abdominal portion of the aorta lies between the inferior border of the twelfth thoracic vertebra and fourth lumbar vertebrae; at this level, the aorta divides into the right and left common iliac arteries and the middle sacral artery, which continues downwards and vertically.

The aorta lies in the retroperitoneal space, in front of the bodies of the lumbar vertebrae.

Anteriorly, it is overlain by the body of the pancreas, the third portion of the duodenum, the root of the mesentery, and the left renal vein. On the right, lies the inferior vena cava; on the left, the left pillar of the diaphragm and the duodenojejunal flexure [6].

The aorta gives rise to the inferior phrenic arteries, the celiac trunk, the superior mesenteric artery, the middle adrenal arteries, the renal and gonadal arteries, and the inferior mesenteric artery (Fig. 1A).

The inferior phrenic arteries are the first two branches of the abdominal aorta. They originate from the lateral walls of the aorta and ascend to the diaphragm, which they vascularize. They supply the superior adrenal arteries.

The celiac trunk arises from the anterior wall of the abdominal aorta at some point between the body of twelfth thoracic vertebra and the disc lying between the first and second lumbar vertebrae, approximately 1.5 cm below the diaphragm. It runs forward, and after 2—3 cm, it divides into the left gastric artery, the common hepatic artery, and the splenic artery.

The large-caliber hepatic artery runs toward the hepatic hilum; after giving rise to the gastroduodenal artery, it continues as the proper hepatic artery. At the level of the hilum, it divides into the two branches, right and left, that supply blood to the liver. Within the hepatoduodenal ligament, the hepatic artery is located anteriorly on the left, the bile duct anteriorly on the right, and the portal vein is in the posterior compartment. These three structures, which make up the hepatic pedicle, form the anterior pillar of the foramen of Winslow. The hepatic artery also gives rise to the cystic artery (which originates from the right branch of the hepatic artery and proceeds to the gallbladder); the right gastric artery (which runs along the lesser gastric curvature and anastomoses with the left gastric artery); and the gastroduodenal artery. The latter artery originates behind the first portion of the duodenum and then divides into two branches. The first is the right gastroepiploic artery, which rises along the greater curvature of the stomach and anastomoses with the left gastroepiploic artery (a branch of the splenic artery). The second branch is the superior pancreaticoduodenal artery, which descends along the medial margin of the second portion of the duodenum and anastomoses with the inferior pancreaticoduodenal artery (a branch of the superior mesenteric artery).

On the left, the left gastric artery ascends, runs along the lesser curvature of the stomach within the hepatogastric ligament, and anastomoses with the right hepatic artery.

The splenic artery is the largest branch of the celiac trunk. It runs toward the spleen, with a winding course, along the upper margin of the pancreas. At the hilum of the spleen, it divides into several branches that penetrate the organ and supply any accessory spleens.

The superior mesenteric artery originates from the anterior wall of the abdominal aorta at level of the D12-L1 intervertebral space, about 1 cm caudal to the emergence of the celiac trunk. It descends behind the pancreas, between the head and the neck, and then emerges between the lower edge of the pancreas and duodenum. Passing in front of the latter, it penetrates the mesentery and curves toward the right iliac fossa. It supplies part of the duodenum, the remaining portions of the small intestine, and part of the large intestine. Its collaterals include the inferior pancreaticoduodenal artery, which merges with the superior pancreaticoduodenal artery and supplies blood to the head of the pancreas and the duodenum; the jejunal and ileal arteries (10—15 branches that vascularize the bowel loops, except those of the last section); the middle colic artery; the right colic artery (which reaches the ascending colon); and the ileocolic artery, which runs to the left iliac fossa. Caudal to the origin of the latter artery, the superior mesenteric branches into smaller-caliber vessels that supply the cecum and the last ileal loops (Fig. 1B) [7].

The middle adrenal arteries originate from the lateral walls of the aorta at the level of the superior mesenteric artery and proceed to the adrenals.

The renal arteries originate from the lateral walls of the aorta below the superior mesenteric artery at the level of the first lumbar vertebra. These two large branches run horizontally to the hila of the two kidneys. Here, each divides into 3—4 branches, which penetrate into the renal pelvis. The right renal artery measures 5—6 cm. It runs posterior to the right renal vein, the inferior vena cava, the head of the pancreas, and the descending portion of duodenum. The left renal artery is about 3—4 cm long. It runs behind the left renal vein, the body of the pancreas, and the splenic vein [8].

The gonadal arteries are the arteries that supply the testes in the male and the ovaries in women [9].

The inferior mesenteric artery originates from the anterior wall of the aorta at the level of the intervertebral disc L3—L4. It proceeds downward toward the left, crossing over the common iliac vessels. It enters the root of the mesosigmoid and reaches the upper end of the rectum as the superior hemorrhoidal artery.