Abdominal Arteriosonography

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Introduction

The ability of Ultra-sound to demonstrate the course and dimensions of major abdominal vessels accurately has long been known. However, it was such technologic advances as gray scale and real-time Ultra-sound that resulted in regular identification of major branch vessels and their divisions. The newer modalities led not only to the recognition of a variety of intrinsic pathological changes in the aorta and inferior vena cava but also to appreciate these normal vascular structures by para-aortic and para-caval disease. In addition, the identification of branch vessels facilitated recognition of the boundaries of organs such as pancreas, thus permitting more reliable demonstration of these organs. The introduction of range-gated, pulsed doppler linked to the realtime equipment affords the opportunity to not only image intra-abdominal vessels but also assess the velocity, direction and nature of blood flow within these vessels. Improvements in surgical techniques now allow the resection of an extensive aortic aneurysm with subsequent reanastamosis of branch vessels. Careful planning of such extensive surgery is vital for successful outcome; therefore, accurate knowledge of the point of origin and course of aortic branch vessels is mandatory.

Sonographic Anatomy of Abdominal Aorta

The aorta enters the abdomen through the aortic hiatus and passes caudally anterior to the vertebral column and slightly to the left of the midline to end by bifurcating in front of the lower part of the fourth lumbar vertebra into right and left common iliac arteries. The aorta lies immediately anterior to the vertebral column except at its bifurcation where the left common iliac vein passes posterior to the aorta interposing itself between aorta and the vertebral column.

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On Ultrasound, the aorta is clearly shown as a tubular, echo-free structure situated in front of the spine and slightly to the left of midline in longtitudinal section. Its proximal part is more posterior than the distal part due to the normal lumbar lordosis. If the lordosis is marked, the aorta may be unusually close to the skin surface near its bifurcation. In thin patients, it may be found 2-3 cm beneath the skin. Since the superficial character of the vessel is accentuated by atheromatosis, it is not surprising that the clinician who is feeling intense pulsations during abdominal examination may misdiagnose an aneurysm. In transverse section, the aorta appears as a round, echo-free area in front and slightly to the left of the spine, whereas the inferior vena cava lies to the right of the spine. It is not usually difficult to distinguish the aorta from inferior vena cava because of its position, course and branches. Similarly the normal arterial pulsation characteristic of the aorta serves to distinguish it from the inferior vena cava.

The calibre of aorta, inspite of slight variations during systole and diatole, remains fairly constant: tapering gradually from a maximum diameter at the level of the diaphragmatic hiatus to a minimum diameter at the bifurcation Normal measurements for the antero-poisterior and transverse diameter based on both contrast radiography and ultrasound are available (Table I).

TABLE-I

	Diameter (mm)			
Type of Procedure	At 11th rib	Above renal arteries	Below renal arteries	At Bifurcation
Aortographic Transverse Measurements (Steinberg et al)	24	21	19	17
Aortographic A.P. Measurements (Goldberg et al)	25	22	19	15
Ultrasonic Measurements (Goldberg et al)	23	20	18	15

Table I Comparison between aortography and Ultrasound in the measurement of aortic diameter.

Comparison of the true luminal diameter as assessed by caliper measurements of resected specimens demonstrates that Ultrasound is at least as accurate as aortography. For the most part, the A.P. diameter of the aorta is used for Ultrasound measurements since the lateral resolution of the Ultrasound beam causes indistinct lateral vessel margins when scanning is performed from the anterior abdominal wall.

Major Branchs of Abdominal Aorta

With modern gray scale signal processing, the major visceral arteries, that is, coeliac axis and its major branches, common hepatic artery and splenic artery, and superior mesenteric artery are almost invariably seen. The right and left renal arteries may be seen in upto 75% of patients, particularly if the right lateral decubitus position is employed. The inferior mesenteric artery is quite infrequently visualized and then only on longitudinal scans.

The visceral arteries are often grouped anatomically into those arising from the anterior, lateral and posterolateral surfaces of the abdominal aorta. These anatomic groupings are also convenient for Ultrasound examination since different techniques are required to image the different groups. Those arising from the anterior surface, that is, the coeliac, superior mesenteric and inferior mesenteric arteries, are imaged by routine anterior wall scanning. Conversely, those arising from the lateral or posterolateral aspect of the aorta, that is, the renal and lumbar arteries, are usually visualized only on transverse scans or scans performed in the decubitus position.

The visceral branch of the aorta that is easiest to show on sagittal scan is the Superior Mesenteric Artery. It originates from the anterior abdominal aorta 0.5 cm below the coeliac axis at the level of first lumbar vertebra. It is pre-aortic over several centimeters. It is a major land mark for the localization of the pancreas. The average diameter of superior mesenteric artery at ultrasound is 7 mm, a figure similar to that found at arteriography. Knowledge of the diameter of superior mesenteric artery can be useful when choosing a catheter for selective angiography. It is also possible to measure the aorto-mesenteric angle by Ultrasound. In normal subjects it measures on an average 14 at a distance of 11 mm from its origin. This angle widens in the presence of aortic aneurysm or enlarged lymph nodes. Occasionally, on real-time examination, branches of superior mesenteric artery may be seen within the mesentery outlined by fat.

Coeliac axis or trunk is the most cephalic of the unpaired branches of

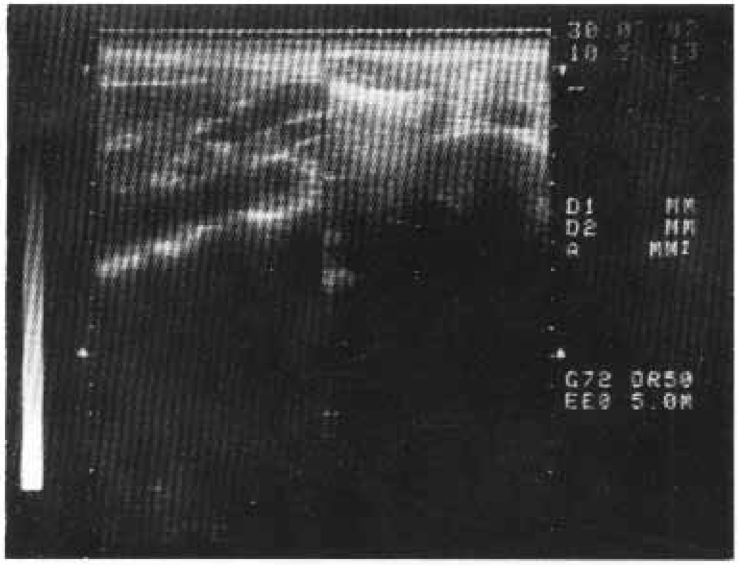

Fig. 1 Longitudinal scan of abdominal aorta with coeliac axis and superior mesenteric artery.
Transverse scan - 1 cm below the umbilicus showing common Iliac arteries.

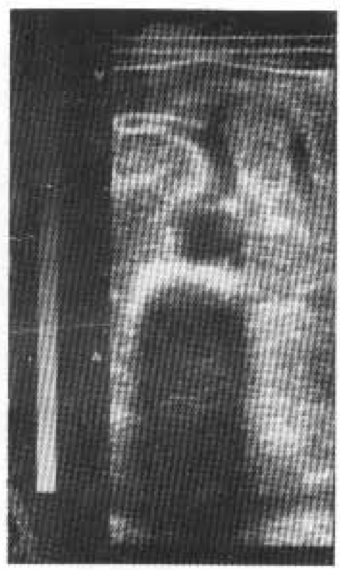

Fig. 2 Transverse scan of abdominal aorta with coeliac axis dividing into hepatic artery (Rt.) and splenic artery (Lt.)

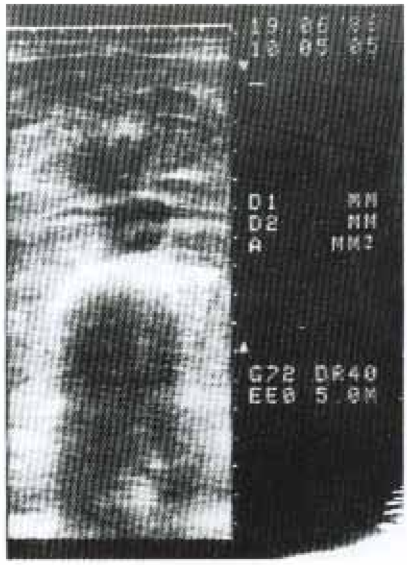

Fig. 3 Transverse scan of abdominal aorta with renal arteries.

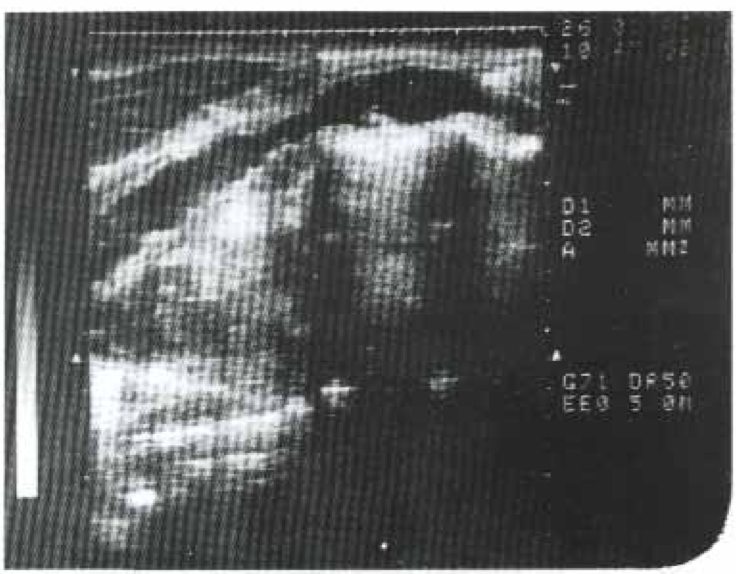

Fig. 4 Longitudinal scan of abdominal aorta. The wall of the aorta appears irregular. Dilatation of distal aorta can be observed.

aorta. This artery arises just below the liver from the anterior surface of the aorta at an angle of 60. The origin of coeliac axis from the aorta appears in transverse section as a "bubble-like" distortion or "slit-like" defect. It is 2-3 cm in length. In the longitudinal section, it can be seen to arise from the anterior surface of the aorta and run anteriorly or slightly upward towards the head. The coeliac axis divides into hepatic artery on the right and splenic artery on the left. These two branches are visible on transverse section at the same level as the junction of splenic and portal vein or just below this point. The hepatic artery runs to the right alongside the portal vein and the main bile duct. It divides into right and left branches which in most cases lie anterior to the right and left portal veins. Transverse scan usually shows the right hepatic artery anterior to the right portal vein giving rise to parallel-channel sign. While the common hepatic artery usually arises from the coeliac trunk, approximately 40% of the normal population demonstrate variations, most commonly an accessory hepatic artery originates from the coeliac axis but in some cases a displaced hepatic artery arises from the superior mesenteric artery. The gastroduodenal artery can be visualized in transverse section anterior to the head of the pancreas. In longitudinal section, the gastroduodenal artery may sometimes be seen passing upwards along the anterior superior margin of the pancreas. The demonstration of gastroduodenal, hepatic and splenic arteries is not easy. It requires ex-perience, patience and fine adjustments of the scanning plane. Some authors have described aneurysms of coeliac and splenic arteries detected by Ultrasound.

Inferior Mesenteric artery is the third and the last median branch of the aorta to the gut. It originates from the abdominal aorta close to the umbilicus. This thin artery may occasionally be imaged as it courses caudally towards the rectum from the central surface of the aorta. As it is usually not parallel to the aorta, it is difficult to see over a long segment.

Renal arteries are seen best on transverse section. The left renal artery is easier to show than the right renal artery. The right renal artery arises from the lateral or anterolateral surface of the aorta. It passes dorsally, caudally and to the right. It runs around the anterior surface of the vertebral body and behind the inferior vena cava. The left renal artery takes an arc-like course originating from the posterior part of the left side of aorta, travelling downwards and sidewards parallel to the spine and to the left to enter the renal hilum. Accessory renal arteries occur in about 20% of patients, usually below the main renal artery. They hve been detected by Ultrasound although they are very small in calibre. Even if imaged, they are often indistinguishable from the prominent lumbar arteries.

Visualization of the Common iliac arteries is usually incomplete and segmental due to bowel gas except when involved by aneurysm. With full urinary bladder, segments of external and internal iliac arteries can be imaged in the pelvis.

Indications for Arteriosonography

Pulsatile palpable abdominal mass.

Questionable abdominal pulsation, particularly when the patient is difficult to examine and when the aorta may be unusually prominent, for example a patient with kyphoscoliosis.

Other clinical or radiologic findings suggestive of abdominal aortic aneurysm.

Abdominal pain, particularly when referred to the back.

Measurement and follow-up of known aortic aneurysm to assess interval growth.

Following aneurysm repair to detect complication such as anastomotic aneurysm, haematoma and infection.

Abnormalities

The most frequent use of arteriosonography is in the demonstration of Aortic aneurysm. The diagnosis of aortic aneurysm by Ultrasound depends on the accurate measurement of the A.P. diameter of aorta. A calibre of greater than 3 cm is considered pathological. The diameter of aneurysm can be easily measured with Ultraound. Abdominal aortic aneurysms are usually arteriosclerotic in origin. In longitudnal section, aortic aneurysms appear as fusiform dilatation of distal aorta usually below the origin of the renal arteries. They usually project anteriorly and to the left of the midline, the path of least resistance. They may continue into the iliac vessels for a variable extent. Because of abrupt change in the aortic calibre at the site of an aneurysm, there is alteration of the laminar flow normally found within the aorta, giving rise to turbulence and eddy currents. Irregularity of flow significantly increases the likelihood of clot formation. Ultrasound is better than arteriography in size measurements because it will also show an aneurysm that is full of thrombi. The amount of mural clot is demonstrable by Ultrasound as the presence of low level echoes within the aortic lumen. The true lumen remains as an echo-free space within the walls. The mural

Fig. 5 Transverse scan of abdominal aorta showing calcification.

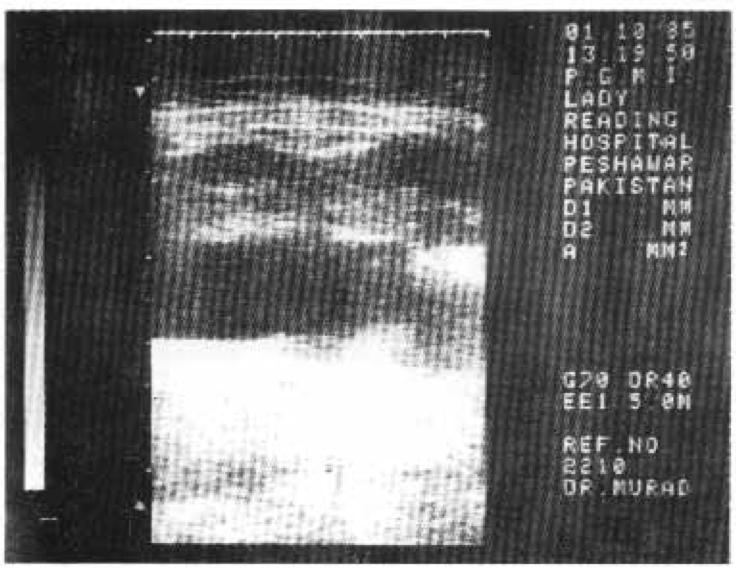

Fig. 6 Aortic aneurysm with mural clot

Fig. 7 Abdominal aorta, mycotic aneurysm.

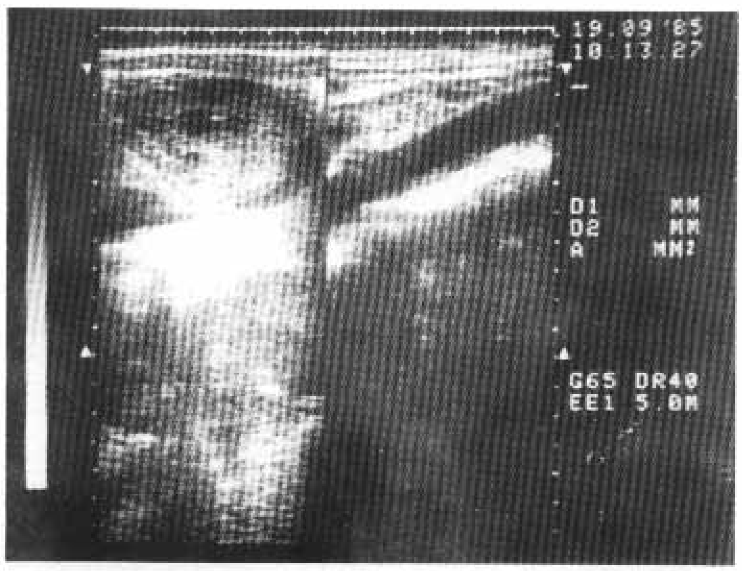

Fig. 8 Pheochromocytoma in para - aortic sympathetic chain which was repeatedly described as abdominal aortic aneurysm on clinical examination.

clot may be circumferential or may predominate on the anterior wall. Calcification may be identified within the wall of aneurysm. Although it is not always possible to demonstrate the exact relationship of the renal vessels to the aortic aneurysm, a high index of suspician can be achieved (even if renal arteries are not imaged), if the aneurysm approaches the origin of the superior mesenteric artery. The morbidity and mortality rates of aortic aneurvsm relate directly to its size. Aneurysm less than 5 cm in diameter is said to rupture rarely. 60-80% of cases rupture when a maximum diameter of 7 cm is reached. In small aneurysms, the likelihood of rupture increases markedly if significant enlargement is shown on sequential studies. It is therefore appropriate to re-examine even small aortic aneurysms 3-6 months after their initial detection. An increase of 5 mm or more in the diameter is considered to be significant.

Ultrasound is more sensitive and more accurate than an x-ray of the abdomen. It gives information comparable to Computerized Tomography (C.T.) without exposure to ionizing radiation or intravenous contrast infusion. C.T. is not as accurate as Ultrasound in determining the presence of a mural thrombus. Ultrasound will identify an aortic aneurysm in over 95% of cases.

Ultrasound can demonstrate changes in Atherosclerosis. The walls of the aorta appear irregular and the vessel becomes tortuous.

Aortic Dissection predominantly effects the thoracic aorta but may extend into abdominal aorta. In dissecting aneurysm, the aorta is dilated and a double lumen is seen. The intimal flap can be imaged as an echo-producing septum within the aortic lumen. On real-time, motion of this intimal flap with aortic pulsation can be identifed.

Enlargement of branch vessels may be a result of enlargement of an organ (e.g. spleen in hypersplenism), the presence of large vascular tumor within an organ producing arterio-venous shunting or the presence of A.V. shunting from other causes. In these situations both arteries and veins are usually enlarged, with the vein enlargement due to distensibility of its walls usually more pronounced.

The presence of significant atheroma within the aortic aneurysm may produce Stenosis. The addition of intraluminal clot may translate this stenosis into complete occlusion. Such stenosis can usually be demonstrated in the abdominal aorta. Aortic stenosis and occlusion, however, are difficult to demonstrate. Occasionally in the presence of fresh clot, complete occlusion of the vessel may not be detected by Ultrasound. A fresh clot, for instance in haemotomas, may be entirely echo-free, thus mimicking the appearance of unclotted blood. Stenosis of branch arteries is demonstrated less reliably. Of particular interest in this respect are the renal vessles in evaluation of systemic hypertension. There have been hardly any reported cases of renal artery stenosis demonstrated by ultrasonic imaging. The use of duplex real-time/doppler machinery now allows much more consistent identification of renal artery stenosis. Nichols et al have reported the successful detection of renal artery stenosis using the same technique. They identified 59 of 61 normal vessels and 10 of 12 stenosed vessels, including 1 of 3 occluded vessles resulting in a specificity of 97% and a sensitivity of 83%.

Reduction in the calibre of aorta or branch vessels is much less commonly seen, but in such disease entities as Takayasu's disease, neurofibromatosis, severe coarctation or congenital infections, the aorta may be significantly narrowed throughout its length. The lumen is usually less than one centimeter in diameter.

With the development of real-time equipment, Ultrasound will be used more and more to perform haemodynamic studies. By combining a real-time scanner with a doppler device both the speed and direction of blood flow can be measured. It will also be possible to use Ultrasound to guide catheters into an abdominal vessel for diagnostic and therapeutic purposes.

References

Bolondi, L., Gandolfi, L., Labo, G., Diagnostic Ultrasound in gastroenterology, Padova, Piccan/Buttermorth, (1984) 339-353.

Goldberg Barry, B., Abdominal Ultrasonography, N.Y. John Wiley & Sons, (1984), 19-40.

Hricak, H., Doppler in Urology, Genitourinary Ultrasound, Ed. Churchil Livingstone, (1986) 241-242.

Morley, F., Donald, G., Sanders R., Ultrasonic Sectional Anatomy, Ed. Churchil Lingingstone, (1983), 174-175,

Nichols, B.T. et al, Non-invasive detection of renal artery stenosis, Bruit 8:26, (1984).

Sanders Roger, C., Clinical Sonography, Boston Little Brown and Company, (1984), 35-36.

Weill Francis, Ultrasonography of digestive diseases, St. Louis The C.V. Mosby Company, (1982), 39-50.