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Ultrasound of the adrenal glands

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Topographical anatomy

The adrenal glands are located within the retroperitoneum. The right adrenal gland faces the right kidney superomedial and is located posterolaterally to the IVC between the lateral right liver lobe and the inferior (lumbar) crus of the right diaphragm. These are the principal landmarks on the right side. Typically the right adrenal gland is visualised behind the right lobe of the liver and anterior to the inferior diaphragmatic crus.

The left adrenal gland is inherently more difficult to scan than the right because it lacks the acoustic window of the liver and is obscured by air in the stomach. Approaching the left adrenal gland is possible using a transverse epigastric scan. Another option is to use an intercostal flank scan with the spleen as an acoustic window. The key anatomical landmarks are the abdominal aorta (medially), the left inferior crus of the diaphragm (dorsally), the lower pole of the spleen, the upper kidney pole (laterally) and the left renal vein and pancreatic tail. Not infrequently, the adrenal glands extend down to the level of the renal hilum (1). Enlarged adrenal glands (wings of glands, 2–5cm long and 6–10 mm thick) are detectable in a high percentage of cases. Normal-sized adrenal glands are visible with skilled or frequently practised examination techniques and by using high-resolution technology (from right to left). On each side the adrenal region appears as a triangular echogenic area bordered by the previously mentioned landmarks [Figure 1 and 2].

Figure 1 **Topographical relation of adrenal glands to the neighbouring retroperitoneal organs (Adr: adrenals; Ao: Aorta; E: oesophagus; ICV: inferior caval vein; K: kidneys; yellow: periadrenal fat).**

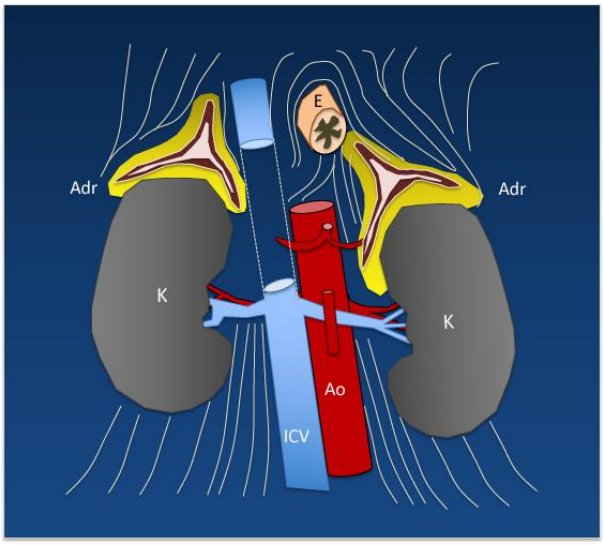
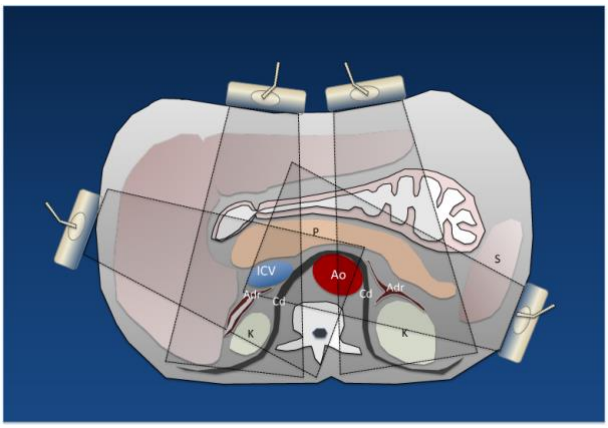


Figure 2 **Cross-section at the level of the adrenal glands. The adrenal glands are the Y-shaped structures anteromedially to the kidneys. Sonographic examination is possible with the patient in a supine position using liver and pancreatic head (right adrenal) or pancreatic tail (left adrenal) as an acoustic window. Moreover, lateral scanning is possible (right adrenal: from a right intercostal space in supine or left oblique patient position; left adrenal: using the spleen or upper kidney pole as an acoustic window in supine patient position) (Adr: adrenals; Ao: Aorta; Cd: diaphragmatic crus; ICV: inferior caval vein; K: kidneys; S: spleen).**



Anatomy

The adrenal glands are small, cap-like glandular organs situated in close proximity to the kidneys. Often these “suprarenal” glands are incorrectly sought above the kidneys, but as the term “adrenal” implies, each gland is predominantly medial to the upper pole of the associated kidney. The right adrenal gland has a linear or V-shape, while the left adrenal gland is more V- or Y-shaped. The wings of each gland are 30 – 60 mm long and 3 - 10 mm thick (2). Their physiological function is hormone production. The adrenal cortex secretes cortisol, aldosterone and sex hormones, while the adrenal medulla secretes epinephrine and norepinephrine.

To visualise the normal adrenal gland with transabdominal ultrasound requires good scanning conditions, a high-resolution transducer and meticulous examination by an

experienced sonographer. It is sometimes useful to speak of evaluating the “adrenal region” rather than the glands themselves. CT can consistently define normal-sized adrenal glands and therefore is the investigation of choice in the primary imaging of these structures.

Endoscopic ultrasound (EUS) of the upper gastrointestinal tract provides the best imaging quality for the adrenal gland [Figure 3]. However, this is consistently possible only at the left side. Endoscopic ultrasound evaluation of the right adrenal gland is only possible in 30 - 70 % of examinations (3, 4). The supplying vessels (left suprarenal arteries and veins) are visible only endosonographically. However, due to its semi-invasive character and the limitations to visualize the right adrenal, EUS is not the standard technique for primary diagnosis of adrenal gland abnormalities (1, 2).

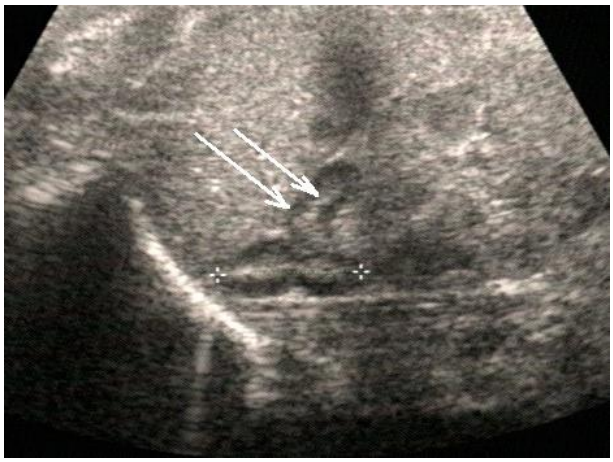
Figure 3 **High-resolution endosonography of the left adrenal gland. The proximal and caudal limbs with its 5-layer structure are visible in high-resolution; the adrenal cortex is depicted as a slim hypoechoic rim-like structure surrounding the hyperechoic medulla. The whole gland is surrounded by an hyperechoic capsule.**

Echogenicity

On ultrasound, normal adrenal glands have a long and hyperechoic narrow shape and typically have a five layer-stratification (hyperechoic medulla surrounded by hypoechoic cortex and a hyperechoic capsule) [Figure 3]. The adrenal glands can almost always be visualised in newborns (5-7). The physiological hypertrophy at this stage of life results in

relatively large glands that can be easily identified; corticomedullary differentiation is easily depicted [Figure 4].

Figure 4 Normal adrenal gland of an infant consisting of a hyperechoic medulla and hypoechoic cortex (shown between markers).



Examination technique

The normal position for examination is dorsal decubitus. The right adrenal is best visualized using a subcostal flank scan, an intercostal scan or oblique subcostal scan. A second opportunity is a transverse section from the right hypochondrium. One option for the examination of the left adrenal is a transverse position of the transducer in the epigastrium with the pancreatic tail used as an acoustic window and aorta, splenic vein and left renal vein as anatomical landmarks. The second option is to use an intercostal flank scan through the spleen or the upper third of the left kidney. Additionally and sometimes with better success, adrenals are examined with the patient in left (for the right adrenal: the right liver lobe is used as an acoustic window) or right lateral position (the spleen or upper third of the left kidney are used as an acoustic window). In the case of intercostal scanning, slow deep breathing by the patient moves the organ from its original position under the ribs, which increases the visible region. Occasionally it is useful to examine the patient lying over a roll

(the so-called gabled position) (8) especially in the prone position. Normally a convex probe with high-resolution at depth and a tissue harmonic function is used.

The normal acoustic obstacle of examination of the left adrenal gland is air in the intestine (stomach, transverse colon, small intestine). Sometimes special preparations (fasting patient, water-filled stomach) and gentle and repeated compression and breathing maneuvers may be helpful. With endoscopic ultrasound, the distance in particular to the left adrenal is very close, and high-resolution imaging as well as sampling of adrenal tumors is possible (4, 9). The basic requirement for examination is a convex abdominal transducer (3–5MHz in B- mode). Vascularisation can be evaluated by power Doppler, and contrast - enhanced ultrasound (CEUS) can visualize the microvascularisation of adrenal gland tumors.

Normal adrenal gland

On the right side the normal adrenal gland is visible in more than 90% of cases [Figure 5]. The normal left adrenal gland is visible in only 40–50 % of cases [Figure 6] (2). The adrenal glands have a long axis of 40 - > 50 mm and a body thickness of approximately 10 mm, whereas the limbs are very slender with a diameter of up to 5 mm.

Figure 5 The normal right adrenal gland is visible dorsal to the right liver lobe as a slender layered organ with two limbs (arrows: right diaphragm).

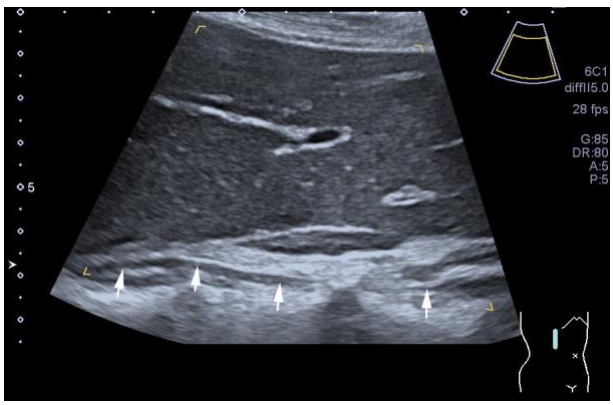
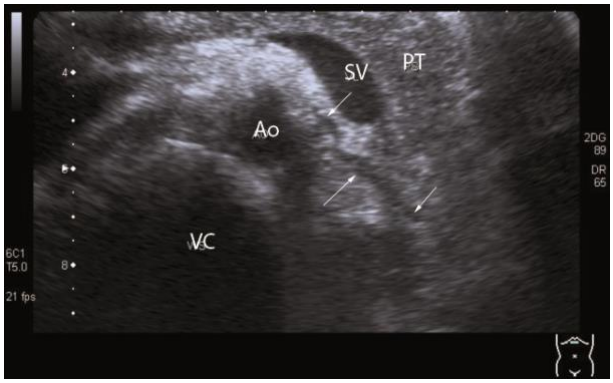


Figure 6 Visualization of the left adrenal gland (arrows) using the pancreatic tail (PT) as an acoustic window. Anatomical landmarks are the aorta (Ao), the vertebral column (10) and the splenic vein (SV).



Enlarged adrenal gland and mass lesions

In adults the adrenal glands are better visible when they are enlarged. Some causes of enlargement have a pathological significance. Diseases of the adrenal glands may or may not be associated with endocrine symptoms [Table 1]. Examination of the adrenal region is indicated for the staging of oncological diseases (M-staging) and in case of endocrine disease. However, adrenal abnormalities are often detected incidentally. In the absence of current diagnosis or history of malignancy, an incidentally detected solid adrenal mass is called an incidentaloma**.**

Differential diagnosis (differentiation from other structures in the surrounding area)

Enlarged or tumorous adrenal glands require distinction from other possibly tumorous structures in the surrounding area of the adrenal gland. Tumors of the kidney, pancreas [Figure 7] and spleen (especially accessory spleen) or vascular abnormalities and lymphoma should be considered in the differential diagnosis. It must be taken into account that adrenal gland tumours always dislocate the surrounding structures. If the adrenal gland tumour is extremely large, it may be difficult to find the neighbouring organs.

Figure 7 Transsplenic examination of a large, hypoechoic malignant tumor of the pancreatic tail; differentiation from left adrenal tumor is difficult.

Adrenal gland hyperplasia

Hyperplastic adrenal glands are usually hypoechoic, especially in the cortical zone. They appear plump and elongated, may show nodular structures and the borderline between cortex and medulla disappears. The adrenal gland in Figure 8 measures > 10 mm**.** Adrenal hyperplasia can occur, for example, as an adaptive response in adrenocorticotropic hormone (ACTH)-dependent Cushing's syndrome. It may have a paraneoplastic cause or occur in hyperaldosteronism. Hyperplasia is found bilaterally in most cases. Differentiation from adenoma is not possible by histology or cytology (FNAB).