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Preliminary Report of the Significance of Ultrasonography (US) in Clinical Practice

Znaczenie ultrasonografii (USG) w praktyce klinicznej. Doniesienie wstępne

INTRODUCTION

For the last two decades physicians have recognized US as a versatile and inexpensive noninvasive method that yields high-resolution images without discomfort or risk. The use of this technique continues to increase not only in total number of performed examinations but also in the type of examinations. US has already been used by radiologists and clinicians, and it can be appriopriate and beneficial to patients if it is used in a responsible manner. It should be stressed that considerable skill is necessary for accurate ultrasonic evaluation. A doctor who practices US needs a strong knowledge of anatomy and the ability to conceptualize in longitudinal and cross-sectional planes. Adequate training of physicians is a complex matter as the range of US applications is so broad and diverse. Echocardiography and Doppler duplex scanning wave are different from what is required for obstetric-gynecologic ultrasound (9, 10, 13). Neurosurgical, intraoperative, or ocular US present different problems in execution and interpretation than intrarectal, transurethral and scrotal US examinations (5, 7, 17, 18, 24). The factors responsible for an excellent pediatric US are different from those of the geriatric patient population (16). Also high-resolution parathyroid US requirements are not the same as those for the US examination of the thorax or the abdomen (14, 23, 26). The technique is so universally accepted that it should be routinely ordered and carried out before any radiologic or other invasive examinations or techniques (19, 28).

The aim of this report is to discuss the diagnostic possibilities and limitations of US in visualization of pathologic changes in the majority of human organs, except those which are inaccessible for examination due to their bone or air cover. The role of US technique among other modern imaging methods, the reasonable use of it and the problem of proper, responsible interpretation of US results are also the topics of this paper.

MATERIAL AND METHODS

Our material consists of 4800 US examinations carried out during the period of the last 2 years. We were investigating our patients with real-time Hitachi Electronic Ultrasound Scanner with Digital Scan Converter, Model EUB 410. We were using selectable transducers of differing frequencies 3.5—5.0 MHz, both convex and linear probe head type. Patients were usually examined early in the morning, completely fasting. All examined organs were evaluated in longitudinal and transvere planes and sometimes in oblique views if necessary. The discovered pathologic changes were recorded on special paper using video copy printer P40U (Mitsubishi make).

RESULTS AND DISCUSSION

The biliary system is exceptionally well presented by US, even in cases of severe jaundice, and there is no need to expose patients to radiation or potential contrast-allergic reactions (28). Gallbladder polyps as small partly pedunculated masses within are well seen (Fig. 1). Biliary calculi are usually well defined, highly reflective structures contained within the gallbladder lumen with characteristic posterior acoustic shadowing (Fig. 2). Sludge will not produce acoustic shadows, whereas gravel may. In the material presented by Zabielski et al. (28) the diagnostic efficacy of US in relation to radiologically diagnosed gallbladder calcinosis is 85.7%. Thickening of the gallbladder wall in excess of 3 mm is abnormal. Irregular thickening of the wall is primarily associated with neoplastic growths (Fig. 3), while symmetrical thickening is more commonly associated with cholecystitis. It is essential to keep the main portal vein in view all the time, as it is the best landmark for US imaging of the biliary ducts, the normal diameter of which is approximately 6 mm. US diagnosis of stones in the biliary tree is more difficult and only 30% of ductal stones are visualized by ultrasound (Fig. 4).

The cystic masses in the liver are well-circumscribed, smooth, thin-walled echo free lesions (Fig. 5). US findings of primary cancer are usually discrete single masses with ill-defined borders. Sometimes their appearance may be hyperechoic, hypoechoic, or complex compared to normal liver parenchyma (Fig. 6). Hemangioma most commonly appears echogenic, size variable and serrated contour (Fig. 7). Metastatic lesions are in most cases multiple with enlarged liver. Target lesion looks like a hypoechoic ring with echogenic center (Fig. 8). Sometimes they can be seen as cystic lesions with irregular walls due to necrosis. Lüning et al. (15) in their prospective study made an attempt to determine the specificity of various imaging methods for defining tumors of the liver rather than presenting their ability to demonstrate these tumors. MR showed somewhat better results in demonstrating the type of lesion (accuracy 80% that CT — 73% and angio-CT — 73%). The results of scintigraphy (53%) and US (69%) were rather worse. The range of accuracy for MR, CT and US varied from 94 — 47%. Partly increased echogenicity of liver sometimes with ascites around it may be a characteristic US pattern of cirrhosis hepatis (Fig. 9). According to Vogel et al. (27) CT and US are superior to MR as far as the detection of focal or diffuse fatty degeneration is concerned. However, MR makes an exact differentiation of fatty changes from neoplasm possible. Concerning Wilson's disease MR showed a characteristic pattern of parenchymal changes.

With the improved resolution in modern real-time instruments, the pancreas is relatively easy to recognize by its dense, echogenic reflectivity and the framework of vessels surrounding it. Pancreatic tissue is generally more dense and mottled in appearance than echoes emanating from liver or kidney (20, 21). Objectivization of echographic examination by means of computer digitization and picture analysis is an important step in making US valuable instrument of noninvasive organ texture analysis (1). Acute pancreatitis will produce an US image of gland devoid of any of the vessels that run posteriorly. This is due to the extreme pressure on the vessels' walls caused by the swollen, heavy gland (Fig. 10). Repeatability of the US examination, as well as its noninvasiveness are the basic advantages in monitoring the course of pancreatitis. US observation facilitates the diagnosis of the type of lesion and in some cases decides about the method and timing of surgery (4). The commonly occurring pseudocysts of the pancreas may be seen as walled-off fluid-filled mass lesions, either in or adjacent to gland (Fig. 11). Their formation may last from 2 weeks to 2 months following the onset of inflammation. Pancreatolithiasis is a characteristic sequela to recurrent and severe chronic pancreatitis. Pancreatic carcinoma is strongly suggested by the presence of complex, primarily solid, but hypoechoic echogenicity within lesion with regular borders (Fig. 12). After statistical analysis performed by Rakoczy and Serafin-Król (20) of US signs according to their occurrence in cancer and inflammatory tumors, 11 essential features were selected. In most cases those features containing symptoms allow to differentiate the character of tumor lesion in the pancreas. The size of pancreas differs with age, it is larger in children and smaller in elderly patients.

The homogeneous parenchymal echoes of the spleen provide an excellent background for the imaging of tissue-altering pathologies. Focal defects may be single or multiple and do not always produce splenomegaly. Nontraumatic causes of focal defects include tumors, infarctions and abscesses (16). Splenomegaly is frequently secondary to hepatomegaly as a result of portal hypertension. Blunt abdominal trauma commonly causes splenic injury. It is important to document whether splenic bleeding is confined to the splenic capsule or has ruptured into the perisplenic region (Fig. 13).

Kidneys were among the earliest organs to be successfully imaged with diagnostic US. A special role in kidney US plays the evaluation of the consistency, location, and nature of any space-occupying lesion. US requires no contrast agents and does not depend on renal function, so it is an excellent option to use in contrast-allergic patients or those with impaired or nonexistent renal function. Renal trauma is a serious treat that may produce hemorrhage in and around the kidney and subcapsular or extrarenal hematomas. Fresh bleeding usually appears as a sonolucent fluid collection (Fig. 14). As this material organizes, it develops internal echoes. Renal tumors are generally highly vascular and their specific echo pattern will vary depending on the nature of the contents. US is very accurate in distinguishing liquid from solid tissue (6). Therefore, its major use in these lesions is to help differentiate cysts (Fig. 15) from solid tumors. Renal calculi may be also well seen (Fig. 16). Adult PKD is presented as random-sized and randomly distributed renal cysts. With time these kidneys will become massively enlarged. Patients with chronic glomerulonephritis will demonstrate varying degrees of renal echogenicity as parenchymal damage occurs (16). End-staged renal disease produces renal scarring and atrophy (19).

Acute renal transplant rejection seemed to be the most frequent nephrologic complication. Unfortunately, most of US features are rather non-specific, like e.g. increased renal volume, prominence of the medullary pyramids and cortical thickening. Most significant features are diminished renal sinus echo, focal parenchymal abnormalities and pelvic wall thickening. However, renal graft biopsy remains the procedure of choice in case of rejection (3).

US imaging enabled US to see the urinary bladder wall rupture (Fig. 17a). Follow up scan revealed decrease of size of wall rupture as well as evolution of accompanying hematoma (Fig. 17b). The patient's urinary bladder should be moderately full at the time of examination (5). In this way polypoid mass within urinary bladder could be diagnosed in case of papillary transitional cell carcinoma (Fig. 18). Masses of urinary bladder wall carcinoma with irregular outline could also be found (Fig. 19).

The most commonly requested studies of the male reproductive system are these of the prostate gland and the contents of the scrotal sac. In the transabdominal US imaging the prostatic hypertrophy could be easily recognized (Fig. 20). Recently, transrectal US of the prostate has gained wide acceptance as a useful imaging modality for patients with prostatic adenocarcinoma. Shelth et al. (24) in their study demonstrate sensitivity of 55% and specificity of 37% for this method in detecting of prostatic carcinoma. Sonography offers a reproducible monitoring of the results of radiotherapy in patients with this lesion (19).

US provides an excellent method of differentiating between testicular and epididimal masses. The presence of inflammatory conditions of the epididymis will produce more sonolucent appearance during the acute phase of infection and more hyperechogenic and swollen appearance in chronic infection (Fig. 21). Hydroceles and hematoceles produce abnormal fluid collection that surrounds the testis. The most common testicular tumor is seminoma, which changes the normally homogenous echo pattern of the testicle to one containing an echo-poor area compared with adjacent normal testicular tissue.

It was found that transabdominal US, especially with the stomach fluid fulfilment gives optimal conditions for examination enabling more accurate assessment of lesions in the stomach wall and adjacent organs. Therefore, US is a valuable completion of standard methods of visualization (26). Botet et al. (7) believe that endoscopic US combines the advantages of direct endoscopic visualization of the bowel wall with the capabilities of high-frequency sonography in visualizing the layers of the bowel wall and the adjacent surrounding spaces. On the basis of endoscopic US we may differentiate, for instance, lymphoma from carcinoma because carcinoma may be more echogenic than lymphoma (7). Some authors believe that this method is a valuable new technique with substantial potential in the evaluation of the upper gastrointestinal tract (6, 7, 9, 19). Transesophageal echocardiography can also provide a dynamic imaging of dorsal cardiae structures such as the right atrium and the superior vena cava (9).

The presence and extent of tumor thrombus within the inferior vena cava may be demonstrated with US (Fig. 22), MR and cavography. US is considered superior to CT and angiography in demonstrating the cranial extent of thrombus, but differentiation between tumor thrombus and blood clot has recently occurred possible by using dynamic CT and MR (12). Our observations proved that US can evaluate an aneurysm of abdominal aorta with great accuracy (Fig. 23). Some authors believe that US can be essential for further decision of a surgical treatment (25). For the first time, intravascular US provided high resolution images of the vessel-wall. Changes in vessel wall can be readily diagnosed and their extent can be accurately described (10).

Ascites is visible as free-moving sonolucent fluid collection which changes as patient changes his position, moving to the most dependent portion of body. Usually bowel loops project into fluid (Fig. 24). Peritoneal abscess appears as irregular border complex mass with debris and hypoechoic center (Fig. 25). It is difficult to distinguish it from hematoma.

Diagnostic US is today capable of making a unique contribution in fetal, neonatal, and pediatric adrenal imaging as a truly noninvasive method. It is also possible to provide valuable information about adrenal pathology in adult patients (16). Adrenal cysts are usually thin-walled, round, and echo-free masses that can attain great size. Neuroblastoma is a highly echogenic, malignant tumor often with hemorrhage, necrosis, and calcification. Masses of right adrenal gland may lie posterior to the inferior vena cava, causing an indentation on its posterior wall and lifting it upwards. Kidneys will usually be displaced inferiorly by large adrenal masses. Pheochromocytoma is another mass that often occurs in the adrenal gland as well as in other locations. The US pattern of this lesion has a homogeneous appearance. As this mass enlarges it causes a distinct rounding of the adrenal outline (6, 16).

It is doubtful whether there is any other area of the body where this is more obvious than the female reproductive system. For over two decades the use of US in gynecology has demonstrated that it delivers diagnostic accuracy in 90% of cases (Fig. 26). In the majority of instances, US accurately distinguishes fluid filled from solid masses (27). While this allows a description of the gross appearance of the pathology, it cannot go much further and deliver a tissue diagnosis (19).

Undoubtedly the greatest impact of US in medical diagnosis has occurred in the field of obstetrics. As a result of US, the fetus has emerged as a patient rather than merely a measuring target (27). Ideally, US dating of pregnancy should take place during the first trimester (13). In dealing with early pregnancy it is imperative to be familiar with the basic structures and constant that take place weekly.

The thyroid gland is easily accessible by US because of its superficial nature, and because the gland is composed mainly of spherical follicles lying in a vascular matrix; its echogenic appearance is one of moderate echogenic homogeneity. US is most useful in the study of goiter, thyroiditis, benign or malignant tumors. Enlargement of the thyroid due to chronic deficiencies of thyroid hormone is termed nontoxic goiter. The US changes observed in the acute and subacute inflammation of the thyroid are visible as glandular enlargement and hypoechoic areas scattered throughout the gland. Cold nodules detected on isotopic examination are mostly adenomas with extensive degeneration rather than congenital cysts (Fig. 27). The most commonly occurring tumor of thyroid is the benign adenoma. It can present multiple US patterns. An echogenicity similar to thyroid tisssue with a hypoechoic halo surrounding the periphery of mass is most common (Fig. 28). Thyroid carcinoma accounts for only 20% of cold nodules. Although cystic degeneration is less extensive than in adenomas, nevertheless it can appear; the only distinction is the poorly outlined and encapsulated quality of the mass and possible evidence of invasion of adjacent cervical vessels or lymph node enlargement (19).

Parathyroid glands appear more homogeneous and less echogenic than the adjacent thyroid tissue. US is especially valuable as a diagnostic tool in postsurgical patients with recurrent or persistent deseases. Parathyroid cysts resemble thyroid cysts but are relatively uncommon. Parathyroid adenomas are generally single lesions which are oval and exhibit hypoechoic or anechoic patterns without clearly depicted posterior enhancement. Another superficial structure can be examined, such as muscular hematoma. It gives an hypoechoic area irregular in shape, commonly compressing adjacent vessels (Fig. 29).

US has been providing valuable information in neurosonology for a few years (17). Intracranial hemorrhage presents initially high echogenicity without accoustic shadowing. After 2 weeks there are visible anechoic areas with sonolucent centers surrounded by echogenic rim. Then it gradually shrinks and porencephalic cysts form as hematoma retracts. Cephalohematoma is seen as mildly echogenic mass separating scalp from bony skull. Periventricular leucomalacia presents hyperechoic margins of lateral ventricles. Hydrocephalus is easily detected on US scan (17).

In a prospective study it has been proved that chest US is superior to conventional X-ray diagnosis of recumbent patients in diagnosing pleural effusion and lung atelectasis (14, 23).

Plucińska (18) analysed the acoustic structure of orbital tumors. It was found that US analysis made a preliminary assessment of the morphotic structure of tumor possible. US imaging correlated with other clinical findings and results of biochemical and immunological data. US may be very helpful in establishing the diagnosis of Grave-Basedow disease.

It has been proved that the US imaging can show anatomical structures of larynx and may be supplementary for laryngological examination when the depth of neoplastic infiltration and the localization of tumors are being estimated (11).

Breast was one of the first organs examined with US. Now this technique comes into wider use after the introduction of equipment specially designed for this goal. Its main use is for the differentiation of cystic and solid palpable and mammographically visible masses. If strict US criteria are used for a simple cyst, the diagnostic accuracy approaches 100% (2).

The advent of enhanced US details has parallelled the decreasing cost of this equipment, leading to wide availability of ultrasound units. Controversy and even rivalry have therefore arisen between medical specialities regarding the use and regulation of US. For example, although the primacy of US in evaluating the fetus and intrauterine environment is unchallenged there is still much controversy who is to perform and interpret these examinations. It is similar in case of cardiology, orthopedic clinic, ophtalmonology as well as patients with breast disease (13, 26). Our opinion is that most qualified clinicians should deal with this kind of examination.

We believe that ultrasound is a diagnostic imaging method that has widespread patients' acceptance, is painless, involves no known up to now biologic hazard, requires no contrast material and in many instances is cost-effective. As the popularity of US increases and the applicability expands, physicians other than trained radiologists seek the expertise to perform US in specialized situations; ophtalmologists for the eye, neurosurgeons for the brain and spinal cord, cardiologists for the heart, mammographers for the breast, surgeons for the diagnosis of congenital hipjoint luxation. Other physicians with less specialized interests see the advantages of the modality as an extension of the physical examination (13).

To avoid an incomplete study with a "missed" lesion, improper interpretation of the sonogram, ultrasound should be restricted to those who have fulfilled criteria of competence and met continuing educational requirements.

Some authors pointed out the practical usefulness in the clinic of the thin-needle biopsy guided by US in the diagnosis of various pathological processes of some organs (8).

We hope that this discussion should contribute to a proper estimation of the importance of US in the social health service, and to the selection of the most appropriate organizational form of the development of this method.

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EXPLANATION TO FIGURES

Fig. 1. Gallbladder polyps. Partly oblique longitudinal left lateral decubitus scans. Small partly pedunculated masses are seen within gallbladder.

Fig. 2. Gallbladder stone. Longitudinal left lateral decubitus scan. An echodense stone within gallabladder with associated posterior acoustic shadowing is seen.

Fig. 3. Gallbladder carcinoma. Transverse left lateral decubitus scan. A fluid-filled gallbladder with markedly thickened wall is noted.

Fig. 4. Choledocholithiasis. Transverse scan. A dilated common bile duct contains a big oval lesion in its distal end.

Fig. 5. Simple hepatic cyst. Longitudinal scan. An anechoic mass is seen in posterior segment of right liver lobe with visible posterior acoustic enhancement.

Fig. 6. Hepatic tumour. Oblique scan. A rounded hypoechoic and partly mixed echogenic mass about 6 cm in diameter in posterior segment of right liver lobe is noted.

Fig. 7. Liver hemangioma. Transverse scan. A well-defined rounded hyperechogenic area is seen in right liver lobe.

Fig. 8. Hepatic metastases. Longitudinal scan. Several hypoechoic rounded lesions in left liver lobe are seen.

Fig. 9. Cirrhosis hepatis. Transverse scan. Partly increased echogenicity of liver with visible ascites around it.

Fig. 10. Acute pancreatitis. Transverse scan. The whole pancreas is enlarged and hypoechoic.

Fig. 11. Pancreatic cyst. Transverse scan. A big oval hypoechoic mass with posterior acoustic enhancement in projection of pancreatic tail is seen. Partly dilated duct of Virsung is noted.

Fig. 12. Pancreatic adenocarcinoma. Transverse scan. A large oval partly hypoechoic mass is seen in the region of pancreatic head. Markedly enlarged distal common bile duct and partly dilated duct of Virsung are also seen.

Fig. 13. Perisplenic hematoma. Longitudinal scan. Hypoechoic crescentic area is seen between left dome and spleen.

Fig. 14. A subcapsular renal hematoma. Longitudinal scan. A big rounded mixed echogenicity mass on the anterior outline of the left kidney is seen.

Fig. 15. Simple renal cyst. Longitudinal scan. A well-defined anechoic mass with distal acoustic enhancement is seen in the lower pole of the right kidney.

Fig. 16. Renal calculi. Longitudinal scan. Two echogenic collecting system calculi with posterior acoustic shadowing in right kidney are noted.

Fig. 17a. Post-traumatic rupture of the urinary bladder. Longitudinal scan. There is rupture of anterior wall of urinary bladder with accompanying anteriorly placed big hypoechogenic hematoma. Uterus is seen posteriorly.

Fig. 17b. Control scan after 8 days reveals marked decrease of size of bladder wall rupture and further evolution of accompanying hematoma.

Fig. 18. Papillary transitional cell carcinoma. Transverse scan. A polypoid mass is seen in the base of the urinary bladder.

Fig. 19. Urinary bladder carcinoma. Longitudinal and transverse scans. A polypoid mass with irregular outline is seen involving posterior wall of the bladder on the left side.

Fig. 20. Benign prostatic hypertrophy. Longitudinal and transverse scans. Markedly enlarged prostate with specially prominent its median lobe is seen.

Fig. 21. Chronic epididymitis. Transverse scan. Epididymis of the right testis is hyperechogenic and swollen. Normal echogenic texture of both testes.

Fig. 22. Carcinomatous embolus of inferior vena cava. Longitudinal scan. A big oval partly hyperechogenic mass is seen in the lumen of upper part of inferior vena cava.

Fig. 23. Dissecans aneurysm of abdominal aorta. Longitudinal and transverse scans. Partly widened aortic lumen, about 3 cm in diameter, is divided in two parts by pathologic echogenic septum.

Fig. 24. Ascites. Longitudinal scan. Loops of small intestine are separated by big amount of free hypoechoic peritoneal fluid.

Fig. 25. Peritoneal abscess. Longitudinal scan. A big hyperechoic ring lesion with hypoechoic centre, is seen in the left midabdomen region.

Fig. 26. Cystic tumour of the left ovary. Pregnancy. Transverse scan. A multicystic hypoechoic mass is seen in the projection of the left ovary.

Fig. 27. Thyroid cyst. Longitudinal scan. A big oval anechoic lesion is seen within enlarged right lobe of thyroid.

Fig. 28. Adenoma of thyroid. Transverse and longitudinal scan. An isoechogenic rounded lesion, separated by a thin hypoechoic ring is seen in middle part of enlarged right lobe of thyroid.

Fig. 29. Muscular hematoma of the right thigh. Big irregular in shape hypoechoic lesion is seen, partly compressing the femoral vein.

STRESZCZENIE

Na podstawie własnego doświadczenia i danych z piśmiennictwa poddano ocenie wartość badania ultrasonograficznego w diagnostyce schorzeń narządów jamy brzusznej, szczególnie podkreślono przydatność tej metody w diagnostyce kamicy dróg żółciowych. Omówiono możliwości badania ultrasonograficznego w diagnostyce narządów miednicy mniejszej, zwracając uwagę na znaczenie tej techniki w praktyce ginekologiczno-położniczej. Okazało się, że technika USG ma także praktyczne zastosowanie w diagnostyce naczyń mięśni oraz narządów położonych powierzchownie (tarczyca, sutki i jądra), a także w okulistyce, neuroradiologii oraz w badaniach endo- i śródoperacyjnych.

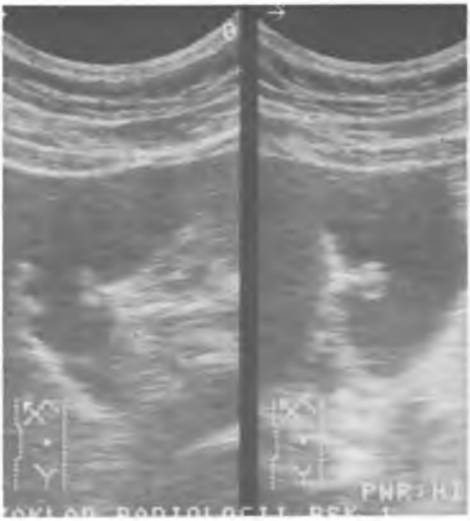

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Fig. 7

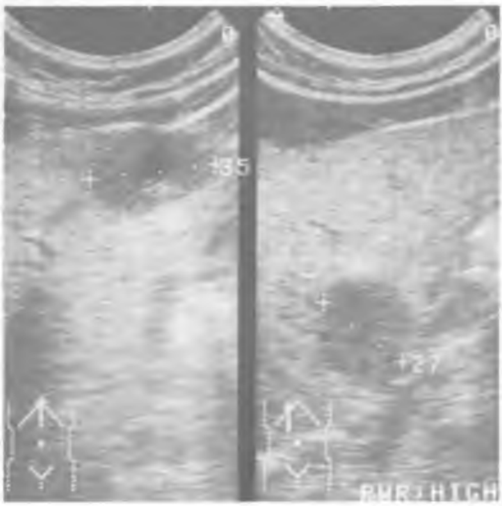

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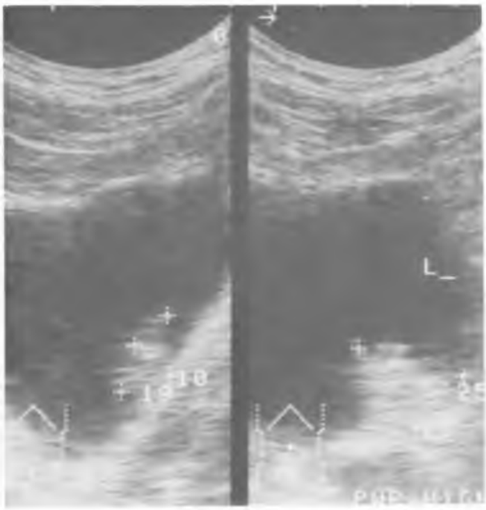
Fig. 17a

Fig. 17b

Fig. 18



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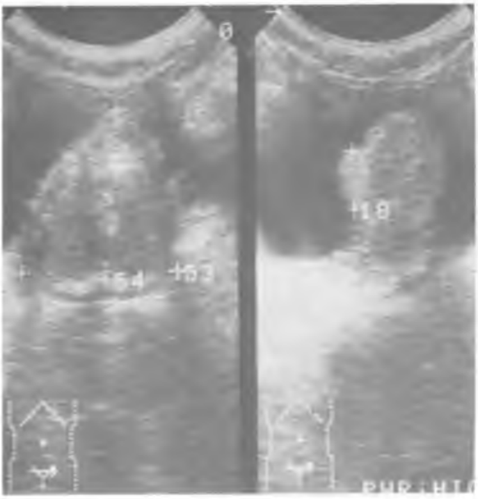

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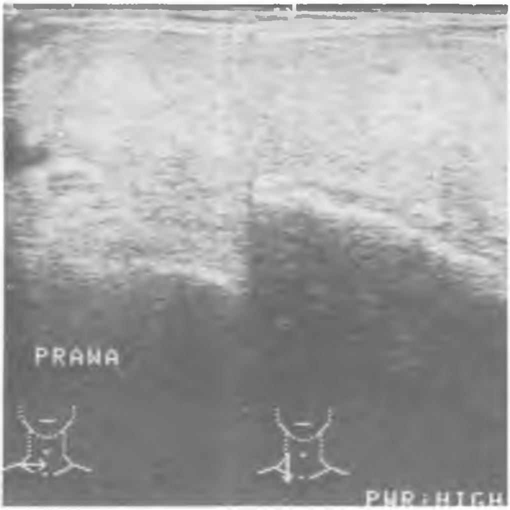

Fig. 28

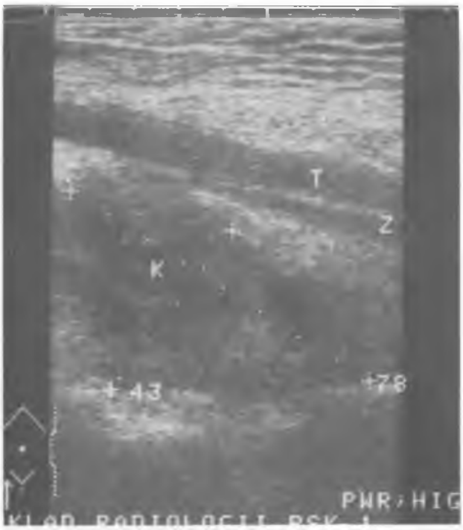

Fig. 29

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