FGBOU VO SOGMA

Educational and methodological developments

For SOGMA students.

Topic: **Radiation diagnosis of diseases of the urinary system, liver and biliary tract and reproductive system of women.**

Purpose of the lesson:

To study the radiation anatomy of the liver and biliary tract, kidneys and urinary tract, reproductive system and mammary gland; methods and possibilities of their radiation research.

Specific objectives of the lesson:

Be able to:

1. Recognize the method of radiological examination of the kidneys (ultrasound, plain radiography, urography, computed tomography, scintigraphy, magnetic resonance imaging, angiography).
2. Determine the anatomy of the urinary system with various methods of radiation diagnostics.
3. Using the protocol of the patient's radiation examination, find and interpret the morphological and functional changes in the urinary system on radiographs, computed tomograms, magnetic resonance imaging, angiograms, scintigrams.
4. Recognize the method of radiological examination of the liver and biliary tract (ultrasound, plain radiography, cholecystography, cholegraphy, cholangiography, computed tomography, hepatobiliscintigraphy, hepatoscintigraphy, magnetic resonance imaging, angiography).
5. Determine the main anatomical structures on various x-ray images of the liver and biliary tract.
6. Using the protocol of the patient's radiation examination, find and interpret the morphological and functional changes in the liver and biliary tract on radiographs, computed tomograms, magnetic resonance imaging, angiograms, scintigrams.
7. Recognize the method of radiation examination of the reproductive system (ultrasound, hysterosalpingography, mammography, pneumocystography, ductography).
8. Distinguish the anatomy of the reproductive system on radiographs and mammograms at different age periods.
9. Using the research protocol, find morphological changes in the organs of the reproductive system on radiographs, mammograms and ultrasound scans.

Know:

1. Radiation anatomy of the kidneys and urinary tract.
2. Principles of preparing the patient for the study of the urinary system.
3. Possibilities of various radiation diagnostic methods in the study of the kidneys and urinary system.
4. The main radiation syndromes in diseases of the kidneys and urinary system.
5. Radiation anatomy of the liver and biliary tract.
6. Principles of preparing the patient for the study of the liver and biliary tract.
7. Possibilities of radiation methods in the study of the liver and biliary tract.
8. Radiation semiotics of the main diseases of the liver and biliary tract.
9. Radiation anatomy of the reproductive system.
10. Principles of preparing the patient for the study of the organs of the reproductive system and the mammary gland.
11. The main radiation syndromes of lesions of the mammary glands and in diseases of the reproductive system.
12. Possibilities of radiation diagnostic methods in the examination of the mammary glands and reproductive system of a woman.

Base of carrying out and material equipment:

1. Study room.
2. Educational set of scans, radiographs, sonograms, computed tomograms, angiograms with the norm and pathology of the urinary system, liver, biliary tract, reproductive system of a woman.
3. Tables, schemes.
4. Case histories of patients with ROD.

Literature:

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2. G.A. Zubovsky "Radial and ultrasound diagnostics of diseases of the liver and biliary tract", M. "Medicine", 1988.
3. G.E. Trufanov "Radiation diagnostics and radiation therapy", St. Petersburg, 2005.
4. E.B. Kampova-Polevaya, S.S. Chistyakov "Clinical Mammology", M. "GEOTAR-Media", 2006.
5. V.N. Demidov, B.I. Zykin "Ultrasound diagnostics in gynecology", M. "Medicine", 1990.
6. V.N. Demidov, Yu.A. Pytel, A.V. Amosov "Ultrasound diagnostics in uronephrology", M. "Medicine", 1989.
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Information block: ____

URINARY SYSTEM

The urinary organs include the kidneys, ureters, bladder, and urethra. All of them play an important role in ensuring the normal functioning of the body. Therefore, early and accurate recognition of their diseases and injuries is essential. In solving this problem, among other diagnostic methods (laboratory, instrumental), radiation studies occupy a leading place.

The main methods of radiation diagnostics in urology are X-ray and ultrasound, it is with their use that radiation examination of urological patients should begin, since this is due to the fact that these methods are the most accessible and economical and at the same time have a fairly high information content. In diagnostically difficult cases, X-ray and magnetic resonance computed tomography can be used at the second stage. For functional studies, the use of the radionuclide method is shown.

Ultrasound scanning (sonography) of the kidneys

In connection with the harmlessness and high information content, sonography in most cases is the first method from which an examination using radiation methods of a patient in a urological clinic is started. Sonography of the kidneys is carried out in various directions: sagittal, frontal, oblique, transverse. Usually, the study is started from the back with the patient in a horizontal position. In any projection, the detector is sequentially moved every 1 1,5 см- , considering the resulting images and making the necessary measurements.

A normal kidney on the sonogram appears as an oval mass with heterogeneous echogenicity. The kidney is surrounded by a thin (about 1- 1,5 мм) hyperechoic fibrous capsule, so it is well differentiated from the surrounding perirenal fat, which is a zone of increased echogenicity and a homogeneous structure.

The median (central) echo complex is located in the middle section of the kidney and corresponds to the renal sinus. It is formed when an echo signal is reflected from the cups, pelvis, vessels, nerves, adipose and fibrous tissue located in the renal sinus. The outer contour of the median echo complex is uneven, serrated. It has a high echogenicity, heterogeneous echostructure, which is associated with uneven reflection of the echo signal from the structures of the renal sinus.

Cups are visible only in the presence of urine in them and are anechoic formations of a rounded shape with clear hyperechoic walls, with a diameter of no more than 5 мм.

The pelvis is not normally visualized. It can only be seen in patients with an extrarenal pelvicalyceal variant. In this case, it has the form of a liquid formation of the correct form with clear hyperechoic walls, located at the hilum of the kidney. When transverse or longitudinal scanning in the sagittal plane, the pelvis looks like two parallel linear hyperechoic echo signals with anechoic content between them.

The kidney parenchyma is a hypoechoic zone and consists of two layers.

The medulla is located between the median structures and the cortical substance and is represented by separate pyramids that look like an almost anechoic round, oval or cone-shaped formation with a diameter of 5 -9 мм.

The cortical layer is located directly under the kidney capsule, extends into the space between the pyramids and is a single whole. The tissue of the cortex is homogeneous, the echogenicity is significantly lower than the echogenicity of the median complex, but higher than the echogenicity of the pyramids.

Normal ureters are not detected by echography. They are detected only with a diameter 10 ммor more. The lower calving of the ureter is visualized only through the filled bladder.

The proximal part of the renal artery is usually visible when scanning from the anterior abdominal wall. The rest of the arteries are not always determined due to the accumulation of gas in the intestine.

On transverse echograms taken from the side of the anterior abdominal wall, the bladder has the shape of a horizontally located oval. The filled bubble is an anechoic formation, devoid of internal echo structures, with a clear and even surface. The walls of the bladder are defined as hyperechoic linear structures, no more than 4 мм. The use of intracavitary sensors in some cases makes it possible to differentiate different layers of the organ wall.

The prostate gland looms directly behind the bladder and normally also has a smooth outline. The tissue of the gland is represented by a continuous alternation of echo-negative areas and small dotted and linear structures. The capsule of the gland is clearly visible. When examining through the urethra or rectum , a clearer image of the prostate gland is achieved, its dimensions, surface area, volume, and, if necessary, use a device that helps to accurately guide the needle for puncture and biopsy.

X-ray method

Native urography - This is an X-ray examination carried out in conditions of natural contrast, the main purpose of which is to obtain an image of the kidneys and to detect various pathological inclusions (calculi, calcifications, foreign bodies, gas accumulations, etc.) in the area of the urinary system organs. The indications for this study are the slightest suspicion of a disease or damage to the organs of the urinary system, as well as the need for differential diagnosis of lesions of these organs with pathological processes in nearby structures.

Native urography includes, first of all, the obligatory execution of a ***standard survey radiograph*** of the urinary organs, starting from the upper ends of the kidneys and ending with the lower wall of the bladder. For this patient, it is necessary to prepare - to clean the intestines the night before and in the morning on the day of the study. The patient must arrive at the X-ray room on an empty stomach. The only exceptions are patients with acute renal colic: they have to be examined without bowel cleansing. The picture is taken with the patient in a horizontal position on his back with bent legs in the hip and knee joints while holding the patient's breath after a shallow breath.

The characteristic of the kidneys according to native radiographs includes an assessment of their position, shape, contours, size, displacement.

Plain native radiography must necessarily precede each radiopaque and should not be reduced to the production of only a standard plain radiograph. Most often, it turns out to be necessary to produce panoramic images in lateral, oblique projections (to clarify pathological shadows), with the patient's body in a vertical position (to assess the displacement of the kidneys), sighting images (for a more detailed study of any area).

Excretory urography (syn. - intravenous, excretory urography) . Plain pictures give only an approximate idea of the anatomy of the kidneys. Much more complete information about the state of the pyelocaliceal system, kidney parenchyma and their excretory and concentration functions is obtained using intravenous excretory (excretory) urography.

Urography is a method of X-ray examination of the urinary system, based on the physiological ability of the kidneys to capture iodinated organic compounds from the blood, concentrate them and excrete them in the urine.

Excretory urography is intended for visualization of the urinary tract, as well as for assessing the excretory and concentration function of the kidneys. Contraindications are severe heart failure of the heart, liver, kidneys and intolerance to iodine preparations.

In clinical practice, four variants of excretory urography are used: traditional, high-speed, high-dose and infusion. They differ from each other in the amount and speed of intravenous contrast agent (verografin, urografin, urotrast, telebrix-35, omnipaque, vizipak, ultravist).

The entire procedure of excretory urography, regardless of its type, is carried out in the X-ray room. First, a native survey urogram is necessarily performed and analyzed, after which RCS is introduced. Usually, the first radiograph is taken 5-7 minutes after the injection, the second - after 10-15 minutes, the third - after 20-25 minutes. Young people should be x-rayed a little earlier, the elderly - a little later. If there is no shadow of the urinary tract on these pictures, then the so-called delayed radiographs are produced - after 40-60 minutes, 1 and 2 hours. characterized by diuretic action. In this case, the first picture is taken to fix the image of the kidneys in the nephrophase immediately after the introduction of the RCS (picture "at the end of the needle").

With a reduced excretory function of the kidneys, which is observed, for example, in patients with pyelonephritis or nephrosclerosis, high-dose, and more often infusion urography is used, in which the patient is slowly injected through a system for dripping liquids with 100-150 ml of RCS in 5% glucose solution or physiological solution. In the course of the introduction of contrast, photographs are taken. All pictures are usually taken in direct projection. At the end of the entire series, a picture is often added with the patient in an upright position in order to assess the displacement of the kidneys and the functional state of the pelvicalyceal system.

The analysis of excretory urograms, along with the characteristics of the kidneys, performed in the same way as in a native study (position, shape, size, contours), includes the following mandatory points:

- the degree and timing of contrast enhancement of the urinary tract, the onset and achievement of a maximum, the total duration;
- characteristics of cups and pelvis;
- assessment of the functional state of the kidneys;
- characteristics of the ureters - position, diameter, preservation of the cystoid structure;
- characteristics of the bladder - position, size, shape, contours.

Significantly increases the diagnostic capabilities of excretory urography, its combination with tomography (*nephrotomography*), as well as the addition of fluoroscopy, the use of medications (*method of pharmacourography*).

It should be emphasized that urography is mainly a method of morphological research. It gives only the most general idea of kidney function and in this respect is decisively inferior to radionuclide methods.

At the time of urination, the contrast agent from the bladder enters the urethra. Filming while urinating is called voiding *cystography* . It allows you to get an image of the urethra *(urethrography*). But a clearer image of the urethra is obtained by injecting a contrast agent through its external opening. Voiding cystography makes it possible to identify such a phenomenon as throwing the contents of the bladder into the ureter - vesicoureteral reflux.

Retrograde pyeloureterography **is** a technique that allows you to obtain an image of the pelvicalyceal complex and ureter by retrograde filling them with a radiopaque substance. A common indication for the use of retrograde pyeloureterography is the need to obtain a good image of the upper urinary tract in cases where this was not possible with intravenous urography. Specific indications most often are suspicions of the presence of urate calculi, papillary tumor of the pelvis, stricture of the ureter.

The catheter is inserted under aseptic conditions using a cystoscope through the urethra into the bladder and then into the corresponding ureter to the selected level (up to the pelvis). After that, a water-soluble iodine-containing contrast agent is slowly injected through the ureteral catheter, having previously sucked out the contents of the pelvis. Sometimes, instead of a water-soluble RCS, gas is injected - a *pneumopyelography technique* . Contraindications are acute inflammatory processes of the urinary tract and male genital organs, total hematuria, cardiac decompensation. Retrograde pyeloureterography also has significant drawbacks that significantly limit its implementation: non-physiological and the need for instrumental intervention (cystoscopy, ureteral catheterization), burdensome for patients and associated with the risk of serious complications.

Pneumoperitoneum, pneumothorax, pneumopericistography **.** On survey pictures with all types of urography, the outer surface of the kidneys and the tissues surrounding them are not always clearly visible. Therefore, special techniques have been developed for displaying retroperitoneal organs, consisting in the introduction of gas (nitrous oxide) into the retroperitoneal space (*pneumoperitoneum*), directly into the perirenal tissue *(pneumoren) or into the* tissue surrounding the bladder *(pneumopericistography).* Due to the development of sonography and computed tomography, these techniques are rarely used.

Renal angiography is a method of X-ray contrast study of renal vessels, intended mainly for studying their architectonics and morphological state, as well as for diagnosing certain renal diseases and assessing the functional state of the kidneys. It is necessary for the diagnosis of lesions of these vessels (anomalies of their branching, aneurysms, stenoses) and for the recognition of a number of diseases that are accompanied by changes in blood flow and morphology of the vascular network of the kidneys.

There are general and selective angiography. First, to determine the number and type of branching of the main renal arteries, a general and survey aortography is performed with the installation of a catheter at the level of the XII thoracic vertebra. Then, taking into account these data, to obtain a detailed image of the vascular system of each kidney separately, a selective study is carried out with the introduction of a catheter alternately directly into one and the other renal arteries (arteriography) or veins (phlebography). After the rapid introduction of a water-soluble contrast agent by an automatic injector (40-60 ml for general angiography, 10-15 ml for selective angiography), a series of images are taken using special devices.

The resulting serial images sequentially display the phases of the passage of the contrast agent in the kidneys and its excretion into the pyelocaliceal complex (Fig. 40)

I - early arterial. The main renal arteries and their branches are well identified.

II - late arterial, characterized by contrasting small branching of the intrarenal arteries.

III - nephrographic. In this phase, the image of the renal vessels is absent, but there is a significant increase in the intensity of the shadow of the parenchyma of the kidney, due to the accumulation of a contrast agent in the capillaries and urinary tubules.

IV is phlebographic, during which weak shadows of the main renal veins appear, which, however, are unsuitable for diagnostic analysis.

V - urographic, occurring when the contrast agent begins to be excreted in the urine (after 2-3 minutes) and an image of the pelvicalyceal complex appears. This final stage of angiography can be continued as an excretory urography if necessary.

Along with traditional analog angiography, a new technology of angioradiological examinations is now increasingly used in clinical practice - digital subtraction angiography, which makes it possible to obtain an isolated image of blood vessels, which significantly improves its quality. The advantages of this technique are also low invasiveness, the use of lower doses of RCS, the possibility of polyprojection research.

CT scan

Computed tomography **is** an X-ray tomography method in which an X-ray beam passes through a thin layer of the patient's body in different directions.

X-ray CT has significantly expanded the scope of the morphological study of the kidneys, bladder and prostate. Helical CT provides all the necessary information for surgical treatment, especially for nephrosparous resections. CT improves detection and characterization of small kidney tumors. SCT without contrast has been proven to be an accurate diagnostic tool in patients with renal colic. CT detects more urinary stones than conventional methods, regardless of their calcium content. CT also detects signs of acute obstruction and acute complications and provides important information for patient follow-up and treatment planning. CT is usually the method of assessing acute trauma, vascular lesions, and infectious complications.

Patient Preparation: Hydration is required for optimal imaging of PCS and to protect against nephrotoxic effects of contrast agents, which is carried out by intravenous administration of fluid or ingestion of it. Hydration can be combined with bowel contrast. 500 ml of contrast medium is sufficient for examination of the kidneys alone, 1000 ml is required for examination of the pelvis. If CT angiography is required in the arterial or venous contrast phases, a negative contrast agent (water) should be used for oral administration.

The patient is placed on the tomograph table in a horizontal position on the back. Removal begins from the level of XI - XII thoracic vertebrae and is completed by making a series of sections through 0.75 - 1,6 смat the height of the III lumbar vertebra (with the normal position of the kidneys).

Before intravenous contrast, a CT scan without contrast should be performed. Native imaging is indispensable for identifying small stones and helps to detect hemorrhage and measure the density of the fat component in angiomyolipomas. A CT scan produces an image of transverse (axial) sections of the abdomen. The normal CT image of the kidneys is always clear even with a native study, which is due to the difference in the X-ray density of the kidneys themselves (+30 ... + 40 H U) and the fatty tissue surrounding them (-70 ... -130 H U). The difference in density also provides differentiation of the image of the kidneys into two parts: the parenchyma and the renal sinus, which also contains fatty tissue. At the same time, the layers of the kidney parenchyma itself (cortical and cerebral) are not differentiated on native computed tomograms due to a slight densitometric difference. This is possible when using the contrast enhancement technique, when the contrast agent accumulates in the cortex to a greater extent than in the brain. The same technique is required for visualization of renal PCS .

In CT with intravenous contrast, the computer screen sequentially displays the phases of the passage of the contrast agent:

- Cortico-medullary (arterial, vascular) phase - begins 20-25 seconds after injection and is characterized by an intense increase in the cortical substance of the kidneys and renal columns;
- Nephrographic (parenchymal) phase - begins 60-80 s after the arterial phase and is characterized by a slow increase in the density of the renal medulla. A delay in the onset of the nephrographic phase indicates impaired renal function.

- Excretory (pyelographic) phase - begins 3-5 minutes after the start of the injection and is characterized by contrast enhancement of the PCS and ureters. In patients with acute or chronic urinary tract obstruction, urine contrast enhancement may be significantly delayed.

Magnetic resonance imaging

This method allows obtaining layer-by-layer images of the kidneys in various projections: sagittal, frontal, axial (Fig.). Modern high-field MRI scanners have unique capabilities for visualizing and detailed characterization of all organs of the urinary system. The basic technique for examining the urinary organs is native MRI. The image of the kidneys is similar to that on CT images, but the border between the cortical and medulla of the organ is more clearly visible.

The possibilities of MRI in the diagnosis of diseases of the urinary organs are significantly expanded using special techniques, including contrast-enhanced MR tomography, MR angiography, diffusion and perfusion MR tomography. A special role is played by magnetic resonance urography. This study can be performed in two versions: native and contrast.

Native MR urography is based on the high specificity of MRI in visualizing fluid structures. At the same time, of course, the use of contrast agents is not required, and therefore, in this embodiment, MR-urography can be performed in patients with severe renal failure and with severe allergic reactions to iodine-containing contrast agents.

Contrast excretory urography is performed by intravenous administration of a paramagnetic contrast agent (magnevist, gadolinium). It allows you to get a fairly large amount of information about both the morphological and functional state of the kidneys and upper urinary tract and, in general, has significant advantages over radiopaque intravenous urography and retrograde ureteropyelography.

Finally, a 3D reconstruction is performed using the maximum intensity projection (Max IP). Such an image gives a visual spatial picture of the urinary tract, which allows planning the technical production of surgical and endoscopic manipulations, lithotripsy, and radiation therapy.

Various layered imaging and minimally invasive urological techniques have reduced the role of excretory urography. Among the layered methods, MRI competes with ultrasound and CT. As a rule, ultrasound is used as the primary method. CT and MRI are equivalent in their diagnostic capabilities. CT has advantages in detecting stones and calcifications. MRI is preferred in patients with impaired renal function or intolerance to contrast agents. MRI also has advantages in diagnosing small, complicated cysts and in imaging the pelvicalyceal system without intravenous contrast (in patients with impaired renal excretory function).

Radionuclide method

In uronephrology, the radionuclide method is mainly used to assess the functional state of the kidneys (glomerular filtration, tubular secretion). In addition, it can be used to detect obstructive disorders of urodynamics, disorders of the blood supply to the kidneys, and detection of ectopic renal tissue. To solve these problems, the following radionuclide techniques are used:

- renography,
- static scintigraphy of the kidneys,
- dynamic scintigraphy of the kidneys,
- angionephroscintigraphy,
- single photon emission computed tomography (SPECT),
- positron emission tomography (PET),
- combined PET-CT.

Radionuclide renography

This technique is intended only for assessing the functional state of the kidneys. It is based on dynamic graphic registration of gamma radiation from each kidney after preliminary intravenous administration of one of the nephrotropic radiopharmaceuticals. The information received is recorded in the form of curves reflecting the level of gamma radiation over time from the kidneys and heart.

In the renographic curves, 3 characteristic segments are distinguished. The first is an initial steep rise for 15–20 s, reflecting the entry of the radiopharmaceutical into the vascular bed of the kidney and thus characterizing the degree of its blood supply. It's called vascular.

The second is a gentle section of the curve up to the maximum, approximately equal in height to the first, lasting 3-5 minutes. This segment reflects the transition of the radiopharmaceutical from the bloodstream to the collecting system of the kidney and is therefore called secretory. The third, excretory, segment is the descending part of the curve, corresponding to the removal of radiopharmaceuticals from the kidney. Normally, the renographic curves from both kidneys have the same character.

In diseases and injuries of the kidneys with a violation of their function, the renographic curves undergo various changes. The following 3 types are very characteristic: hypoisostenuric, obstructive, afunctional.

The hypoisostenuric type of the renogram is characterized by a flattening of its peak, a decrease and lengthening of the second and third segments. It is characteristic mainly of diffuse chronic kidney diseases (pyelonephritis, glomerulonephritis).

The obstructive type is characterized by a gentle rise in the second segment of the renogram with a significant increase in its duration, so that sometimes the renographic curve does not reach a peak even 20 minutes after intravenous administration of the radiopharmaceutical. Such changes are characteristic of obturation of the urinary tract.

The afunctional type is characterized by a sharp decrease in the height of the vascular segment and the absence of secretory and excretory segments. The same changes are observed with a non-functioning or absent kidney.

Static renal scintigraphy

This technique is used in urology mainly to assess the anatomical and topographic features of the kidneys. The study is carried out with radiopharmaceuticals that selectively accumulate in the functioning kidney parenchyma. Normally, the accumulation of a radiotracer in the kidneys is symmetrical, intense and uniform. In pathology, it is characterized by a diffuse decrease, unevenness, the presence of foci or zones of a decrease in the accumulation of radiopharmaceuticals or its complete absence.

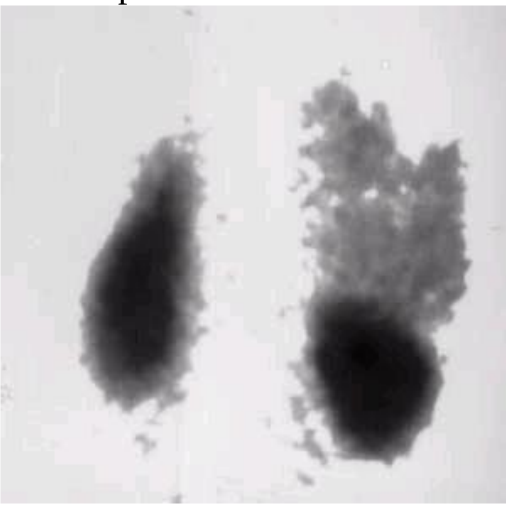

Рис. 1. Сцинтиграфия опухолей забрюшинного пространства. Определяется смещение правой почки книзу опухолью надпочечника.

Dynamic renal scintigraphy

This technique is currently the most widely used in urological practice. It allows you to evaluate both the anatomical and topographic features of the kidneys and their functional state, as well as the urodynamics of the upper urinary tract. The basis of the technique is the dynamic registration of radioactivity in the kidneys and blood after intravenous administration of nephrotropic radiopharmaceuticals.

Visual analysis of scintigrams includes an assessment of the following points:

- topography, shape, size of the kidneys;

- level and uniformity of radiopharmaceutical accumulation in the kidney parenchyma;

- dynamics of radiotracer excretion accumulation from the kidneys and upper urinary tract.

Normally, the radiopharmaceutical begins to enter the kidney parenchyma at the same time and is distributed evenly in them. At 5-10 minutes, most of it moves into the renal pelvis. At this time, the ureters can also be visualized.

Quantitative assessment of the "activity-time" curves from the areas of the kidneys and heart, reflecting the intake and excretion of radiopharmaceuticals, is carried out in the same way as the curves obtained using the radionuclide renography technique.

Angionephroscintigraphy

This technique is mainly used to detect violations of the blood supply to the kidneys. This provides both visualization of the renal arteries and blood flow through them. Radionuclide angiography is of the greatest importance in establishing the vasorenal nature of symptomatic arterial hypertension. The basis of the technique is the registration of the passage of an intravenously administered bolus of radiopharmaceutical through the abdominal aorta and renal arteries.

Currently, radionuclide examination of the kidneys is beginning to be carried out using new technologies: ***SPECT and PET*** . The main advantage of SPECT is the ability to obtain layered images, which significantly increases the resolution of the method. Positron emission tomography, which makes it possible to obtain functional images that reflect the vital processes of organs and tissues at the molecular level, is especially effective in urological practice in diagnosing malignant tumors of the kidneys, prostate, testicles and in detecting metastases of any localization. The combination of PET with CT further expands the diagnostic capabilities of radiation methods.

In general, the radionuclide method in uronephrology has now become a necessary addition to other radiation studies, allowing you to obtain important diagnostic information about the functional state of the urinary system.

Radiation semiotics of diseases of the urinary organs

Doubling of the kidney

X-ray, ultrasound : lengthening of the kidney; the presence of retraction on its lateral contour, so that the kidney appears to consist of two parts: upper (smaller) and lower (larger).

Excretory urography : the presence of two non-communicating pelvicalyceal complexes, each with its own ureter.

Рис.2. Внутривенная урография.
Хорошо видна полностью удоенная левая почка
почка и верхняя треть левого мочеточника.

kidney dystopia

Radiography : low location of the kidney (in the lumbar, iliac region, in the pelvis); the absence of its physiological displacement when transferring the patient from a horizontal to a vertical position.

Excretory urography : the ureter is short and straight, running in front of or from the lateral contour of the kidney, due to its rotation around the longitudinal axis by 90-180.

Angiography : low location of the level of discharge from the aorta and the horizontal course of the renal artery; frequent doubling, tripling of the renal artery.

Nephroptosis

X-ray : the kidney is lowered to varying degrees and deployed in the frontal plane so that its upper pole departs laterally from the midline, and the lower pole, on the contrary, approaches the midline. The displacement of the kidney when transferring the patient from a horizontal to a vertical position and back exceeds the height of the bodies of two vertebrae.

Excretory urography : the ureter is convoluted; the longitudinal axis of the pelvis forms a straight line or even an acute angle with the ureter, open laterally down.

kidney abscess

X-ray : local bulging of the contour of the kidney.

Ultrasound, CT : the abscess cavity itself is visualized. Initially, its shape is irregular, the contours are uneven, the contents are heterogeneous. Subsequently, the abscess acquires a correctly rounded shape, the contours become even, the contents are homogeneous

Excretory urography, retrograde pyelography : the abscess cavity, when communicating with the pelvicalyceal complex, is filled with a contrast agent.

Chronic pyelonephritis

Radiography : the kidney is reduced in size, located vertically, its contours are uneven.

Ultrasound, CT, MRI: reduction in the thickness of the parenchyma.

Excretory urography : slowing down and reducing the intensity of contrasting of the pyelocaliceal complex (Fig. 3).

Radionuclide renography : hypoisostenuric or afunctional type of radiograph. Winter's index is over 55%.

Рис. 3. Экскреторная урограмма (25-я минута). Двухсторонний пиелонефрит, гипотоническая стадия. Двухсторонняя пиелоэктазия, краевой симптом псоаса. Неравномерное контрастирование полостной системы, деформация и нечеткость чашечек правой почки.

Tuberculosis of the kidney, cavernous

X-ray : local swelling of the contours of the kidney; calcifications of the parenchyma of varying severity.

Ultrasound, CT, MRI : cavity cavities are visualized.

Excretory urography, retrograde pyelography : the cavities of the caverns, when they communicate with the pelvicalyceal complex, are filled with a contrast agent.

Urolithiasis disease

Radiography, CT: shadows of stones in any parts of the urinary tract (cups, pelvis, ureter, bladder), (Fig. 4).

Ultrasound: hyperechoic structure in the urinary tract, giving an acoustic shadow.

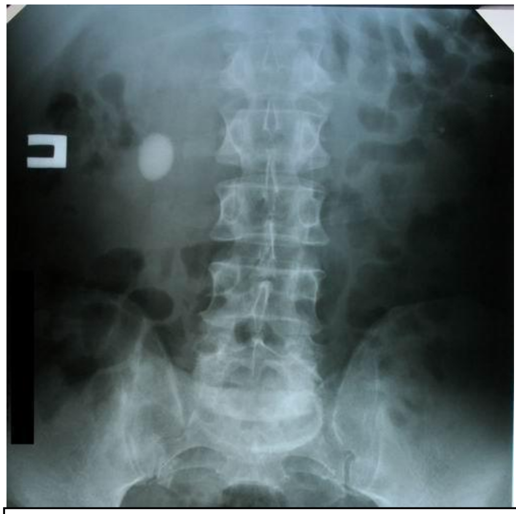

Рис.4. Обзорная рентгенограмма брюшной полости. В проекции правой почки видна округлая тень рентгенпозитивного камня правой почки.

hydronephrosis

Radiography: an increase in the size of the kidney, the waviness of its contours.

Ultrasound, CT, MR-urography, excretory urography, retrograde pyelography : dilatation of the pyelocaliceal complex of varying severity, a decrease in the thickness of the parenchyma (Fig. 5).

Radionuclide renography: hypoisostenuric or afunctional type of renogram. Winter's index is over 55%.

Рис.5. Экскреторная урография больного с двусторонним обструктивным мегауретером.

kidney cancer

<u>*Radiography:*</u> increase in size, deformation, uneven contours of the kidney, the possible presence of calcifications.

<u>*Excretory urography, retrograde pyelography:*</u> displacement, compression, deformation of various structures of the pelvicalyceal complex.

<u>*Ultrasound, CT, MRI* :</u> visualization of the tumor node itself (Fig. 6).

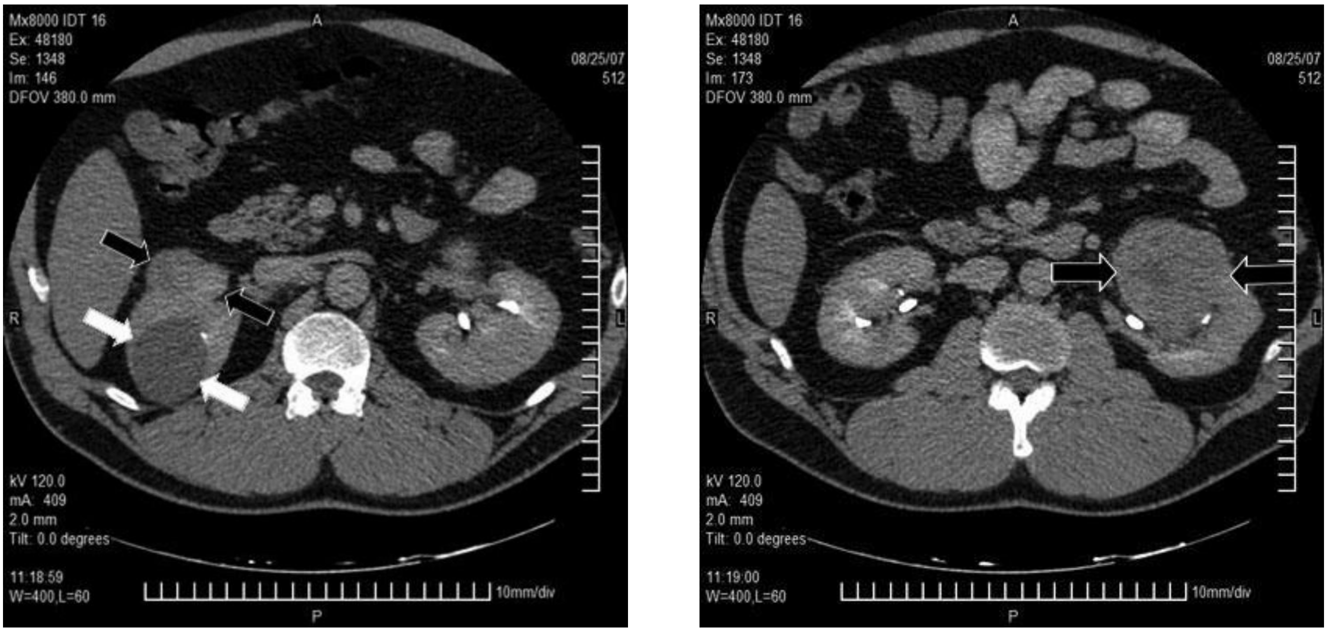

Fig.6. CT scan. Bilateral primary multiple renal cell carcinoma: two tumors T1aN0M0 of the right kidney, T2N0M0 of the left kidney (black arrows). Intraparenchymal cyst of the upper segment of the right kidney (white arrows).

Renal cyst solitary

<u>*X-ray:*</u> local bulging of the contour of the kidney.

Ultrasound : visualization of a uniformly anechoic rounded mass with even, clear contours, giving the effect of dorsal enhancement.

CT, MRI : visualization of a rounded formation containing fluid (Fig. 6).

Polycystic kidney disease

Radiography : an increase in the size and waviness of the contours of both kidneys.

Ultrasound, CT, MRI : visualization of many rounded formations containing fluid.

Radionuclide renography: hypoisostenuric type of renogram. Winter's index is over 55%.

METHODS RADIATION EXAMINATION OF THE LIVER AND BILE TRACTS

X-ray method

Native radiological techniques . X-ray and fluoroscopy of the liver without contrast agents is currently not used, however, the liver is visualized on a plain radiograph of the abdominal organs.

On a *survey radiograph of the abdominal organs* , the liver is normally defined as a homogeneous, rather intense shadow in the right upper abdominal cavity with clear, even contours, approaching a triangle in shape. Its upper border corresponds to the right dome of the diaphragm, the lateral one looms against the background of extraperitoneal fatty tissue, and the lower one goes in the projection of the right costal arch and is usually clearly visible against the background of other abdominal organs. The gallbladder on the survey radiograph is normal, as a rule, is not defined.

radiopaque techniques . With the advent of modern highly informative methods of radiation diagnostics, radiopaque methods for examining the biliary tract and abdominal vessels have not lost their relevance, although the indications for them have noticeably decreased.

There are three groups of methods of contrasting the gallbladder and biliary tract.

Cholecystography is a method of studying the gallbladder, in which the patient takes a contrast agent orally on the evening before the study. Once in the body naturally, the contrast agent is absorbed from the digestive tract and, once in the liver, is excreted along with the bile. During the night, the bile in the gallbladder is concentrated (the patient should refrain from eating), and in the morning, a contrasting shadow of the gallbladder is observed on radiographs. The maximum concentration of the contrast agent in the gallbladder is reached 10-15 hours after ingestion of the contrast agent.

On cholecystograms, a normal gallbladder looks like a homogeneous, intense oval-shaped shadow with even, clear contours, somewhat tapering upward, measuring 6-10 by 2- 4 см. the position of the bladder, its size and shape vary somewhat depending on the age of the patient, his position at the time of the study, individual anatomical features, etc.

With the advent of the ultrasound method, the importance of cholecystography has noticeably decreased, and at present it is performed extremely rarely.

Cholegraphy is a method of studying the gallbladder and biliary tract, in which the contrast agent is injected intravenously slowly, due to which a high concentration of the contrast agent in the bile is achieved and already 5-7 minutes after the start of the infusion , the bile ducts begin to be visualized on the radiographs, and then the shadow gallbladder. Thus, with the help of cholegraphy, it is possible to assess the functional and morphological state of the biliary system. A rather long study time, as well as a significant number of allergic reactions to the administration of contrast (often fatal), led to the fact that with the advent of ultrasound, the indications for cholegraphy narrowed sharply.

Cholangiography is a group of methods of X-ray contrast examination of the biliary tract, when a contrast agent is injected directly into their lumen. Depending on where and how the contrast is injected, there are:

- *percutaneous transhepatic cholangiography* - a special needle through the skin directly into the bile duct;

- *percutaneous transhepatic cholecystography* - a special needle through the skin into the gallbladder;

- *endoscopic retrograde cholangiopancreatography (ERCP)* - through a cannula, which is endoscopically inserted into the major duodenal papilla (Fig. 7);

- *intraoperative cholangiography* - directly into the bile duct during surgery;

- *postoperative cholangiography* - through the drainage installed during surgery to decompress the biliary tract.

Рис. 7. Нормальное “дерево” желчевыводящих протоков и холецистолитиаз. Хорошо видны законтрастированные внутри- и внепеченочные желчные протоки, панкреатический проток, камни в желчном пузыре.

Angiography of the abdominal cavity - at present, the so-called digital subtraction angiography techniques are mainly used, in which, using computer processing, you can achieve the best image quality, as well as remove the shadows of organs that interfere with assessing the state of the vessels.

Celiacography - a contrast agent is injected through the catheter into the celiac trunk, as a result of which a series of angiograms receive an image of all its branches (left gastric and splenic arteries, common hepatic artery, gastroduodenal artery, own hepatic artery and its branches).

Recurrent splenoportography is essentially the final phase of celiacography; a series of angiograms is obtained at the moment when the contrast agent, having passed through the arteries and the capillary network, is in the portal vein system.

Portography is a group of methods of direct contrasting of the portal vein system:

- *splenoportography* - a special needle is injected through the skin into the pulp of the spleen;

- *percutaneous transhepatic portography* - a special needle is injected through the skin into one of the intrahepatic branches of the portal vein.

Interventional angiography - angiographic techniques allow embolization of hepatic vessels with significantly less risk than open surgery.

Ultrasonic method

Ultrasound, due to its availability, non-invasiveness, lack of contraindications, and high information content, has received well-deserved recognition, and at present, almost any study of the liver and biliary tract begins with it.

Traditional ultrasound. Ultrasound scanning is performed in the supine position and on the left side, first against the background of calm breathing of the patient, and then in a state of forced inspiration. When examining the liver, oblique and longitudinal scanning techniques are used, as well as scanning in the intercostal spaces. With longitudinal scanning, most often performed with the patient lying on the left side, it is possible to more fully study various parts of the liver, as well as the gallbladder and bile ducts. Scanning in the eighth - tenth intercostal space is performed in order to best visualize the gallbladder.

Scanning should begin with the location of the sensor along the lower edge of the costal arch from the right anterior axillary line. Then the sensor is moved along the edge of the costal arch along the left mid-clavicular line.

When interpreting the echogram of the liver and gallbladder, the following parameters are used:

1. the shape, position, contours and dimensions of the liver;
2. echostructure (the nature of the distribution of echo signals in the field of vision) and echogenicity (the degree of reflection of echo signals by density) of the parenchyma of the liver and gallbladder;
3. the size and nature of the vessels of the liver;
4. condition and size of the common bile duct;
5. position, shape, size of the gallbladder, characteristics of its walls.

The structure of the liver parenchyma is a fine-grained image with single small and echo-negative areas of peripheral vessels. The posterior contour is represented by a high echogenicity band, which represents the liver capsule. The gallbladder is defined as an echo-negative oval formation separated from the surrounding parenchyma by a clearly defined wall. its dimensions are from 6 to 12 смlong and from 2.5 to 4 смin diameter, wall thickness - from 2 ммin the area of the bottom and body to 3 ммat the funnel and neck. Image of the cavity of the gallbladder of a homogeneous structure, much less dense than the surrounding parenchyma of the liver. Medial to the gallbladder, the region of the gate of the liver and the inferior vena cava with the hepatic veins flowing into it are determined. In the region of the gate of the liver, the so-called hepatic triad is visualized: the portal vein (diameter of the main trunk 1,4 смis 0.9-), the hepatic artery (diameter is 0.45- 0,51 см), and the common bile duct (diameter is about 0,7 см).

Dopplerography (echoangiography). With the help of Doppler ultrasound, it is possible to non-invasively assess the state of all the main vessels of the liver and the intensity of blood flow in them. This technique is especially effective when using a color Doppler mapping system.

CT scan

In CT examination of the abdominal organs, it is considered preferable to perform spiral computed tomography (SCT) or multislice computed tomography (MSCT), because. this allows you to study the entire abdominal cavity at one breath hold and subsequently build high-quality reconstructions of this area. CT is used primarily for the detection, evaluation of tumors and their resectability, although it provides useful information in a wide range of other diseases of the liver and gallbladder (hematoma, abscesses, trauma, vascular, etc.). Except in cases in which the study is performed to rule out hemorrhage or hemochromatosis, liver CT should use intravenous contrast. However, biphasic MSCT and various MRI modes are increasingly replacing intra-arterial contrast agent administration – hepatic CT angiography (CTAA) and arterial portography CT (CTPA).

The CT technique begins with the performance of standard digital radiographs in the frontal projection (topogram), on which the area for further scanning is selected. The scanning range includes the area from the diaphragm to the symphysis. The thickness of the slice, depending on the methodology and specific objectives of the study, can differ markedly (from 10 - 12 ммwith a survey scan of the entire abdomen (SCT) to 1 and even 0,625 ммwith MSCT of a specific area). The study should be given a contrast agent per os in a volume of 1000 ml, taken within 60-90 minutes before the study. Positive contrast agents are still the standard, but negative contrast agents (water, methylcellulose) are becoming increasingly important, the advantage of which is the absence of superposition of intestinal loops on vessels in CTA and an improved image of the intestinal wall.

Native CT . In current practice, there are only limited indications for native CT: suspicion of traumatic hemorrhage, calcifications, hemochromatosis, and documentation of confluent fibrosis in cirrhosis. On native CT images, the liver normally has clear, even edges, a homogeneous structure and a density of 60-70 HU , in addition, venous vessels of the liver (30-50 HU) are clearly visible against its background. The gallbladder is determined at the level of Th 11 - Th 12. CT gives a detailed idea of its condition, shape, size, localization, the presence of calculi in it, etc. at the level of the gates of the liver, the common bile duct can sometimes be distinguished, but normally it is not clearly defined. The portal vein, on the contrary, is visualized quite well - focusing on its branches, as well as on the left longitudinal groove, in which the round ligament of the liver passes, it is possible to differentiate liver segments. Intrahepatic bile ducts are normally not visible.

CT with enhancement (with the introduction of a contrast agent). If necessary, a CT scan can be performed using contrast agents. If a contrast agent is injected into a vein in a small amount (20-40 ml) with a conventional syringe, then computed tomograms obtained later are called "enhanced". They can assess the nature of the blood supply to the pathologically altered liver parenchyma is extremely important in the differential diagnosis between various pathological formations.

If SCT is performed with the introduction of a bolus of a contrast agent (100-150 ml) into a vein at a high speed (3-3.5 ml / sec) under pressure using a special automatic syringe, then the study is called *CT angiography (SCTA).* The SCTA technique is extremely informative, since, by accurately calculating the start time of the scan, it is possible to track the passage of contrast through various vessels (the arterial and venous phases of the SCTA are distinguished), which makes it possible to study in detail the vascular network of the liver. In addition, with the appropriate software, it is possible to quantify the amount of perfusion of the liver parenchyma.

Magnetic resonance imaging

Due to the absence of radiation exposure to the patient, high shadow image contrast, and the ability to obtain a slice in any projection, MRI has gained a well-deserved recognition in the diagnosis of liver diseases and injuries.

Traditional MRI. As with CT, when analyzing MR images, it is customary to evaluate the liver at certain levels: the level of its caval gate (the place where the hepatic veins exit the liver parenchyma) and the level of the portal gate, at which the branches of the portal vein, hepatic veins, and hepatic arteries are determined. , common hepatic and bile ducts, as well as segments 1-7 of the liver and lymphatic vessels. The contours of the liver are clear, even. The signal intensity on the T1-weighted image is quite high (slightly more intense than the signal from the spleen and skeletal muscles), and on the T2-weighted image it is low. The gallbladder is also well visualized, especially when the study is done on an empty stomach.

Special MRI techniques . The use of MR contrast agents makes it possible to arbitrarily change the magnetic parameters of protons in tissues and organs, thereby significantly increasing diagnostic capabilities. Allocate extracellular (vascular), organ-specific and enteral contrast agents.

Performing dynamic contrast enhancement makes it possible to obtain images in the arterial, portal and interstitial phases of contrast enhancement, greatly facilitating the diagnosis of various pathological formations of the liver.

MR angiography allows you to study in detail both the vascular bed of the liver and the state of the parenchyma of the organ. For MR angiography, extracellular (vascular) preparations (magnevist, omniscan) are used. They shorten the T2 and T1 relaxation times, resulting in increased signal intensity on T1 weighted images.

Appropriate software allows non-invasive imaging of the biliary tract - ***MR-cholangiopancreatography*** (MRCP), the main advantages of which over traditional radiopaque techniques are non-invasiveness, as well as visualization of the biliary tract both above and below the stricture. It is also possible to collect information about the chemical composition of the liver - ***MRI spectroscopy*** (MRS) of the liver, which is essentially the only technique that allows in vivo and non-invasively assessing liver metabolism at the cellular level, not by indirect signs (biochemical blood test), but directly by its chemical composition .

Radionuclide method

To diagnose diseases of the liver and biliary tract, the method of radionuclide diagnostics is used and a radiopharmaceutical (RP) is administered intravenously to the patient, after which a series of scintigrams is obtained on a gamma camera.

Hepatobiliary scintigraphy (GBBS) or dynamic GBSB is performed using ^{99m}Tc labeled iminodiacetylic acid derivatives, which are collectively called HIDA . With the help of a gamma camera, it is possible to record the passage of the radiopharmaceutical throughout the body of the subject.

The study is carried out on an empty stomach without prior drug preparation of the patient. The image of the liver begins to appear within 5 minutes after the introduction of the radiopharmaceutical, reaching its maximum at 10-15 minutes (parenchymal phase of the study). After 7 minutes from the start of the study, an image of the bile ducts appears (maximum contrast at 20-25 minutes), and the gallbladder begins to be visualized at 8-20 minutes. After 60 minutes, the patient is given a fatty (choleretic) breakfast. After 5-7 minutes, this leads to a contraction of the gallbladder and a significant acceleration of the excretion of the radiopharmaceutical into the choledochus and duodenum. According to scintigrams, the shape, size and position of the liver, gallbladder and main bile ducts are determined. The nature of the capture and distribution of radiopharmaceuticals in them, as well as the possibility of constructing quantitative curves for the passage of radiopharmaceuticals through certain structures, evaluate the functional parameters of the hepatobiliary system.

Hepatoscintigraphy. For radionuclide study of the reticuloendothelial system of the liver, colloidal solutions with particles labeled with ^{99m}Tc are used as radiopharmaceuticals . After intravenous administration of the drug, a series of images of the liver is obtained, on which the degree of vascularization of the organ, the activity of stellate reticuloendotheliocytes, topography and anatomical and morphological structure of the organ are assessed. Normally, the distribution of radiopharmaceuticals in the liver is quite uniform, with the exception of the area of the gallbladder bed, where there is a slight decrease in the accumulation of radiopharmaceuticals. In addition to the visual assessment of scintigrams, there are also a number of quantitative indicators that help in the differential diagnosis of various pathological processes in the liver.

Scintigraphic angiography of the liver. To assess the blood supply system of the liver, ^{99m}Tc-labeled autoerythrocytes are used as radiopharmaceuticals. The main indication for this study is the suspicion of the presence of cavernous hemangiomas of the liver.

Radiation semiotics of diseases of the liver and biliary tract

Diagnosis of various diseases and injuries of the liver and biliary tract requires an integrated approach and should be based not only on the data of radiation methods of research, but also on anamnesis, physical, laboratory and other methods of examination.

Diffuse liver disease

Hepatitis

There are no specific radiation symptoms.

Ultrasound, CT, MRI, radionuclide method : a slight increase in the size of the liver and spleen, as well as heterogeneity in the structure of the liver parenchyma.

Cirrhosis of the liver

Radiation diagnostic methods : changes in the size of the liver (increase at the beginning of the disease and decrease in its later stages); heterogeneity of the structure of the parenchyma of the organ, the tuberosity of its contours.

Ultrasound: changes in the size of the liver, its uneven, knotty surface, changes in the vessels of the liver, effusion into the abdominal cavity.

MRI , CT : heterogeneity of the structure of the parenchyma of the organ (nodules of regeneration, areas of growth of connective tissue); signs of portal hypertension; fluid in the abdomen.

Hepatoscintiraphy: a significant increase in radioactivity in the spleen and a decrease in radioactivity over the liver; pronounced heterogeneity of the structure of the liver, due to increased accumulation of radiopharmaceuticals in the foci of regeneration and reduced accumulation in areas of connective tissue growth.

Hepatobolic scintigraphy: radiopharmaceuticals are captured by hepatocytes for a long time, are slowly excreted into the bile ducts (signs of damage to hepatocytes).

Angiography: changes in almost all vessels. One way or another involved in the liver blood supply system (the hepatic artery and its branches are sharply narrowed, and the splenic and gastric arteries are dilated; the branches of the portal vein are narrowed, and the portal and splenic veins themselves are dilated).

Focal liver disease

cysts

, MRI, ultrasound : fluid-filled rounded formations with clear, even contours and a density (signal intensity / echogenicity) corresponding to water. With ultrasound, it is possible to visualize cysts with a diameter of up to 0.5- 1 см, and with CT and MRI - up to 2 мм.

Liver abscesses

CT, MRI : The density of the abscess content is higher than the density of water, which is quantified on CT. The use of contrast enhancement techniques during CT and MRI allows more confident detection of pathologically altered tissue surrounding the abscess.

Ultrasound : allows you to identify a liver abscess. However, his picture is less specific.

Benign tumors of the liver

Hemangioma is the most common benign tumor of the liver.

CT: irregularly shaped focal pathological mass with a heterogeneous structure, jagged edges and reduced density. After amplification, a significant increase in the density of this formation is noted.

MRI: focal pathological formation of irregular shape with a heterogeneous structure and uneven edges. On T2-WI, the hemangioma has an increased signal intensity. After contrast enhancement, the dynamics are the same as with enhanced CT.

Ultrasound: hyperechoic formation of a round or oval shape with clear contours and a homogeneous structure.

Angiography : the nature of the vascular network of the pathological formation is radiated in detail.

Malignant tumors of the liver

May be primary (hepatocellular carcinoma - hepatoma) or secondary (metastases of malignant tumors in the liver)

Hepatomas are more common in men; cirrhosis and hepatitis B are considered predisposing factors to their occurrence.

Ultrasound: a zone of uneven density with uneven contours. Identification of both hyper- and hypoechoic areas is characteristic.

CT, MRI, scintigraphy : focal lesions of the liver of a heterogeneous structure with uneven contours; the density and nature of the formation structure can vary (Fig. 8); the use of contrast enhancement techniques significantly improves the accuracy of diagnosis.

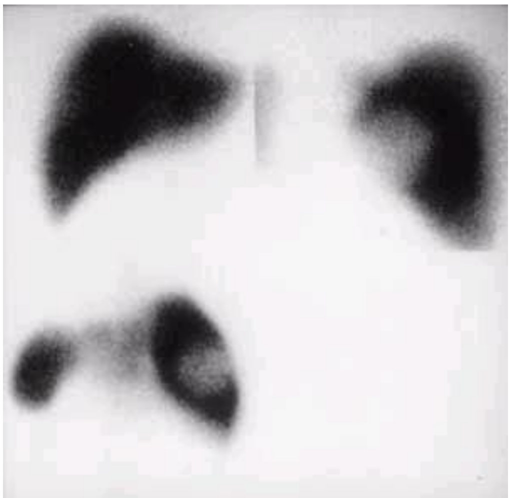

Рис. 8. Сцинтиграфия печени с коллоидом технеция-99м в трех проекциях. Дефект накопления не виден в передней проекции и хорошо определяется в правой боковой и задней проекции.

Metastases of malignant neoplasms in the liver , as a rule, are multiple. Radiation picture depends on the number and size of lesions.

Ultrasound: multiple hypo- or hyperechoic areas, often heterogeneous in structure

CT: low-density areas that do not accumulate contrast agent when enhanced. However, metastases from some tumors (eg, hypernephromas) are hypervascular and therefore accumulate contrast media. In addition, some tumors may be iso- or even hyperdense relative to the parenchyma of the organ.

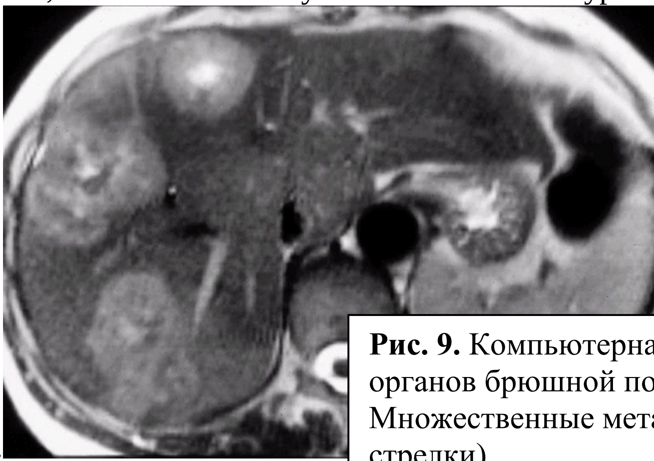

Рис. 9. Компьютерная томография органов брюшной полости. Множественные метастазы печени (белые стрелки).

MRI: due to the high shadow image contrast and better visualization of blood vessels, this method has several advantages over CT. The use of contrast enhancement techniques is of great importance.

Diseases of the biliary tract

Cholelithiasis

Gallbladder stones are almost twice as common in women as in men. There are cholesterol, pigment, calcareous and mixed stones.

X-ray : 15-20% of stones contain calcium, which makes it possible to identify them on survey pictures.

Ultrasound: allows you to detect stones in the gallbladder up to 1.5 2 ммin diameter and is the primary method of examination for this disease (detection accuracy is 95-98%). Stones on sonograms have a characteristic pattern of an echopositive lesion with a typical "soundtrack" behind it.

Cholecystography : gallstones are defined as filling defects in the contrasted gallbladder (detection accuracy 85-90%).

The disadvantage of the method is that in the pathology of the gallbladder, its contractility suffers, therefore, often with such diseases, there is no contrasting of the gallbladder.

CT : allows you to fairly confidently diagnose calculi with a diameter of up to 1 мм, containing calcium in their composition; if there is no calcium in the stones, the effectiveness of this method is markedly reduced.

Stones in the extrahepatic bile ducts

Ultrasound : when diagnosing gallstones in the extrahepatic bile ducts, it turns out to be ineffective (detection accuracy of 20-50%), since part of the common bile duct is covered by the duodenum (intestinal contents and gas significantly impair the visualization of the bile ducts).

CT: in the presence of calcium in the composition of the stones, it allows diagnosing calculi regardless of their location.

Cholangiography : this group of techniques is highly informative and accurate. The main disadvantage is invasiveness (Fig. 10).

Рис. 10. Расширение холедоха. Камень в холедохе. Литоэкстракция корзинкой Дормиа FG-22Q. Струна-проводник в холедохе.

MR-cholangiopancreatography allows non-invasive visualization of stones and strictures of the bile ducts throughout.

Acute cholecystitis

Ultrasound: the gallbladder is enlarged, the wall is thickened, an edema zone is determined around; often (90-95%) stones are detected in the lumen of the bladder (calculous cholecystitis). An indirect sign of acute cholecystitis is the limited mobility of the right dome of the diaphragm during breathing.

MRI, CT: allow you to identify the above changes, however, these methods are rarely used purposefully for the diagnosis of acute cholecystitis.

Chronic cholecystitis

Ultrasound: all the symptoms listed above, characteristic of acute cholecystitis, can also be detected in chronic cholecystitis, but their severity will be somewhat greater.

The size of the bladder, as a rule, is increased, but it can also be reduced (with shrinkage of the gallbladder); its walls are thickened, the shape is often deformed, the hepatic tissue surrounding the gallbladder is compacted.

Hepatobiliscintigraphy: violation of the contractile and concentration function of the gallbladder of varying severity.

IMAGING METHODS OF THE REPRODUCTIVE SYSTEM OF A WOMAN

Ultrasound of the uterus and appendages

Currently, ultrasound of the female internal genital organs is performed using transabdominal (TA) or transvaginal (TV) scanning, which complement each other. For good visualization of the uterus and ovaries on TA sonography, the bladder must be full. It serves as a kind of acoustic window into the small pelvis. However, better visualization is achieved with vaginal probes. They can be brought close to the studied organs - the uterus and ovaries. TV sonography does not require bladder filling.

With longitudinal scanning, the uterus is visualized as a pear-shaped formation with an average level of echogenicity.

With ultrasound of the endometrium, its thickness, structure and compliance with the phase of the MC are evaluated. The thickness of the endometrium depends on the phase of the menstrual cycle. Immediately after the end of menstruation, the endometrium appears as a thin echogenic line. At the time of ovulation, it is separated from the myometrium by an echogenic ring. After ovulation, the median echo gradually disappears in the endometrium undergoing secretory changes until only the echogenic layer of the endometrium remains. To assess the thickness of the endometrium, the measurement of the anterior-posterior size of the M-echo (median uterine echo) is used, which is a total image of the endometrium of the anterior and posterior walls, as well as the uterine cavity. Measurement of the thickness of the endometrium should be carried out only on the longitudinal section of the uterus, when the direction of the ultrasonic beam is strictly perpendicular to the longitudinal axis of the organ cavity.

The normal myometrium is a homogeneous, hypoechoic structure clearly demarcated by an echogenic serous layer. It can be crossed by anechoic blood vessels. The echogenicity of the body and cervix is the same.

The ovaries look like ovoid-shaped formations with a homogeneous internal structure, medium echogenicity. The ovaries are located on the side of the body of the uterus, the right one is slightly higher than the left one. The reference point for their location is the internal iliac vein. The length of the ovary is on average 29 мм, thickness - 19 мм, width - 27 mm, the average volume of the ovary in a healthy woman of childbearing age is 7,7 см.

Ultrasound provides an opportunity to follow the formation of the follicle in the ovary, determine its size and set the time of ovulation. Ultrasonic parameters of a maturing follicle clearly correlate with functional diagnostic tests, the level of most hormones (FSH, LH, prolactin, estradiol, progesterone, etc.). the diameter of the follicle capable of ovulation is 20- 25 мм, its structure is anechoic, the capsule is not detected. After ovulation and until the 21st-22nd day of MC, a hypoechoic formation of the same diameter (corpus luteum) is noted at the site of the follicle, which also does not have a capsule and disappears by the time the cycle begins.

Normally, the fallopian tubes are not visualized by ultrasound, which, however, is possible with ultrasound using echocontrast agents (echovista, etc.).

The vagina is easily detected by ultrasound in its normal anatomical condition. On longitudinal sonograms, it is defined as a tubular structure connecting at a slight angle to the cervix. At the same time, a median hypoechoic structure is determined in the center of the vagina, which is an ultrasonic reflection of the contacting mucous membranes of the anterior and posterior walls of the vagina. The thickness of the walls of the vagina is normally 3- 4 мм.

Hysterosalpingography - a method of artificial contrasting of the pelvic organs in women with their subsequent x-ray examination. With HSG, it is possible to determine the anatomical and functional state of the cervical canal and the uterine body cavity, visualize the fallopian tubes and resolve the issue of their patency **.**

HSG requires a preliminary examination of a woman for the absence of latent infections in order to exclude the possibility of an exacerbation or development of an acute inflammatory process. The examination is usually painless and must be performed under aseptic conditions.

Complications during HSG can be an allergic reaction to the introduction of a contrast agent, exacerbation of infection, bleeding, perforation of the uterine wall.

The study should be carried out in the 1st phase of the MC (8-11 days). The uterine cavity on the HSG has the shape of an isosceles triangle with even internal contours, at the top of which there is an internal pharynx, passing into the cervical canal. From the proximal corners of the triangle, narrow shadows of the uterine (fallopian) tubes begin. Their lumen has a different width, increasing from 2 3 ммin the intramural part (sphincter) to 8 10 ммin the ampullar part (pipe funnel area); the dimensions of the lumen of the tubes are variable, which is associated with their peristalsis. With preserved patency of the fallopian tubes during HSG, the contrast agent flows freely from the ampullae into the pelvic cavity.

METHODS OF RADIATION EXAMINATION OF THE BREAST

X-ray examination of the breast (mammography)

The great importance of breast radiography in the recognition and differential diagnosis of breast diseases is generally recognized. The role of the method is especially great in the detection of non-palpable tumors, in the so-called preclinical phase of their development, and therefore mammography has become an integral part of mass preventive examinations aimed at detecting the early stages of breast cancer.

The technique of conducting a mammographic examination and strict adherence to the technological process are of decisive importance.

Examination of women is carried out in the intermenstrual period, in the first half of the cycle, when the gland tissue is the least edematous and painless.

Standard styling with dosed compression is the most important condition for obtaining a high-quality image. The use of dosed compression allows you to analyze the contours, the density of the formation, to identify stellate structures, the presence and localization of microcalcifications. However, even if the technology is followed, the entire breast tissue cannot be captured in one picture.

When examining a patient, images are taken in two projections: direct (craniocaudal) and oblique (with a tube tilt of about 30 to 60 degrees). Sometimes an additional lateral projection with a mediolateral beam path is used.

When properly laid on the "oblique" images visualized:

- partially the pectoral muscle should be depicted posteriorly, at least to the line of the nipple of the mammary gland;
- retromammary fiber;
- transitional fold;

on the "direct" images are visualized:

- nipple brought to the contour of the gland;
- all structural elements of the mammary gland;
- in 30% of cases - pectoral muscle

To clarify the nature of the contours, the structure of individual sections, for better visualization of calcifications, targeted radiography is performed using special tubes of various sizes.

This better delimits the pathological area, and the use of dosed compression increases image clarity. With the help of targeted radiographs, it is possible to bring the tumor to the edge of the gland.

At the same time, it is detected more clearly, the lymphatic path and the condition of the skin in the adjacent areas are better defined. Aimed shots avoid errors due to projection effects of shadow summation. In some cases, it is advisable to use targeted radiography with direct magnification of the x-ray image.

To assess the prevalence of the process allows radiography of the soft tissues of the axillary regions, which reveals enlarged lymph nodes. It should be noted that the possibilities of sonography in identifying the state of the lymph nodes of regional zones are higher than those of mammography.

Mammographic methods using artificial contrast

Pneumocystography. The technique consists in introducing gas into the cavity. After aspiration of the liquid contents of the cyst, air is introduced (the amount of air introduced should not exceed the volume of the extracted fluid). Then radiography is performed in two mutually perpendicular projections. The introduced air contrasts the cyst, which leads to the visualization of the inner surface of the capsule - this makes it possible to visualize parietal growths. The use of pneumocystography, in addition to diagnostic purposes, has a therapeutic effect (increases adhesive processes in the cyst and reduces the risk of re-accumulation of fluid)

Sonography greatly facilitates the visualization of the inner surface of the cyst cavity without invasive interventions and radiation exposure.

Allows for a controlled puncture biopsy of both the fluid component of the cyst and a solid parietal formation.

Ductography - artificial contrasting of the milk ducts. The technique is used for secerating mammary glands, when the nature of the discharge from the nipple cannot be identified using clinical methods and conventional mammography.

Ductography allows you to assess the state of the ducts (type, structure, their caliber and localization, as well as contours), makes it possible to identify intraductal formations (papillomas or cancer), and allows you to judge the location, size and shape of the tumor. Prior to ductography, a cytological examination of the secretions of the ducts of the mammary gland is mandatory (the presence of atypical cells and inflammatory changes is a contraindication to the study).

The ductography technique is simple. It is necessary to establish from which duct there are discharges. For this purpose, you can use a magnifying glass with additional lighting. With significant secretions, the mouth of the canal is expanded, and it is easy to find it. When droplets of secretion appear, the staging duct is identified and a needle with a blunt end (or a special cannula) is inserted into the external opening to a depth of 1- 1,5 см. The needle should be inserted freely, without effort, so as not to damage the duct wall. Any water-soluble contrast medium can be used. From 0.5 to 1 ml of contrast (urotrast or verografin) is slowly injected through the needle. The introduction is stopped as soon as the patient feels a feeling of pressure or tension in the gland; pain with the correct insertion technique should not be.

Next, take pictures in the craniocaudal and lateral projections. The needle or cannula can be left in place until the images are taken, or removed by closing the orifice of the canal by applying a small amount of colloidal substance (as a spray) to the nipple.

Ductography does not always allow assessing the condition of the inner walls of the ducts. Therefore, a method of double contrasting was proposed, the essence of which is the sequential filling of the ducts first with an iodine-containing preparation, and then, after its removal, with air. The technique ensures the detection of the most initial parietal changes in the ducts and in the cavity of intraductal cysts.

Ductography has along with diagnostic capabilities and therapeutic effects. In 40% of cases, after ductography, pathological secretion from the nipple stops due to washing the duct system with iodine-containing preparations.

Analysis of changes on mammograms

The amount of information obtained on radiographs depends significantly on the method of analysis of the radiographic picture. Despite the fact that the mammary glands are a skin formation, functionally they are so closely related to the activity of the internal secretion organs, and above all with the activity of the gonads, that they cannot be considered in isolation from the endocrine system. There is a very clear dependence of the structure of the mammary glands on age and the general hormonal level of the body, on the phase of the cyclic activity of the organs of the female genital area. Throughout the life of a woman, the mammary gland undergoes continuous changes, undergoing deep structural restructuring, therefore there is no static X-ray anatomy of the mammary glands, there is a dynamic age-related and functional X-ray anatomy.

X-ray anatomy of the breast

Throughout a woman's life, changes in the structure of the mammary glands are constantly occurring, which is reflected on x-ray mammograms.

In accordance with the functional age periods, three types of the mammary gland are distinguished.

I. The gland of a girl or a young woman (up to 20-25 years old). The structure of the gland is almost homogeneous, the milk ducts are almost invisible, the width of the premammary space does not exceed 5 мм. Tumor formations arising in such a gland are practically indistinguishable on radiographs. In this regard, non-contrast mammography of the mammary glands at this age is inappropriate.

II. Functionally active gland (from 20-25 to 35-40 years). On mammograms, the mammary gland has a conical or hemispherical shape, the nipple is well developed and clearly defined. Differentiation into parenchyma and stroma occurs, the premammary space expands, small shadows of venous vessels and Cooper's ligaments appear. The shadow of the glandular triangle becomes heterogeneous, with a wavy outer contour due to an increase in the size of the glandular lobules. Behind the nipple appear stranded formations - images of the milk ducts.

According to the ratio of glandular, fibrous and adipose tissues in the reproductive period, three radiological types of the structure of the mammary glands are distinguished:

1) Fibroglandular type of structure - glandular tissue is well developed in the mammary gland, fibrous tissue is expressed in partitions and ducts, and the amount of adipose tissue is minimal;
2) Fibro-fatty type of structure - glandular tissue is moderately expressed, the ratio of glandular and adipose tissue is approximately the same, ducts can be seen against the background of adipose tissue;
3) Adipose type of structure - glandular tissue is weakly expressed, adipose tissue prevails over dense structures.

III . In the period of fading functional activity of the mammary glands, which begins at the age of 40-45, involutive changes progress.

In the most common fatty variant of involution, the glandular tissue gradually disappears and is replaced by adipose tissue. The shadow of the glandular triangle decreases in size, becomes heterogeneous, light accumulations of fatty tissue appear, against the background of which loopy-mesh connective tissue strands become distinct. In the future, the remnants of the glandular tissue are shading of various shapes, which appear against the background of light adipose tissue. Against the background of adipose tissue, shadows of tortuous veins, arteries, sometimes with calcifications, shadows of fibrous cords are clearly visible.

With a rarer fibrous variant of involutive changes, the glandular tissue is replaced by fibrous tissue. The entire mammary gland appears dense, its structure is heterogeneous. The delimitation of the glandular triangle from the retromammary and premammary adipose tissue becomes sharp, the border is uneven, with multiple strands directed from the body of the gland towards the skin.

IV . In the period of pronounced involution (old age), the glandular tissue is completely replaced by fat. Against the background of a homogeneous, "transparent" gland, multiple fibrous strands are detected, going in different directions, but more often towards the areola, the shadow of convoluted veins, and calcified arteries. The border between the glandular triangle and fatty tissue of the premammary and retromammary spaces is not traced.

Age is the main factor determining the structural type of the breast. However, the radiographic picture of a normal breast is very variable and also depends on the constitution, the state of the endocrine system, and the phase of the menstrual cycle.

When reading mammograms, there are: skin, nipple, areola, subcutaneous adipose tissue, glandular tissue, connective tissue structures.

The skin on mammograms of a normal mammary gland is visible in the form of an even, uniform, darkened strip bordering the gland. On high-quality mammograms, clear and even contours of the outer and inner surface of the skin are visible. The skin is separated from the glandular tissue by a light strip of subcutaneous fatty tissue

- the so-called premammary space. The thickness of normal skin is 1- 2 мм. From the skin into the premammary space, there are delicate linear and triangular darkening stripes, displaying Cooper's ligaments.

In the anterior part of the mammary gland, in its most protruding part, the skin gradually thickens, passing without a clear boundary into the areola. The skin in the areola has a folded structure.

Between the skin and the glandular tissue is a layer of fatty tissue. Due to the fact that the density of fat is low, the fiber on mammograms looks more transparent than the skin and glandular tissue. Against the background of adipose tissue, the shadows of the veins are clearly visible. Arteries are distinguished by the deposition of calcium salts in their walls.

Actually the glandular part of the mammary gland has the form of a convex anteriorly cone or disk, the base of which is adjacent to the thoracic fascia, and the top ends with the nipple. The glandular tissue is grouped into 15-20 lobules, which look like pyramids, directed towards the nipple and separated by layers of connective tissue. Each share is divided, in turn, into slices. The main structural unit of the mammary gland is the acinus, which is a group of small lactiferous passages ending in terminal vesicles. On non-contrast mammograms, neither lobes, nor lobules, nor ducts are perceived differentially.

Volumetric formations

Most pathological processes in the mammary gland are accompanied by tissue compaction and, accordingly, in the x-ray image they give a blackout symptom. In the presence of these changes in two projections, we can talk about a volumetric formation (mass). If the darkening is visualized in one projection, we can only talk about compaction, and not about a volumetric formation (mass). When analyzing a volumetric formation (shading), attention should be paid to the shape, contour and density.

Shape analysis:

- round or oval;
- lobulated;
- wrong.

Contour analysis:

- the presence of a capsule;
- the presence of a rim of enlightenment;
- clarity or fuzziness of the contour of education.

Density analysis (the ratio of the degree of X-ray attenuation of the signal of the affected area relative to the attenuation of the signal from an equal volume of glandular breast tissue):

- low density (comparable to adipose tissue);
- mixed density (heterogeneity);
- high density (higher than the density of the tissue of the gland itself or comparable to the density of the tissue of the gland - isodense).

Shape analysis

The rounded or oval shape is more characteristic of benign neoplasms. Irregular shape is more common in malignant processes. The lobular form of education can be present in both malignant and benign processes, reflecting the anatomical features of tumor growth.

contour analysis

The capsule with round and oval nodular formations in the mammary gland is clearly differentiated in the presence of adipose tissue in the compaction structure. Most common in:

- lipomas;
- fatty cysts;
- galactocele;
- fibroadenolipomas.

The presence of an enlightenment rim (full or partial) in most cases indicates a benign process (with the exception of rapidly growing nodular breast cancer).

The clarity of the contour of the formation indicates mainly the good quality of the process (excluding intracystic breast cancer, sarcoma, medullary carcinoma, etc.)

The fuzziness of the contour of the nodular formation is associated with infiltration of the surrounding tissues, increased vascular pattern. There are three options for the manifestation of contour fuzziness:

- type "tail tail";
- spiky strands;
- blurred, poorly differentiated contour.

In most cases, the fuzziness of the contour indicates the malignancy of the process (especially with spicular bands), however, if a “comet tail” is detected, additional studies are needed - sonography, since the fuzziness of the contour can occur with fibroadenomas, cysts, hematomas, breast cancer in the cyst, etc.

Blurring of the contour of education occurs in malignant tumors of the breast and inflammatory diseases (abscess).

Density analysis

Of all the tumor and tumor-like processes, only adipose tissue can look more transparent compared to the surrounding background of the mammary gland. Therefore, the diagnosis of lipomas, fatty cysts, galactocele, etc. presents no difficulty.

High-intensity darkening in the picture causes any pathological process of a productive or exudative order (benign tumor, cyst, breast cancer, sarcoma, etc.).

Darkening of inhomogeneous density is due to the presence of fatty elements in the pathological focus and occurs with fibroadenolipomas, leaf-shaped tumors, galactocele, hamartomas, enlarged lymph nodes.

Only an analysis of the contour, the state of the surrounding tissues, the structure of the formation does not always allow us to differentiate various processes in the mammary gland. Often you have to resort to ultrasound research.

Asymmetry of breast tissue density

The asymmetric density of the breast tissue detected by mammography corresponds to both non-tumor processes (asymmetric involution of the gland tissue, post-traumatic and post-inflammatory changes, adenosis) and tumor processes (BC). To clarify the nature of the compaction, additional sighting images and sonography are necessary. Detection of retraction of the breast tissue contour to the area of asymmetric density in sighting images in most cases corresponds to intense breast cancer.

The combination of density asymmetry with violation of the tissue architectonics reflects both fibrotic changes in the breast tissue (after operations, punctures, injuries, etc.) and the initial signs of breast cancer.

Calcifications

Localization in the breast tissue should be distinguished: lobular, ductal and stromal calcifications.

When analyzing calcifications, it is necessary to evaluate their shape, size, quantity and nature of distribution. By the nature of the distribution, they are distinguished: grouped (with a volume of less than 2 cubic cm), linear (when calcifications form a line), segmental (distribution within one lobule), regional (distribution within one lobe), diffuse (distributed randomly throughout the tissue mammary gland). Calcifications in benign processes are characterized by a diffuse location, always more homogeneous and more uniform (large, clumpy, like "popcorn", "eggshell", "lens frames"). Malignant neoplasms are characterized by a chaotic arrangement of calcifications, small sizes (microcalcifications from 50 to 600 microns), have a different shape (small, worm-like, like “broken stone”, “lumps of cotton wool”, “snake skin”, etc.) Often with Breast cancer microcalcifications resemble "powder". According to Rogers (1972) and Mengers (1976), a clear relationship has been established: "The more calcifications and the smaller their size, the higher the likelihood of breast cancer."

Microcalcifications (calcifications) in the mammary gland should be considered a sign suspicious of cancer, but not absolutely pathognomonic for this disease.

Sonography of the breast

Breast ultrasound is recommended to be used only as a diagnostic method, but not as a means of mass screening, because. does not allow with a high degree of accuracy to detect microcalcifications, which are the earliest sign of intraductal cancer in situ (DCIS).

Breast ultrasound in women younger than 30 should be performed without prior mammography. In women older than 30 years, ultrasound should be performed in addition to mammography to further evaluate specific clinical changes.

Breast sonography is performed with the patient in the supine position. One or both hands must be placed behind the head or neck (to stretch the muscles and better fix the mammary gland in a fixed position).

Examination of the mammary glands is carried out by moving the sensor from the outer parts of the gland to the nipple or in the opposite direction, which corresponds to the anatomical location of the glandular structures and milk ducts. All changes found in one mammary gland are compared with symmetrical areas in the contralateral mammary gland. In conclusion, the state of regional zones of lymphatic outflow is necessarily assessed.

In recent years, Doppler sonography (color and energy) has become more widely used, which makes it possible to obtain images of the object under study in real time and a color image of blood flow. This makes it possible to determine the anatomical structure and functional state of the vessels, the degree and nature of tissue vascularization. The advantage of the method is to obtain instantaneous information about functional and anatomical disorders in the blood supply to the mammary gland. Determination of qualitative and quantitative indicators of blood flow is of particular importance in non-palpable breast tumors.

The presence of blood vessels is an important indicator of the development, prognosis, and differential diagnosis of tumors. The use of color Doppler mapping and power Doppler allows a non-invasive method to visualize the blood flow and identify some features in the newly formed tumor vessels, such as: violation of the architectonics of the vascular pattern; irregular shape of the vessels (convoluted, looped, etc.); variable diameter of vessels, abundance of arteriovenous shunts; absence of the muscular layer of the vascular wall. Visualization of blood vessels in the tumor can be improved by the use of contrast agents (levovist).

Ultrasound anatomy of the breast

Ultrasound examination allows a good differentiation of various tissue structures in the mammary gland.

Evaluation of breast ultrasound data is based on the differentiation and comparison of the acoustic density (echogenicity) of tissues of all types found in this organ. In terms of ultrasound anatomy of the breast, three categories of tissues can be distinguished based on their echogenicity: hyperechoic structures, structures with an average level of echogenicity, and hypoechoic.

Hyperechoic structures

Structures that are presented on ultrasound images as light shades of gray, bright or white formations are commonly called hyperechoic, that is, giving a high reflected ultrasound signal. Tissues present in the breast that form hyperechoic areas on ultrasound images include skin, Cooper's ligaments, superficial and deep fasciae, ribs, and fibroglandular tissue. These structures are easily identified on ultrasound images.

Structures with an average level of echogenicity

As the initial level of the reflected acoustic signal on ultrasound images, for comparison with the surrounding structures , it is customary to use the echogenicity of adipose tissue. Structures that generate a medium intensity echo and are represented by medium intensity gray color include adipose tissue, glandular tissue, fibrous tissue surrounding the ducts and lobules of the breast, and muscles.

Hyperechoic structures

Structures that appear darker than adipose tissue are commonly referred to as hypoechoic or even anechoic. On ultrasound images, such structures correspond to the darkest shades of gray, fading to black. Usually, the milk ducts and blood vessels located in the mammary gland have this appearance.

If an atypical structure is detected, the sensor returns to this zone. In doing so, it is necessary to evaluate:

- the shape of the formation (round, oval, irregular), including the depth/width ratio;
- contours of education (smooth / uneven, clear / fuzzy);
- the internal structure of education (homogeneous / heterogeneous);
- condition of the surrounding tissues;
- distal acoustic effects (amplification, attenuation, acoustic shadow);
- side shadows (symmetrical, asymmetric, not defined);
- calcifications;
- the presence of vascularity.

Breast cysts are the most common pathology associated with the expansion of the ducts of the mammary gland or lobular acini with fluid. If fluid accumulates in the ducts faster than it is absorbed, breast cysts form. Simple cysts are nonreflective (i.e. black) and round in shape with well-structured, even echogenic walls and acoustic enhancement.

The most common type of benign solid tumors found in the breast, especially in women under 30, are fibroadenomas. In some cases, they look like typical benign formations: well-structured, rounded, without an acoustic effect or even with an increase in the acoustic signal. In other cases, fibroadenomas may exhibit the acoustic properties of malignant tumors, making it difficult to differentiate them from true malignant neoplasms. Therefore, if a palpable volumetric formation shows even the slightest signs of malignancy, it is necessary to conduct a biopsy.

On sonography, breast cancer is a hypoechoic formation of irregular shape without clear contours of an inhomogeneous structure with or without an acoustic shadow. The echographic sign of the blurring of the contour of the formation is regarded by most experts as the most significant differential diagnostic criterion for benign and malignant lesions of the mammary gland. Most malignant breast tumors are hypervascular. Typical pathological symptoms of malignant neoangiogenesis: uneven vessel diameter, tortuosity, an abundance of arteriovenous shunts, sinuses, the absence of dichotomous division with a gradual decrease in the cross section of the vessels.

The use of power Doppler sonography and contrast agents makes it possible to increase the number of visualized blood vessels from 36% to 95% in malignant neoplasms and from 14% to 21% in benign ones. This improves the visualization of the architectonics of the tumor vessels. This avoids unnecessary diagnostic biopsies.

X-ray computed tomography is inferior to mammography in the detection of preclinical forms of cancer, the size of which does not exceed 1 смin diameter. Given the complexity, high cost, high radiation exposure, lack of devices in practical healthcare, the X-ray computed tomography method is limited in its use for the primary diagnosis of breast diseases.

In recent years, the possibility of using **magnetic resonance imaging in the diagnosis of breast cancer has been studied** . The advantages of this method are high resolution and contrast of displaying soft tissue elements, non-invasiveness, and the possibility of obtaining an image in any arbitrary plane without mechanical movements. The role of contrast enhancement in order to increase the information content of the MRI method is discussed. The rationale for the use of contrast enhancement is the neovascularization of a malignant tumor with a diameter of more than 2 мм, but a significant proportion of such tumors are avascular. The sensitivity of MRI with dynamic contrast in the diagnosis of breast cancer is 95.5%, the specificity is 73.5%.

The high cost of the study dictates the expediency of its use in complex diagnostic cases, in particular, if it is necessary to differentiate gross cicatricial changes from a malignant process.

The experience of using MRI shows that the problem of differential diagnosis of benign changes in the mammary gland remains, since it is noted that the high sensitivity of the method is combined with the low specificity and accuracy of MRI for detecting breast cancer. In addition, as in the case of RCT, this method has the problem of the ratio of the capabilities of the method and the cost of its application. Thus, each of the above methods has its own capabilities and limitations, which determine the indications for their use and place in the complex diagnosis of diseases.

Test tasks

1. The most important in the differential diagnosis of dystopia and nephroptosis is:

а) level of the pelvis
б) ureter length
в) level of origin of the renal artery
г) location of the ureter
д) length of the ureter and level of origin of the renal artery

2. Kidneys in a healthy person are at the level of:

а) 8-10 thoracic vertebra
б) 12th thoracic and 1st-2nd lumbar vertebrae
в) 1-5 lumbar vertebrae
г) 4-5 lumbar vertebrae

3. Expansion of the renal pelvis and calyces, atrophy of the parenchyma of the kidney, an increase in size with undulating bulges of the lateral contour, a sharp decrease or lack of function are the most typical:

а) For solitary cyst

б) For kidney tumor
в) For hydronephrosis
г) For chronic pyelonephritis

4. All of the following symptoms indicate the presence of renal colic, except:
а) No nephrographic phase
б) Absence of urinary tract contrast
в) Late appearance of contrast material in the urinary tract
г) Dilatation of the urinary tract

5. Signs that may cause suspicion of a tumor on a survey urogram include:
а) Calcification in the area of the kidney
б) Increasing the intensity of the shadow of the kidney
в) Deformation and enlargement of the kidney
г) Changing the position of the kidney

6. During hysterography, the uterine cavity is deformed, a filling defect with uneven, broken, not quite clear contours, having an irregular shape, a depot of a contrast agent in the center of this defect, around which an enlightenment strip is located, are the most characteristic:
а) For submucosal fibroids
б) For diffuse fibroids
в) For exophytic cancer
г) For chronic tuberculous endometritis

7. A direct sign of a kidney stone on ultrasound is:
а) Echopositive formation in the projection of the PCS
б) Hyperechoic formation, not less than5 мм
в) A well-defined echopositive lesion with an acoustic shadow behind it
г) Echo-positive formations that disappear with a decrease in the operating mode of the device

8. Malignant tumors of the kidneys are
а) Hyperechoic formations
б) Hypoechoic formations
в) Isoechoic formations
г) May be hypoechoic, hyperechoic or isoechoic

9. Mammography is preferred
а) From the 1st to the 5th day of the menstrual cycle
б) From the 6th to the 12th day of the menstrual cycle
в) In the second half of the menstrual cycle
г) Does not matter

10. Against the background of glandular tissue, lipoma is detected as

а) Shading with clear, smooth contours
б) Enlightenment with clear and even contours
в) Lipoma does not stand out against the background of glandular tissue
г) Darkening with clear and even contours and a rim of enlightenment along the periphery

11. The use of ultrasound scanning is limited
а) With x-ray established dense mammary glands
б) In the study of involutive mammary glands
в) In the differential diagnosis of benign and malignant tumors
г) When microcalcifications are detected

12. Hypervascularization in breast cancer manifests itself
а) An increase in the caliber of blood vessels
б) An increase in the number of vascular branches
в) tortuosity of vessels
г) An increase in the caliber and number of vascular branches, their tortuosity

13. If a liver tumor is suspected, the most informative method is
а) Plain radiography of the abdomen
б) CT scan
в) Contrast study of the biliary system
г) Scintigraphy

14. Ultrasound picture of a liver cyst is not typical
а) Education with reduced echogenicity
б) oval shape
в) round shape
г) The presence of a shadow behind the formation

15. The main signs of obstruction at the level of the common bile duct on ultrasound
а) The gallbladder is enlarged and does not contract under the action of a choleretic breakfast, the intrahepatic and extrahepatic ducts are dilated
б) The gallbladder is enlarged and shrinks under the action of a choleretic breakfast
в) Dilated intrahepatic ducts
г) The gallbladder is enlarged, the ducts are not dilated

16. Main ultrasound signs of high obstruction of the common hepatic duct
а) Intrahepatic ducts are dilated, choledoch is not dilated, gallbladder is not enlarged
б) The ducts are not dilated, the gallbladder is not enlarged
в) The gallbladder is enlarged, does not respond to choleretic breakfast

г) The ducts are dilated, the gallbladder is enlarged, does not respond to a choleretic breakfast

Answers to test tasks

1. e 10. b
2. b11. г
3. in12. г
4. a 13. b
5. in14. г
6. at 15. a
7. at 16. a
8. G
9. b

Lesson number 9

Topic: **Radiation diagnosis of diseases of the pancreas and spleen, spinal cord and brain.**

Purpose of the lesson:

To study the radiation anatomy of the pancreas, spinal cord and brain; methods and possibilities of their radiation research.

Specific objectives of the lesson:

Be able to:

1. Recognize the method of radiation examination of the pancreas (ultrasound, plain radiography, endoscopic retrocholangiopancreatography, computed tomography, scintigraphy, magnetic resonance imaging, angiography).
2. Identify the main anatomical structures on various x-ray images of the pancreas.
3. Using the protocol of radiation examination of the patient, find and interpret morphological and functional changes in the pancreas on radiographs, computed tomograms, magnetic resonance imaging, angiograms, scintigrams.
4. Recognize the method of radiation examination of the brain (radiography, angiography, computed tomography, magnetic resonance imaging, ultrasound, scintigraphy).

5. Distinguish the anatomy of the brain on radiographs, angiograms, computed tomograms, magnetic resonance imaging, scintigrams).
6. Using the protocol of the patient's radiation examination, find and interpret morphological and functional changes in the brain on radiographs, angiograms, computed tomograms, magnetic resonance imaging, scintigrams.
7. Recognize the method of radiation examination of the spinal cord (radiography, computed tomography, scintigraphy, magnetic resonance imaging).
8. Determine the anatomy of the spinal cord with various methods of radiation diagnostics.
9. Find and interpret morphological and functional changes in the spinal cord on radiographs, computed tomography, magnetic resonance imaging, and scintigrams using the protocol of the patient's radiation examination.

Know:

1. Radiation anatomy of the pancreas.
2. Principles of preparing the patient for the study of the pancreas.
3. Possibilities of various radiation diagnostic methods in the study of the pancreas.
4. The main radiation syndromes in diseases of the pancreas.
5. Radiation anatomy of the brain.
6. Principles of preparing the patient for the study of the brain.
7. The possibilities of radiation methods in the study of the brain.
8. Radiation semiotics of the main diseases of the brain.
9. Radiation anatomy of the spinal cord.
10. Principles of preparation of the patient for the study of the spinal cord.
11. The main radiation syndromes of spinal cord injury.
12. Possibilities of radiation diagnostic methods in the examination of the spinal cord.

Base of carrying out and material equipment:

1. Study room.
2. Educational set of radiographs, sonograms, computed tomograms, angiograms with the norm and pathology of the pancreas, brain and spinal cord.
3. Tables, schemes.
4. Case histories of patients with ROD.

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Block of information:

METHODS OF RADIATION EXAMINATION OF THE PANCREAS AND SPLEEN

X-ray method

Native X-ray examination. Plain radiographs of the abdomen in patients with signs of an acute disease of the abdominal organs ("acute abdomen") in some cases allow visualization of radiological symptoms indicating the presence of a pathology of the pancreas or spleen. Therefore, despite its low information content, plain radiography of the abdominal organs has not lost its relevance.

On survey radiographs, attention is paid to visible pathological formations; condition of parenchymal and hollow organs; detection of free gas and liquid in the peritoneal cavity; the presence of various calcifications and stones; condition of bone structures; changes in fatty layers and soft tissues of the abdominal wall.

When conducting fluoroscopy of the stomach and duodenum, signs of pathology and the pancreas or spleen can be detected. These include: medial displacement of the stomach gas bubble, displacement and depressions on the greater curvature of the antrum and the posterior wall of the stomach, pyloric stenosis, edema and inflammatory reaction of the mucous membrane. There may be an expansion and reversal of the horseshoe of the duodenum, uneven serration or straightening of its internal contour, wall rigidity and persistent narrowing of the lumen.

Functional changes include a slowdown or acceleration of evacuation from the stomach, increased peristalsis, duodenostasis, prolonged retention of barium sulfate suspension due to paresis of the small intestine.

However, the detected changes in the stomach and duodenum are not pathognomonic and occur in other diseases.

Much more information can be obtained using special methods of X-ray examination: endoscopic retrocholangiopancreatography, angiography of the pancreas, fistulography, splenoportography. Other x-ray techniques, such as examination of the pancreas under conditions of retropneumoperitoneum, are now rarely used and are of more historical interest.

Endoscopic retrocholangiopancreatography is one of the most informative techniques. Under the control of the endoscope, catheterization of the large duodenal papilla is performed and a contrast agent is injected into the ductal system of the pancreas and bile ducts. After that, an x-ray of the liver and pancreas is performed. Using this method, the anatomical relationship of the bile and pancreatic ducts, their deformation, the presence of a stricture, the localization and shape of the calculi are revealed. The technique allows to obtain an image of small pancreatic ducts of the second or third order, which is almost impossible to achieve using other methods of radiation diagnostics. If a pathology is detected during this study, therapeutic measures (papillotomy, stone removal) can be carried out.

If it is impossible to catheterize the major duodenal papilla, percutaneous transhepatic cholangiography with and without drainage of the bile ducts is used. In this study, a thin needle is inserted through the skin into the bile ducts and their image is obtained, after which the formed channel can be expanded to allow the drainage tube to be inserted through the conductor.

Endoscopic retrocholangiopancreatography is one of the invasive procedures. Sometimes it is associated with complications in the form of the development of acute pancreatitis, due to the irritating effect of the contrast agent on the pancreas, as well as the introduction of drugs into the ducts under excessive pressure.

Angiography of the pancreas and spleen

Direct injection of a contrast agent into the arteries of the pancreas is not feasible due to the anatomical features of its blood supply. With aortography, small-caliber vessels are not filled enough, and their image is blocked by large vascular trunks near the lying organs. Therefore, selective probing of the celiac trunk is used, followed by its contrasting. At the same time, digital subtraction angiography is preferred, since it allows you to immediately obtain an image and has a high contrast resolution.

Performing angiography, a whole series of images is produced, on which three phases of the passage of a contrast agent are sequentially displayed: arterial, parenchymal and venous. The peak of accumulation of the contrast agent is observed in the arteries, capillaries, and veins of the pancreas, respectively.

In some cases, when examining the venous system of the pancreas or spleen, splenoportography or return portography is used. At the same time, the course and patency of the main venous trunks, as well as the state of their walls, are determined. A complication is intra-abdominal bleeding, since a puncture of the spleen is necessary for its implementation.

Ultrasonic method

Ultrasound examination of the pancreas is detected in the epigastric region anterior to the main vessels (inferior vena cava, aorta) and the spinal column. The markers of the location and boundaries of the pancreas are, first of all, the vessels of the abdominal cavity - the inferior vena cava, the aorta, the superior mesenteric vein and artery located below the body of the pancreas, the celiac trunk and its branches lying more cranially, the splenic vessels passing along the posterior surface of the tail of the pancreas, and gastroduodenal artery.

Visualization of the body and head and pancreas is successful in 90%, the tail in 50% of cases. Normally, on ultrasound examination, the pancreas has a horseshoe shape, clear contours. Normal anteroposterior dimensions of the head of the pancreas are 22- 24 мм, body 14- 18 мм, tail 18-22mm. The structure of the parenchyma is defined as uniform, homogeneous and has a fine-grained character. The shape, size and structure of the pancreas depend on the age, sex and constitution of the patients.

The pancreatic duct can normally be visualized only in a third of patients. It is usually visualized as a thin, not exceeding 2 ммlinear structure, defined in the region of the head and body of the pancreas.

The spleen is located in the upper floor of the abdominal cavity under the dome of the diaphragm, sickle-shaped, with clear contours and echogenicity of the parenchyma slightly exceeding that of the liver.

However, the assessment of various indicators during ultrasound examination so far remains quite subjective and depends on the constitutional characteristics of the patient, the technical characteristics of the apparatus, environmental conditions; therefore, usually the results of ultrasound are tried to be confirmed by other methods of radiation diagnostics.

X-ray computed tomography

Computed tomography is becoming increasingly important in the examination of patients with symptoms of diseases of the pancreas or spleen. On spiral and multislice computed tomography, the study is carried out quickly, is well tolerated by patients and provides a large amount of fully reproducible information. In the diagnosis of certain conditions (trauma, acute pancreatitis), computed tomography has become the method of choice. The faster acquisition of projection data on modern CT scanners has also made it possible to reduce radiation exposure, despite the much thinner slices (1- 2,5 мм) that are used.

Before the study, 200-400 ml of a 3% water-soluble contrast agent is administered orally beforehand to contrast the lumen of the stomach, duodenum and small intestine. Scanning is carried out in a spiral mode from the level of the dome of the diaphragm to the upper anterior iliac spines, and, if necessary, to the level of the pubic symphysis. The standard technique uses sections with a thickness of 5- 8 мм. However, on a multislice CT scanner, it is desirable to use thinner slices (1- 2,5 мм), as this increases the sensitivity of computed tomography, especially for detecting small formations. To increase the contrast resolution of the method, 40-50 ml of a radiopaque substance is administered intravenously to the patient , and then scanning is performed according to the standard method.

Much more information can be obtained from computed tomography using a bolus intravenous injection of a contrast agent using an automatic injector. At the same time, a contrast agent in the amount of 100 ml is administered intravenously using an automatic injector at a rate of 3-5 ml/sec. Scanning of the selected area starts after 25-30 seconds and is carried out in several phases. The best visualization of the arteries is achieved in the early arterial phase, the image of the pancreatic parenchyma and veins of the portal vein system is obtained in the portal phase. Sometimes, to assess the dynamics of changes in the accumulation of a contrast agent in the pathological focus, a delayed scan is performed.

Magnetic resonance imaging

This method of radiation diagnostics is becoming more widespread in the study of the abdominal organs, especially in the study on magnetic resonance tomographs with medium and high magnetic field strength (0.5-3 T).

Imaging of the upper abdomen requires T1- and T2-weighted imaging. At the same time, any pathological formations, especially those containing liquid, are more clearly visualized on T2-WI, and T1-WI is more consistent with the features of the anatomical structure. It should be noted that MRI with the use of contrast enhancement is based on the study of the dynamics of changes before and after the administration of a contrast agent (preparations based on gadolinium compounds) on T1-WI, which is manifested by a change in the intensity of the signal from pathological formations due to a shortening of the T1 time.

Often, the HASTE pulse sequence is used to obtain an image of the abdominal organs . It is not susceptible to motor and respiratory artifacts, provides high resolution and contrast of the parenchyma, soft tissues. On the obtained tomograms, the liver, gallbladder, liver hilum, intra- and extrahepatic bile ducts, duodenal horseshoe, pancreas, main pancreatic duct, spleen are well visualized.

technique of non-contrast magnetic resonance cholangiopancreatography , which belongs to the generation of projection magnetic resonance images of the biliary tract and pancreatic ducts, requires special consideration .

The basis for obtaining images in magnetic resonance cholangiopancreatography is the fact that bile in the bile ducts and gallbladder, as well as pancreatic secretion in the pancreatic duct, are practically motionless fluids and have a long time of transverse (spin-spin) relaxation - T2. Parenchymal organs (liver, pancreas) have a significantly shorter T2 time, so the use of pulse sequences for magnetic resonance cholangiopancreatography with T2-weighted images provides a sufficiently high spatial resolution, while the gallbladder and ducts look like areas of high signal intensity on tomograms against the background of an extremely low intensity signal from parenchymal organs and flowing blood.

If necessary, as the second stage of the study, magnetic resonance scanning is performed under conditions of dynamic administration of a contrast agent. Dynamic contrast enhancement is based on the sequential acquisition of images of the same area of interest as the contrast agent passes through it at short intervals, which ensures its visualization in the arterial, venous and parenchymal phases. At the same time, paramagnetic contrast agent is administered manually or using an automatic injector at a dose of 0.1 mmol / kg of body weight or 0.2 ml / kg, but not more than 20 ml.

Radionuclide method

Single photon emission computed tomography

For the diagnosis of diseases of the pancreas, scintigraphy or single photon emission tomography with Se -labeled methionine is used . Normally, the processes of synthesis of various protein compounds actively proceed in the pancreas, so this radiopharmaceutical actively accumulates in it. In inflammatory processes, there is a significant inhibition of the functions of enzyme synthesis, which is accompanied by a reduced accumulation of the radiopharmaceutical. Similar changes are observed in neoplasms.

In addition to scintigraphy of the pancreas using Se -methionine, there are a number of radionuclide research methods that make it possible to indirectly judge its condition by changing the secretion of pancreatic enzymes and determining the exo- and endocrine function of the pancreas. At the same time, the absorption of fats, the content of gastrointestinal hormones are determined.

Leukocytes labeled with 99 mTc or In are used to diagnose an abscess or infiltrative pseudocyst of the pancreas, as they can accumulate in the area of the inflammatory focus.

To identify hormonally active tumors and clarify their localization, octreotide labeled with In is used .

Positron emission tomography

Recently, positron emission tomography has been actively used in clinical practice. Being a part of radionuclide diagnostics, this method has unique possibilities for determining the regional metabolism of natural biologically active substances. The use of this method for the study of the pancreas is still practically little studied.

For differential diagnosis, positron emission tomography is performed in dynamic mode, for which sodium butyrate labeled with C is used . At the same time, the degree and uniformity of the accumulation of radiopharmaceuticals by the pancreatic tissue, as well as the dynamics of accumulation of the radiopharmaceutical, are evaluated. When determining the degree of accumulation of the radiopharmaceutical, the activity in the pathological formation is compared with the activity of the liver tissue, the healthy part of the pancreatic parenchyma, or the surrounding parapancreatic tissue.

Radiation semiotics of pancreatic diseases

Chronic pancreatitis.

X-ray examination: indirect signs of pancreatitis can be obtained by X-ray examination of the stomach and duodenum.

Enlargement of the pancreas in chronic pancreatitis leads to separation of individual segments of the duodenum. Depressions, rigid areas appear on the medial wall of the duodenum. The elasticity of the intestinal wall in this place disappears, the folds of the mucous membrane take on a transverse course. Adhesions of the pancreas and stomach affect the limitation of displacement of the latter in the posterior-anterior direction.

CT: diffuse enlargement of the pancreas, lime deposits in the parenchyma and pancreatic ducts, heterogeneity of densitometric parameters of the parenchyma, the presence of multiple cysts in the pancreatic parenchyma.

Contrast CT: with intravenous administration of a contrast agent, enhancement of the pancreatic parenchyma in chronic pancreatitis may be reduced and heterogeneous.

Endoscopic retrocholangiopancreatography: changes in the ductal system in the form of uneven expansion of the main pancreatic duct and its branches.

Angiography: expansion of the upper and lower pancreatoduodenal arteries, dorsal and large pancreatic arteries.

A separate form is pseudotumorous pancreatitis, which, on ultrasound, computed or magnetic resonance imaging, looks like a local increase in a part of an organ, often the head.

Differential diagnosis of this form of pancreatitis with a tumor of the pancreas remains difficult. Often the final diagnosis is established only after long-term follow-up or with the help of repeated biopsies.

Acute pancreatitis.

Plain radiography of the abdomen allows to exclude the presence of free gas in the abdominal cavity, to assess the nature and severity of paresis of the small intestine, which often accompanies pancreatitis. A “severed colon” symptom can be detected, the appearance of which is probably associated with inflammation of the colon-phrenic ligament. This symptom on x-ray appears as a sharp break in the column of gas in the distended transverse colon at the level of the splenic flexure, while no gas is detected in the descending colon.

Ultrasound: echogenicity of the pancreas often decreases due to interstitium edema.

There is a local or diffuse enlargement of the pancreas. The accumulation of fluid in the omental bag or fatty infiltration on ultrasound (when they are expressed to a large extent) make it possible to suspect the presence of foci of necrosis in the pancreas. The retroperitoneal tissue itself can contrast sharply with the perirenal tissue, which is less frequently involved in the process. Sometimes a thickening of Gerota's fascia is revealed.

CT: mild acute pancreatitis may occur without any manifestations; sometimes there is a slight increase in its size and an unexpressed increase in the density of the fiber surrounding the gland.

Contrast CT: when using intravenous bolus administration of a contrast agent, it becomes possible to detect avascular necrotic areas in the parenchyma.

With computed tomography, a detailed assessment of the spread of infiltrative changes in the tissue is possible, which can be very extensive and reach the tissue of the small pelvis and posterior mediastinum.

The semiotics of acute pancreatitis in magnetic resonance imaging is generally similar to that in computed tomography.

Tumors of the pancreas

Radiation diagnosis of malignant neoplasms of the pancreas is based on the detection of a focal lesion with a change in structure, an increase in its separate part. The minimum size of the formation, which can be detected in this case, is 1- 1,5 см.

Fluoroscopy and radiography: a contrast study of the stomach and duodenum reveals a change in the contours of the stomach and duodenum, wall rigidity, the disappearance of characteristic folding and germination of the walls.

Angiography: changes in the course of blood vessels, displacement of the main vascular trunks, as well as the presence of pathological plexuses and ruptures along the periphery of the focal formation.

Ultrasound: the tumor appears as a focus of hypo-, hetero- or hyperechoic structure with uneven contours. At the same time, in addition to direct signs of a tumor, indirect ones can also be detected. These include: a change in the state of the gallbladder, expansion of the intrahepatic bile ducts, infiltrative tumor growth in neighboring organs, ascites, metastases to regional lymph nodes, metastatic liver damage.

CT, MRI: local enlargement of the organ and change in the contour of the gland. Often, when the tumor is localized in the head area, signs of atrophy of the body and tail of the pancreas are observed.

METHODS OF RADIATION DIAGNOSIS OF THE BRAIN

The main methods of radiation diagnostics in neurology and neurosurgery are CT and MRI. This is due to the fact that these methods are the most informative in the diagnosis of many diseases and injuries. In connection with their development, the traditional X-ray method has faded into the background, but in many cases retained its importance. In diagnostically difficult cases, special CT and MRI techniques can be used. For functional studies, the use of the radionuclide method (SPECT and PET) is shown.

X-ray method

Air, oxygen and nitrous oxide are used as contrast agents. CSF spaces can be contrasted in three ways: by lumbar puncture, by suboccipital puncture, and by puncture of the lateral ventricle through a burr hole. Studies using the first two methods of gas injection are called pneumoencephalography, a study with the introduction of gas by ventricular puncture - ventriculography. Each of them has strictly defined indications. With the introduction of gas into the liquor pathways through the lumbar puncture, the ventricles of the brain and the subarachnoid space are filled. This filling depends on the position of the head. When the head is tilted anteriorly, the ventricles of the brain are predominantly filled, while when tilted backwards, the subarachnoid space is filled. With the introduction of gas in the suboccipital way, the ventricles of the brain are filled mainly, the subarachnoid space is rarely filled. When gas is injected into the ventricles of the brain, the subarachnoid space is not filled with gas.

Currently, contrast methods of research are used much less, which is associated with the widespread introduction of CT and MRI into clinical practice.

Pneumoencephalography (PEG) is a method of contrasting the ventricles and subarachnoid spaces, carried out by lumbar injection of gas into the cerebrospinal fluid. Indications: inflammatory diseases, brain tumors, consequences of traumatic brain injury. Contraindications to PEG are tumors of the posterior cranial fossa, III ventricle, temporal lobe, causing occlusion of the CSF spaces and hypertensive-dislocation phenomena. The main danger is the acute development of the dislocation of the brain stem and its infringement in the notch of the cerebellar tenon or the large occipital foramen after a lumbar puncture and removal of the cerebrospinal fluid.

After the introduction of gas, radiographs are taken, first in typical projections (anterior-posterior, posterior-anterior and two lateral), and then in additional stacking to visualize all parts of the ventricular system.

In pathological processes, pneumoencephalograms show changes in the ventricles and subarachnoid spaces. So, in the presence of a volumetric formation, the corresponding sections of the ventricular system are shifted in the opposite direction. After inflammatory processes, adhesive changes often occur in the membranes, as a result of which the subarachnoid spaces are obliterated and cease to be visible on radiographs. With cystic changes, an uneven expansion of the subarachnoid spaces is observed. These changes are observed in cerebral arachnoiditis.

Suboccipital pneumoencephalography. The study is carried out in cases where, due to a sharp increase in intracranial pressure, lumbar gas administration is contraindicated. A suboccipital puncture is performed, a small amount of cerebrospinal fluid is removed and 20-30 ml of gas is injected. Radiographs are taken following the same principles as for lumbar PEG. The study is highly informative for assessing the position, shape and size of all parts of the ventricular system of the brain. Subarachnoid spaces are poorly filled, as a result of which it is difficult to judge their condition.

Currently, this study is carried out extremely rarely, only if there are strict indications.

Pneumobulbography. The method is used in the study of the cerebrospinal fluid spaces of the posterior cranial fossa (large occipital cistern, lateral cisterns of the pons, IV ventricle, Sylvian aqueduct), where the pathological process is usually accompanied by occlusion of the cerebrospinal fluid spaces and, consequently, hypertensive syndrome. The danger of wedging the barrel into the foramen magnum requires compliance with strict guidelines. With complete occlusion of the CSF spaces at the level of the posterior cranial fossa, gas does not penetrate into the cavity III and lateral ventricles.

At present, this method is rarely used.

Ventriculography. The study is carried out with occlusion at different levels of the ventricular system, when the ventricles are not filled with the lumbar injection of gas. A burr hole is applied, respectively, to the anterior or posterior horn of the lateral ventricle, through which the ventricle is punctured. A small amount of cerebrospinal fluid is removed and gas is injected. The information content of the study is the same as with suboccipital PEG. All parts of the ventricular system are clearly visible.

With occlusions of the ventricular system, ventriculography is the only way to contrast the ventricles, especially in the postoperative period.

Pneumocisternography. The study is carried out to determine the degree of growth of the pituitary tumor upward. After a lumbar puncture, 10-20 ml of gas is injected and craniograms are performed in a lateral projection with the patient in a sitting position with a maximum tilting of the head back. With the head thrown back, the main part of the introduced gas is distributed over the base of the brain and fills the tanks located above the entrance to the Turkish saddle. Normally, gas is visible just above the seat diaphragm. With tumors of the pituitary gland, in cases of their spread upward, the perisellar cisterns are compressed and shifted upward, the lower contour of the cisterns filled with gas borders the upper pole of the tumor.

Cerebral angiography

The method of contrasting cerebral vessels. It must be strictly substantiated by relevant evidence.

Currently, specialized neurosurgical hospitals are equipped with modern angiographic complexes that allow performing digital subtraction angiography with automatic injection of a contrast agent. This study can be carried out in two ways: by puncture of the common carotid artery on the side of the injury or by selective catheterization with puncture of the femoral artery (according to Seldinger).

When performing cerebral angiography, up to 10 ml of a contrast agent is injected intra-arterially at an injection rate of 8-10 ml per second. Angiograms are performed in standard (direct and lateral) and in oblique arbitrarily chosen projections by moving the x-ray tube around the victim's head. It is obligatory to obtain the arterial, capillary and venous phases of the blood flow.

X-ray computed tomography

Computed tomography is the most informative method of radiation diagnosis of diseases and injuries of the skull and brain. When clinically indicated and available, CT should be performed prior to any radiopaque studies.

Densitometric indices of brain structures were developed in absolute units (Hounsfield scale - HU). Thus, the density of gray matter is 30-35 HU , white - 25-29 HU , the density of periventricular zones - 5-8 HU .

The possibilities of detecting various diseases and injuries of the brain using CT are associated either with a violation of normal anatomical relationships in the cranial cavity, or with various attenuation of X-ray radiation by normal and pathologically altered tissues. So, normally, the ratio of the densities of all structural elements of the brain tissue is stable. With pathological processes, it changes. For example, an increase in the water content in the intra- and extracellular spaces leads to a decrease in tissue density, which is observed with cerebral edema. That is why the content of most cystic formations is low-density. The reason for the decrease in density during demyelinating processes is the structural degradation of lipids.

If the tumor tissue is rich in blood vessels or the degree of differentiation of its cells is low, then such a pathological process looks denser than the surrounding medulla and its density increases significantly after intravenous administration of a radiopaque substance due to increased microcirculation and a violation of the blood-brain barrier (high-density structure).

If the cellular elements of the tumor are at a high stage of differentiation or the tissue is poor in blood vessels, then it will look like a low-density pathological formation on computed tomograms or will have a density equal to that of the surrounding tissues, that is, it will be iso-dense.

Along with densitometric indicators, an important criterion for evaluating a CT image is the detection of violations of spatial anatomical and topographic relationships in the studied area of the head. The presence of any additional pathological focus leads to the development of secondary changes in the form of compression of the CSF spaces, displacement of the median structures of the brain:

transparent septum, III ventricle and pineal body ("mass effect"), their movement in the vertical direction with the development of signs of transtentorial herniation of the brain stem brain - signs of lateral and axial dislocation.

Special CT techniques

Computed tomographic angiography allows, after intravenous bolus administration of RCS in the amount of 50-100 ml at a rate of 3-4.5 ml/s, to obtain an image of arterial and venous structures that are displayed simultaneously.

The advantages of the method are the speed of the study and the good agreement of the obtained data with the results of intra-arterial angiography. The disadvantages of the method include the use of a contrast agent and the lack of information about the characteristics of the flow. The technique has practically no specific artifacts.

The introduction of spiral CT technology into clinical practice has significantly changed the method of studying cerebral vessels. The total head scan for helical CT is only 20-30 seconds. Non-ionic preparations are currently used as contrast agents: omnipaque and ultravist of various concentrations (from 240 to 370 mg/ml).

The use of CT angiography in neurooncology makes it possible to assess changes in vascular topography, identify stenosis of the main vessels due to the impact of a neoplasm, and visualize structural features of the tumor's own vascular network (including intratumor shunts).

Computed tomography cisternography. This technique is carried out with suspicion of neoplasms of the chiasmal-sellar region. After lumbar puncture, water-soluble radiopaque preparations of 5-7 ml are administered. CT is performed in 15-30 minutes. To assess the cisterns of the brain, not only axial sections are used, but also sagittal and frontal image reconstructions.

Deformation, displacement, change in the size of the contrasted cisterns make it possible to judge the presence of tumor spread.

Currently, due to the development of MRI, the need for this technique has been significantly reduced.

Perfusion CT . A method that allows you to evaluate the time and volume indicators of the perfusion of the brain substance by assessing the dynamics of its passage through the vessels of the brain.

To perform CT perfusion, a rapid intravenous injection of a contrast agent in a volume of about 50 ml at a rate of 8-10 ml/sec is necessary.

The advantage of this method is the rapidity of the study, which makes it a valuable method for diagnosing emergency conditions, such as ischemic stroke. The disadvantage of the method is the need to use a contrast agent and limit the length of the study area.

Perfusion CT is most often used in the diagnosis of acute cerebrovascular accidents. In neurooncology, perfusion CT makes it possible to assess the degree of vascularization of a neoplasm and the characteristics of its blood supply, as well as the effect of preoperative tumor embolization.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is one of the main methods for studying the structure of the brain. On MRI tomograms, the structural elements of the brain are more clearly distinguished, white and gray matter, all stem structures are more clearly differentiated. In this case, it is possible to obtain both axial and frontal, sagittal and oblique layers. Along with the layered image, with MR examination, it is possible to reconstruct the three-dimensional display and anatomical orientation in all structures of the skull and brain. A special advantage of MRI is the absence of radiation exposure during the study. The standard examination of the brain includes the mandatory acquisition of T1- and T2-weighted tomograms (Fig. 1).

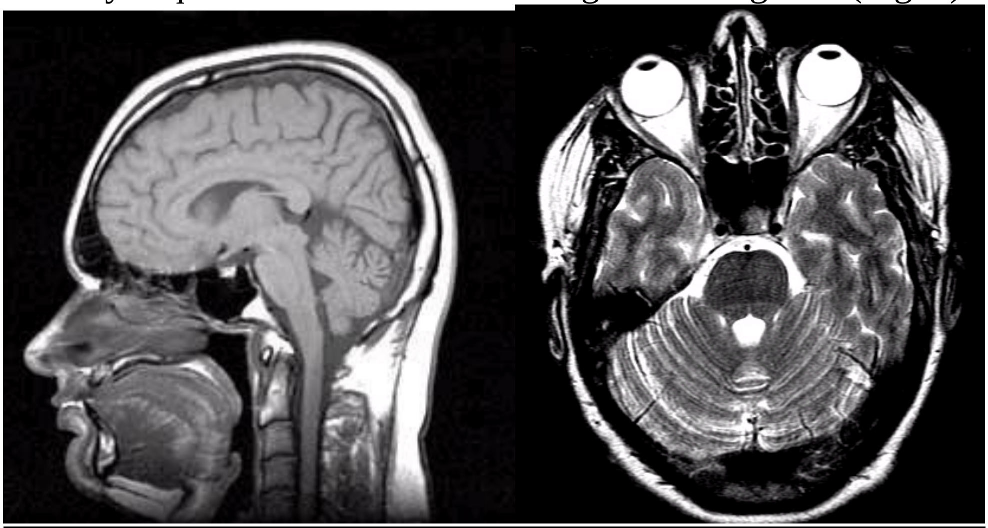

Fig.1. Normal MRI of the head in sagittal and axial projections.

Magnetic resonance angiography

The most important feature of MRI is the possibility of obtaining images of arterial and venous vessels of the brain without the use of contrast agents (Fig. 2).

With MR angiography, it is possible to visualize the main arteries, including the main trunks of the internal carotid, vertebral arteries and their intracerebral segments, as well as superficial and deep veins, including the meningeal veins, the direct and transverse sinus, the superior sagittal sinus and the veins flowing into it, and also the sigmoid sinus and the whole group of basal sinuses. Visualization of the venous system with MR phlebography is an important diagnostic link in the diagnosis of volumetric pathological formations of the brain and allows you to assess the relationship of sinuses, veins with neoplasms. Therefore, it is advisable to combine the performance of MR angiography with MR phlebography in case of suspected cerebral neoplasm or in differential diagnosis with vascular malformations. In cases of cerebrovascular accident, MR angiography makes it possible to establish abnormalities in the extra- and intracranial arteries.

The possibility of obtaining images of cerebral vessels without the introduction of a contrast agent, knowledge of the normal anatomy of the arterial and venous systems of the brain and their structural variants during MR angiography greatly simplifies the diagnostic algorithm.

Рис.2. Нормальная МР-ангиография головного мозга.

<u>Diffusion and perfusion MRI</u>

Diffusion MRI makes it possible to differentiate zones of fast and slow diffusion of protons. At the same time, zones with rapidly moving protons (with less diffusion restrictions, for example, during the acute period of ischemic stroke) have a higher signal compared to unaltered brain tissue.

Most often, diffusion-weighted MR images are used for early diagnosis of ischemic damage to the brain substance, as well as for assessing the dynamics of stroke. The ischemic zone begins to be visualized approximately 45 minutes after the occlusion of the great vessel.

Perfusion MRI allows assessing tissue perfusion by comparing the dynamics of the passage of a paramagnetic contrast agent through the substance of the brain. It allows you to calculate the temporal characteristics of cerebral blood flow.

<u>Functional MRI</u>

This technique makes it possible to identify areas of neuronal activation that occur in response to various motor, sensory, and other stimuli. Obtaining a map of the functional activity of the brain is based on the BOLD effect, which makes it possible to evaluate the perfusion of the brain substance by the ratio of oxyhemoglobin and deoxyhemoglobin, which have different magnetic properties. The use of functional MRI in patients with brain tumors makes it possible to determine the sensorimotor zone of the cortex.

<u>Proton MR spectroscopy (PMRS)</u>

PMRS is a method that uses magnetic resonance phenomena to identify individual chemical compounds.

PMRS is based on the registration of a "chemical shift" and allows you to evaluate the content of individual chemical compounds (N-acetylaspartate, choline-containing, creatinine, lactate, alanine, myoinositol, etc.) in certain areas of the brain. So, with neoplasms of a high degree of malignancy, there is a tendency to an increase in the content of choline, a decrease in the ratio of N-acetylaspartate to creatinine, and an increased content of lactate can also be recorded.

With regard to clinical practice, the use of PMRS is appropriate for differential diagnosis between neoplastic, demyelinating and infectious lesions, as well as for dynamic monitoring in order to detect recurrence or continued tumor growth.

Radionuclide method

Single photon emission computed tomography.

The principle of operation of SPECT is based on the registration of photons emitted by an isotope. Data on the distribution of the isotope in the brain are recorded by a detector rotating around the patient's head. In addition, you can get "sections" of the brain, as in CT and MRI.

The radiopharmaceuticals based on the following isotopes are currently the most widely used in brain studies using SPECT: Xe , I , mTc , In , Tl . They have a number of common properties: they penetrate well through the blood-brain barrier, are distributed in the brain in proportion to the blood flow, and stay in it for a time sufficient to obtain an image.

The radiopharmaceuticals, depending on the purpose, are divided into several groups:
-used for the study of cerebral perfusion (Ce retec);
-tumorotropic radiopharmaceuticals (T l chloride);
-neuroreceptor ligands, i. e. agents that specifically bind to various receptors in the brain.

A new direction that is currently developing intensively is called immunoscintigraphy with labeled monoclonal antibodies (CEA- scan , Verluma) to a certain type of tumor and the development of radiopharmaceuticals based on labeled peptides (Neospect).

Positron emission computed tomography-

a method of radioisotope diagnostics based on the use of radiopharmaceuticals labeled with isotopes, positron emitters.
PET allows to obtain functional images that reflect the life processes of the brain, including glucose metabolism and oxygen utilization, assessment of blood flow and perfusion. Like CT and MRI, PET uses a tomography technique that allows you to obtain sections in various planes.

Unlike CT and MRI, PET evaluates functional changes at the level of cellular metabolism. This is very important, since changes at the functional cellular level often precede morphological changes. Therefore, many diseases are diagnosed with PET much earlier than with CT and MRI.

PET uses radiopharmaceuticals labeled with oxygen, carbon, nitrogen, glucose, which are natural metabolites of the body and are included in the metabolism on an equal footing with their own endogenous metabolites: sugar, water, proteins, oxygen. As a result, it becomes possible to assess the processes occurring at the cellular level.

The most common radiopharmaceutical for PET is fluorodeoxyglucose (FDG). The relatively long half-life (110 minutes) allows its production to be located separately, transporting the resulting radiopharmaceutical to several nearby PET centers. In addition to FDG, other radiopharmaceuticals can be used in PET: C-methionine, C-tyrosine, C-sodium butyrate with a shorter half-life.

Combined PET-CT allows you to simultaneously obtain data on the presence of anatomical (CT) and functional (PET) changes in the brain.

In general, the radionuclide method in neurology and neurosurgery has now become a necessary addition to other radiation studies, allowing you to obtain important diagnostic information about the functional state of the brain.

Ultrasound procedure

Ultrasound methods allow you to visualize the vessels (pulsation and width of the lumen) and assess the degree of stenosis.

Currently, the most effective method for diagnosing vascular lesions is *duplex scanning* , which combines real-time ultrasound scanning to assess the anatomical structure of the artery with pulsed Doppler analysis of blood flow in the vessel lumen of interest.

Duplex scanning, although non-invasive and widely available, requires sufficient experience and constant comparison of the results with subsequent angiography data to ensure the accuracy of stenosis measurements and avoid errors.

Duplex sonography is a screening method for selecting patients with ICA stenosis or occlusion for catheterization angiography and angioplasty.

Transcranial dopplerography is a non-invasive research method that can be used to obtain information about the speed of blood flow and its direction in the intracranial arteries.

Transcranial ultrasound is often difficult in adults due to the low permeability of the temporal "windows". Transtemporal access allows full visualization of cerebral vessels. Nevertheless, in some cases, it is possible to visualize intracranial volumetric formations through intact skull bones (with a significant size of the neoplasm, its high echogenicity, good permeability of the temporal "windows").

Ultrasound examination through a trepanation defect is much more informative than transcranial scanning, especially in identifying changes that lie in the projection of the defect. Visualization through a trepanation defect allows to identify local postoperative complications (hemorrhage in the bed of the removed tumor, intracranial hematomas, ventricular hemotamponade, etc.), to assess the severity of edema, "mass effect", dislocation phenomena and hydrocephalus.

The advantages of the method include its ease for the patient and the speed of execution, however, the ultrasound method does not always provide sufficient diagnostic information and often its results are the reason for more informative studies.

Radiation semiotics of brain diseases

Tumors of the brain.

The leading methods of radiation diagnosis of brain tumors are CT and MRI. The blood supply of tumors is specified during cerebral angiography. The radionuclide method (SPECT and PET) allows you to clarify the malignancy of the process.

CT and MRI diagnostics of brain tumors is based on the identification of direct and indirect signs.

CT: direct signs - detection of pathological formations with a change in density in the substance of the brain: an increase, decrease in density or without its change. Direct CT signs include the detection of areas of pathological calcification.

MRI: direct signs include the detection of pathological formations with varying degrees of intensity of MR signals: an increase in the (hyper-) intensity of the MR signal; lowering (hypo-); without changing the intensity (isointensity).

Indirect signs:

- displacement (lateral dislocation) of the median structures of the brain ("mass effect");
- displacement, compression and change in the size of the ventricles;
- blockade of the CSF pathways with the development of occlusive hydrocephalus;
- narrowing, displacement and deformation of the basal cisterns of the brain;
- swelling of the brain, both near the tumor and along the periphery.
- axial dislocation (estimated by the deformation of the enclosing tank).

The density of the tumor can be increased compared to the density of the surrounding brain tissue as a result of hemorrhages or deposition of calcium salts in the tumor tissue. These changes are characteristic, first of all, for tumors of the meningovascular series. A decrease in density is observed due to the content of a large amount of water or fat-like substances in the tumor. The heterogeneity of the tumor structure is characterized by alternating areas of increased density (hemorrhages and calcifications) against the background of low density of the tumor itself. The tumor density may not differ from the surrounding brain tissue. Edema, which captures the white matter of the brain, is characterized by a zone of reduced density around the tumor.

CT and MRI contrast assesses the change in density (MR signal intensity) of tumors after contrast. Richly vascularized tumors intensively accumulate a contrast agent.

PET: malignant tumors are characterized by increased accumulation of radiopharmaceuticals compared to normal tissue.

Cerebral angiography: signs of brain tumors are divided into general and local. Local angiographic signs include: the tumor's own vascular network; the presence of vessels draining the tumor. Common angiographic signs of tumors include hydrophilic expansion of cerebral vessels and displacement of the anterior cerebral artery in the opposite direction.

Craniography:

а) local direct changes (tumor calcification);

б) local indirect changes due to the direct effect of the tumor on the bones of the skull;

в) general changes due to intracranial hypertension.

Direct local signs include calcification of the tumor itself. Calcification in meningiomas on craniograms is presented in a variety of ways: either in the form of fine-grained shadows, conglomerates, or stripes with dotted inclusions, or an amorphous cloud-like shadow, complete ossification of the tumor is rarely noted.

With gliomas, a different type of calcification is also observed. Oligodendrogliomas are characterized by calcification in the form of linear and amorphous shadows; linearity is explained by calcification of vessels in these tumors.

Local indirect changes on craniograms include hyperostosis, sclerosis, destruction, atrophy of the bone from pressure, corresponding to the location of the tumor.

General (secondary) - changes in the structure, shape and size of the Turkish saddle, due to its osteoporosis. As hypertension develops, the back shortens, osteoporosis spreads to the bottom of the Turkish saddle, the entrance to the saddle expands, the posterior parts of the bottom of the Turkish saddle and the back move down. In addition, common signs on craniograms can be determined in the form of divergence of cranial sutures, deepening of digital impressions.

Demyelinating diseases.

Demyelination is the process of destruction of normally formed myelin, which can be caused by many different agents - infections, ischemia, toxic effects, autoimmune processes.

Pathological changes are reduced to the progressive destruction of normal myelin and myelin-producing oligodendrocytes. Areas of demyelination and gliosis are localized around small veins, forming plaques. Edema is observed around the plaques in the acute phase. The disease proceeds with periods of deterioration and remission of neurological symptoms, or it is constantly progressing.

MRI: Demyelination lesions are hyperintense on T2 images. On T1-WI, only 20% of lesions are visible, which reflect the complete destruction of myelin. The size of the foci is often up to 5 мм, sometimes they merge and increase in size. Localization - white matter of the brain. The plaques are usually located paraventricularly.

A sign of the activity of the process is a moderate increase in the MR signal from the foci: a nodal homogeneous increase indicates a new plaque, and an increase in the signal in the form of a "ring" means reactivation of the old plaque.

CT: demyelination processes are accompanied by a decrease in X-ray density due to excessive hydration of pathologically altered tissues. Demyelination often ends in severe atrophy.

Encephalopathy.

CT, MRI: small foci of hyperintense signal on T2 images and low density on computed tomograms, localized in the periventricular parts of the brain, less often in the basal ganglia. In addition, signs of dyscirculatory encephalopathy are the identification of varying degrees of atrophic changes in the brain in the form of expansion of the ventricular system and subarachnoid spaces with excessive accumulation of cerebrospinal fluid.

Ischemic stroke (brain infarction).

Ischemic stroke is a zone of necrosis formed as a result of persistent metabolic disorders in neuronal and glial structures, due to insufficient blood supply, thrombosis or embolism of the cerebral arteries (Fig. 3a).

CT: in the acute stage, the processes of ischemia, necrosis and edema of the brain tissue are characterized by zones of reduced density.

CT angiography allows assessing the condition of the vessels (lumen and condition of the walls) (Fig. 3b).

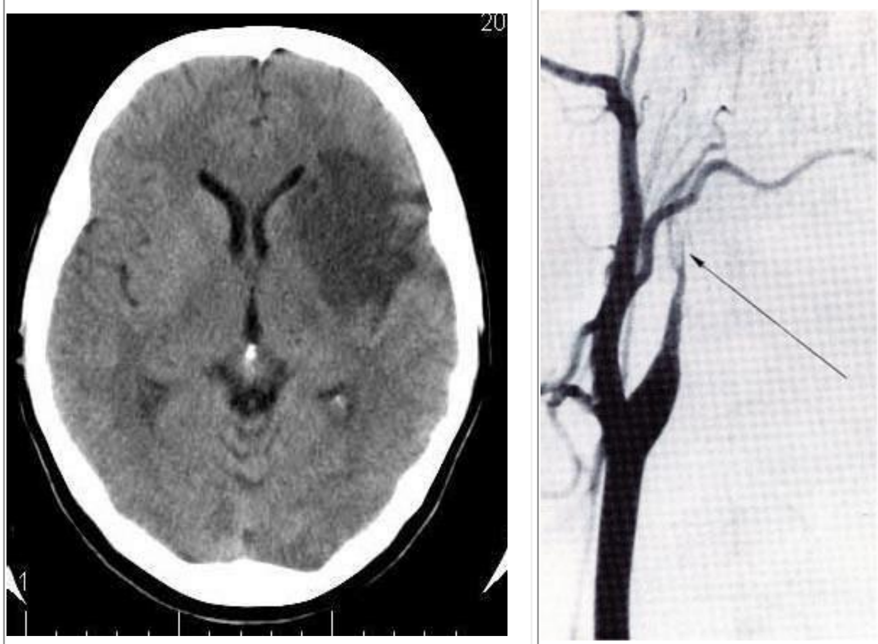

Fig. 3. (a, b)

but. CT scan of the brain with ischemic stroke in the pool of the left middle cerebral artery (center of hypodense density in the left parietal and temporal lobes and in the subcortical nuclei on the left).

b. Angiography of the same patient (critical stenosis of the left internal carotid artery leading to ischemic stroke).

MRI native: focal amplification of the signal on T2-WI. The zone of hyperintensity tends to increase, which reflects the expansion of the infarction zone.

MR angiography : complete occlusion of a vessel, or reduced blood flow in the affected vessel.

MR diffusion and MR perfusion are the earliest changes reflecting the development of the ischemic process in the brain. Characterized by an increase in the MR signal and a decrease in the diffusion coefficient, as well as an increase in the average transport time and peak of the contrast agent compared to the opposite hemisphere of the brain.

intracerebral hemorrhage

Spontaneous intracerebral hemorrhage can develop with arterial hypertension, rupture of an arterial aneurysm, or arteriovenous malformation. Hemorrhages can be observed in ischemic strokes, tumors or metastases.

Visualization of intracerebral hemorrhage, depending on the stage of the process, is different with CT and MRI. Fresh hemorrhage is better visualized with CT, in the subacute stage and the stage of organization - with MRI.

CT: fresh hemorrhage (Fig. 4) is characterized by high density (60-80 HU).

MRI: on the first day, the diagnosis of hemorrhage using MRI is difficult, since the signal from the blood is isointense to that from the surrounding white matter on both T1 and T2 tomograms. This is due to the fact that oxyhemoglobin does not have paramagnetic properties.

In the acute stage (up to 2 days), the hematoma on T1-WI looks isointense, and on T2 - with a low signal, therefore, in the acute period of hemorrhage, CT is preferable, in which a fresh hematoma has increased densitometric parameters.

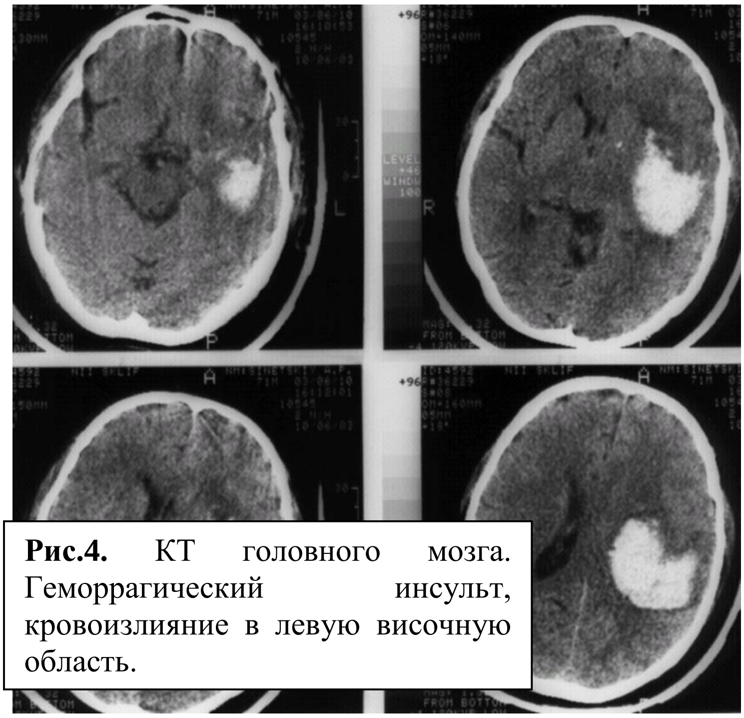

Рис.4. КТ головного мозга. Геморрагический инсульт, кровоизлияние в левую височную область.

Infectious diseases

Pathogens: bacteria, viruses, protozoa.

brain abscesses

CT: round or oval low-density pathological mass with an isodense capsule.

MRI: on T1-WI, the abscess cavity is hypo- or isointense, the capsule is hyperintense, on T2, the abscess is hyperintense.

CT, contrast MRI: a clear enhancement of the abscess capsule.

Meningitis

CT, MRI: leptomeningeal enhancement and concomitant involvement in the process of the brain.

Encephalitis

CT: changes are not specific. With herpes encephalitis, small hemorrhages can be detected.

MRI: nonspecific foci of increased MR signal on T2.

Tuberculous encephalitis is characterized by the presence of abscesses, granulomas, or the presence of a miliary form. Increases the efficiency of diagnostics contrast enhancement.

empyema

<u>*CT, MRI:*</u> the presence of accumulations (pus) in the subdural and epidural spaces. Empyema is a consequence of the spread of the infectious process from the paranasal sinuses.

Parasitic diseases (cysticircosis, echinococcosis, toxoplasmosis)

<u>*CT, MRI:*</u> with cysticircosis, intracerebral and meningeal cysts containing calcifications are detected. With toxoplasmosis, multiple small nodules are determined in the basal ganglia of the brain, in the cerebral hemispheres.

Brain damage

Shake

<u>*Computed tomography and magnetic resonance imaging*</u> usually do not show signs of changes in the density (CT) or intensity of the MR signal (MRI) of the brain tissue. The dimensions of the ventricular system and cisterns of the base of the brain were not changed. At the same time, in some cases, local expansion of the basal or convexital subarachnoid sulci up to 8- can be observed 15 мм, which indicates an acute violation of the circulation of cerebrospinal fluid in the subabdominal spaces.

Injury

<u>*On CT*</u> , brain contusions can be displayed as foci of different density, both increased (Fig. 5), low and mixed, and <u>*on MRI*</u> , by a change in the intensity of the MR signal of varying degrees. On craniograms with bruises of the brain, various skull fractures can be detected. <u>*Angiographically*</u> , brain contusions are characterized by various types of dislocation of the main vessels.

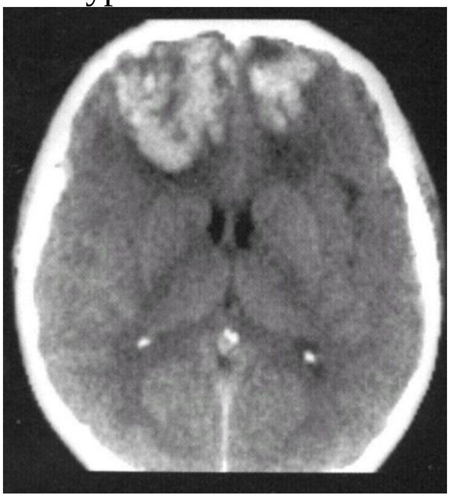

Рис. 5. КТ головного мозга. Ушиб головного мозга тяжелой степени, внутримозговые гематомы обеих лобных долей.

compression

The most common causes of brain compression in blunt traumatic brain injury are intracranial hematomas and hydromas. Less common are compression by bone fragments and the development of traumatic cerebral edema.

Craniographic diagnosis of intracranial hematomas is based on the identification of indirect radiological signs. These signs primarily include the displacement of physiological calcifications, primarily the pineal gland.

Epidural hematomas

Occur with fractures of the skull bones with damage to the meningeal arteries, less often - diploic veins, venous sinuses or pachyon granulations.

CT and MRI: biconvex, plano-convex or, much less often, crescent-shaped zone of altered density (on CT) and MR signal (on MRI), adjacent to the calvaria (Fig. 6).

Pathognomonic signs: displacement of the border between the white and gray matter of the brain (in the absence of edema) and the displacement of the brain from the inner sheet of the dura mater at the edges of the hematoma adjacent to the bones of the skull. On CT, acute epidural hematomas usually have an increased density. Reduced density is characteristic of hematomas containing fresh unclotting blood.

Cerebral angiography: displacement of vessels located on the convex surface of the cerebral hemisphere from the adjacent area of the inner surface of the skull with the formation of an avascular zone (a symptom of the border).

Рис. 6. КТ головного мозга. Острая эпидуральная гематома в левой затылочной области с дислокацией головного мозга и его сдавлением.

Subdural hematomas

With a closed craniocerebral injury, subdural hematomas most often occur when the pial vessels and veins that flow into the sinuses of the brain rupture.

CT, MRI: foci of a convex-concave (lunate) shape with an uneven inner surface, repeating in its outlines the relief of the brain in the area of hemorrhage. Important differential diagnostic signs of acute subdural hematomas are a significant area of hemorrhage, sharp edges of the hematoma, a tendency to spread into the sulci and subarachnoid fissures, the absence of symptoms of displacement of the boundary between the white and gray matter, as well as the displacement of the brain from the inner layer of the dura mater. On CT, the density of acute subdural hematomas is in the range of +65 +73 HU (Fig. 7).

Cerebral angiography: avascular area, displacement of the anterior cerebral artery in the opposite direction. The severity of dislocation changes in vessels depends on the volume, localization of the hematoma and the time elapsed after the injury.

Рис. 7. КТ головного мозга. Острая субдуральная гематома в правой лобно-теменной-височной области с дислокацией головного мозга и его сдавлением

Subarachnoid hemorrhages

MRI: hyperintense signal on T2-WI.

CT: increased density of cerebral cisterns and blood clots in the subarachnoid space.

Intracerebral hematomas

CT: high-density (+65 +75 HU) homogeneous foci of round or oval shape with fairly even contours. A characteristic feature is the presence around them of a narrow strip of low density, due to the accumulation of plasma separated from the blood clot during its retraction.

MRI: the image of intracerebral hemorrhage has its own characteristics, due to the stage of the process. Acute hematoma is isointense with gray matter on T1 and hyperintense on T2 scans. On the following day, on T1 tomograms, the hematoma remains isointense with respect to the substance of the brain, and on T2 tomograms, the hyperintense signal changes to a low one. In the subacute stage, there is an increase in the intensity of the MR signal on T1 tomograms along the periphery of the hematoma with a gradual spread to the center.

Cerebral angiography: displacement of large arterial vessels with the expansion of their branches and the formation of an avascular zone between them.

RADIATION DIAGNOSIS OF DISEASES SPINAL CORD

Methods of radiation diagnostics

The main methods of radiation diagnostics in vertebrology are MRI and CT. This is due to the fact that these methods are the most informative in the diagnosis of many diseases and injuries. In connection with their development, the traditional X-ray method has faded into the background, but in many cases retained its paramount importance.

X-ray contrast techniques for the study of cerebrospinal fluid spaces of the spinal cord

In order to identify changes in the spinal cord and other anatomical structures of the spinal canal, a number of contrasting methods for studying the cerebrospinal fluid spaces of the spinal cord, venous plexuses, and epidural tissue have been proposed. The most widely used in neurological and neurosurgical practice is *pneumopyelography* (contrast study of the cerebrospinal fluid spaces of the spinal canal using gas) and *positive myelography* (instead of gas, contrast agents are injected endolumbally - omnipaque, ultravist). Currently, contrast methods for studying the cerebrospinal fluid spaces of the spinal canal have become much less frequently used due to the introduction of MRI and spiral CT into clinical practice.

Pneumopyelography. At present, contrasting of subarachnoid spaces at any level of the spinal cord is performed by lumbar injection of 40-60 ml of oxygen or air. Before the introduction of gas, the head end of the x-ray table is lowered. Depending on the purpose of the examination and the level of the block of the subarachnoid space to be examined, the gas moves when the angle of the X-ray table changes.

Pneumopyelographic diagnosis of pathological processes in the spinal canal is based on the assessment of deformities, local compressions or expansions of the subarachnoid spaces in various tumors of the spinal cord. Obliteration of subarachnoid spaces in a limited area occurs with adhesive arachnoiditis. Concentric compression of the subarachnoid spaces is characteristic of epiduritis. On pneumopyelograms, a picture of a complete block of the subarachnoid spaces caused by a tumor or an inflammatory process can be detected.

Currently, this research method is used extremely rarely due to the greater informativeness of positive myelography, especially MRI and non-contrast MR myelography.

Positive myelography. Currently, for positive myelography, water-soluble contrast agents (omnipaque, ultravist) are used, which have a higher specific gravity than cerebrospinal fluid. By changing the tilt of the x-ray table, the contrast agent is moved cranially when introduced into the final tank - *ascending myelography* . By injecting the drug into the cisternus magnus and raising the head end of the table, the contrast agent will sink down, which is called *a descending myelography* .

After endolumbar injection of a contrast agent, myelograms are performed in frontal, lateral and oblique projections. Normally, the dural sac and subarachnoid spaces extend to the level of the second or third sacral vertebrae. On myelograms in the lateral projection, the contrast agent outlines the anterior wall of the spinal canal, while the posterior sections of the unchanged disc protrude somewhat posteriorly in relation to the posterior surfaces of the vertebral bodies. Posterior disc prolapse reveals filling defects along the anterior contour of the contrast medium column at the level of the affected discs. Epiduritis is characterized most often by circular compression of the contrasted dural sac. With a tumor, a filling defect or a complete block of subarachnoid spaces (the lower border of a volumetric formation) is detected.

X-ray computed tomography

The helical scanning technology makes it possible to obtain accurate images of the structures of the spine, despite their different ability to absorb X-rays (absorption coefficient) throughout the scan. This includes soft tissues of the paravertebral region, bone structures with trabecular and cortical layers, tissues of the spinal canal, including adipose tissue, soft tissue structures of the spinal cord, nerve roots, cerebrospinal fluid.

To enhance the image in order to increase the diagnostic information content, intravenous administration of a radiopaque substance (omnipaque, ultravist) fractionally or bolusally, as well as endolumbally, can be used.

Computed tomograms of the vertebra clearly show: its body, spinal canal, outlines of the dura mater of the spinal cord, articular processes of the vertebrae, spinous and transverse processes. Computed tomography allows to determine the location and extent of a vertebral fracture, the presence and location of bone fragments and their relationship to the spinal canal. Osteophytes, bone tumors are clearly seen. The use of CT allows visualization of posterior prolapse of the intervertebral discs. Obtaining images of the spinal cord using CT is difficult due to the low information content of the method even after the introduction of a radiopaque substance.

Computed tomography myelography

In order to better visualize the structures of the spinal canal, CT myelography is performed. At the same time, either in the department or directly on the tomograph table, the patient is given a lumbar puncture, 5-7 ml of liquor is removed, and the same amount of a non-ionic water-soluble contrast agent is injected into the subarachnoid space.

On CT myelographic examination, against the background of subarachnoid spaces filled with a contrast medium, the contours of the spinal cord are well visualized. It seems possible to estimate the size of its diameter, location in the spinal canal, the width of the subarachnoid spaces.

All patients undergo a secondary reconstruction of the image in the sagittal and frontal planes, since this creates conditions for better visualization of spinal canal deformities, assessment of the state of the subarachnoid spaces of the spinal cord throughout the studied segments.

The main advantage of this technique is the ability to determine the patency of the subarachnoid space, as well as to assess the degree of displacement of the subarachnoid space and spinal cord.

Magnetic resonance imaging

Regardless of the technical features of the equipment, it is mandatory to obtain T1- and T2-weighted tomograms of the examined spine in the sagittal plane. In the future, depending on the pathology detected on the sagittal sections, sections are performed in the axial or frontal plane at the level of the lesion.

MRI image of the spine and spinal cord is normal.

The image of the structures of the spine and spinal cord is best seen on T1-WI. At the same time, the spinal cord on tomograms in the sagittal plane has a uniform high intensity of the MR signal against the background of a hypointense signal from the subarachnoid space and ligamentous apparatus. Its contours and location in the lumen of the spinal canal are clearly visualized.

On T2-WI, the spinal cord, as well as the bone marrow of the vertebral bodies and the ligamentous apparatus, have a hypointense MR signal. The cerebrospinal fluid has a pronounced hyperintense signal. The central part of the intervertebral discs also has a high MR signal compared to the spinal cord due to the high content of hydrogen protons. The outer part of the annulus fibrosus forms the peripheral hypointense part of the disc. The thickness of the spinal cord is not the same, the largest in the region of the lumbar enlargement.

Axial MRI scans show that the spinal cord consists of gray matter located in the middle and white matter along the periphery.

A horizontal line is visualized in the posterior part of the vertebral bodies with a hypointense signal on T1 and hyper on T2-weighted images, indicating the presence of veins and venous plexuses (MR signal from a slowly flowing fluid).

Parasagittal images visualize facet joints formed by the superior articular process of the overlying vertebra and intervertebral foramina filled with fat with a hyperintense signal. Against the background of this signal, the spinal nerve exiting through the intervertebral foramen is clearly visualized.

On axial MRI, the contents of the dural sac and surrounding structures are clearly visualized. The intervertebral canal is clearly visible. Against the background of a bright signal from fat located in the intervertebral foramina, the roots are clearly visualized.

MR myelography is a technique for visualizing the structures of the spinal canal without the introduction of a contrast agent, based on obtaining a signal from the cerebrospinal fluid, when the signal from bone structures and soft tissues is suppressed.

On MR myelograms, the dural sac with its contents is clearly visualized. The main indications for MR myelography are pathological conditions that cause compression, deformation, and defects in the filling of the dural sac and subarachnoid spaces. Such conditions include herniated discs, extra- and intramedullary tumors, traumatic injuries of the spine and spinal cord.

Radionuclide method

For radionuclide studies of the spine, radiopharmaceuticals based on technetium (99 m Tc). This is due to the relatively low radiation exposure, high quality of the obtained images, high information content of the study, as well as the possibility of conducting studies in dynamics. These include: pirfotech and technefor labeled with technetium (99 m T s).

Scintigraphy is carried out on a two-detector gamma camera, which allows obtaining two projections of images simultaneously (anterior and posterior), three hours after intravenous administration of a radiopharmaceutical at a dose of 500 MBq.

SPECT is carried out with the subsequent construction of three-dimensional reconstructions.

Indications for the use of radionuclide scintigraphy of the spine and skeleton are primary metastatic tumors, systemic lesions and inflammatory diseases. Radionuclide scintigraphy is considered the best screening method for patients with suspected spinal metastases.

Radiation semiotics of diseases of the spinal cord, spinal cord tumors

In relation to the spinal cord, tumors are divided into two groups:

1) intramedullary, located inside the substance of the spinal cord;
2) extramedullary, growing outside the spinal cord and its roots.

intramedullary tumors

MRI: the most informative method in the detection of intramedullary tumors. MRI diagnostics is based on the detection of pathological formations of varying intensity of the MRI signal in the lumen of the spinal canal. MRI allows you to establish the true boundaries and prevalence of tumors. MRI diagnostics is based on the detection of pathological formations of varying intensity of the MRI signal in the lumen of the spinal canal. MRI allows you to establish the true boundaries and prevalence of spinal cord tumors: on tomograms in the sagittal and frontal (coronal) planes, the upper and lower poles of tumors are visualized. Anterior-posterior extension of the tumor is best seen on tomograms in the axial or sagittal planes.

Intramedullary tumors are almost always accompanied by an increase in the volume of the spinal cord and perifocal edema. An increase in the transverse size of the spinal cord in the zone of the volumetric process causes a narrowing or blockade of the subarachnoid space. The tumor appears as an increase in the MR signal on T2 tomograms, on T1 it may not be visible due to the same intensity of the MR signal with normal tissue of the spinal cord, or it may have a slight decrease in the intensity of the MR signal.

Native CT: uninformative, since in most cases it is difficult to differentiate the isodense tissue of the tumor from the spinal cord.

CT contrast, CT myelography: a contrast agent delineates the boundaries of the tumor.

Spinal angiography reveals a richly vascularized tumor node with large adducting arteries.

Positive myelography: characterized by thickening of the spinal cord in the area of the tumor, the spread of a contrast agent in the form of thin stripes around the thickened spinal cord; with large tumor sizes, complete blockade of the subarachnoid space can be observed.

Spondylography: not informative.

Extramedullary tumors

A characteristic feature of this group of tumors is not thickening, but compression of the spinal cord with expansion of the subarachnoid space above and below the tumor.

MRI: the most informative method for diagnosing extramedullary tumors. The use of the contrast enhancement technique significantly increases the sensitivity of the method. MRI is characterized by: the presence of a nodule in the dural sac, deformation of the subarachnoid space, asymmetry of the position of the spinal cord in the spinal canal and its compression.

MRI contrast: tumors accumulate a contrast agent, which significantly improves the visualization of the structure of the tumor node and the prevalence of the neoplasm.

MR myelography allows you to assess the state of the dural space: the presence of narrowing or blockade of it, the location and size of the tumor.

The detection of multiple nodes on MRI, located both inside the spinal canal and outside it, may be a sign characteristic of neurofibromatosis (Recklinghausen's disease).

Native CT detects nodular dense (35-45 HU) formation in the dural sac, calcifications in the tumor, changes in the bone structure of the walls of the spinal canal in the form of sclerosis, hyperostosis, destruction, atrophy.

Contrast CT reveals an increase in density in the tumor.

CT myelography allows to clarify the compression of the spinal cord with a corresponding expansion of the subarachnoid space above and below the tumor. On CT myelograms, these tumors are visualized as a zone of a defect in the filling of the dural sac; deformation and displacement of the spinal cord by a volumetric formation are also detected.

Positive myelography: areas of filling defect in the subarachnoid space of the spinal cord with displacement and compression of the spinal cord.

Spondylography: symptoms of atrophy from pressure - an increase in the frontal diameter of the spinal canal due to atrophy of the roots of the arches (Elsberg-Dyck symptom); shortening of the root of the arc; expansion of the intervertebral foramen, deepening (excavation) of the dorsal surfaces of the vertebral bodies.

Demyelinating diseases

Of all the demyelinating diseases, multiple sclerosis is the most common. In the acute stage of the disease, all elements of inflammation and degeneration are determined.

The priority method of radiation diagnosis is MRI, although foci of demyelination can also be detected by CT, but much worse. Demyelination processes are accompanied by a decrease in X-ray density due to excessive hydration of pathologically altered tissues.

CT: Type I - focal decrease in density (0-15 HU) without accumulation of a contrast agent; Type II - isoplottic foci accumulate a contrast agent, but enhancement is most often delayed, and therefore CT should be performed no earlier than 10-25 minutes after intravenous administration of a radiopaque agent.

MRI: pathognomonic sign - detection of intramedullary plaques. Most often they are localized in the cervical spinal cord, less often in the thoracic. Multiple sclerosis plaques are better detected on T2-WI, on which they look like a hyperintense formation against the background of an unchanged spinal cord. In the active stage, in addition to plaques, local edema of the spinal cord is determined.

Contrast MRI allows you to establish the activity of the process by the degree of accumulation of the contrast agent and the number of plaques.

Inflammatory diseases

In the diagnosis of inflammatory diseases of the spine, the main role is assigned to radiation imaging methods. One of the main tasks is to determine the prevalence of the pathological process, the nature of destructive changes in the bone tissue, in the intervertebral discs and the epidural space, as well as the differential diagnosis of osteomyelitis and tuberculous lesions.

Inflammatory diseases of the spine and spinal cord according to localization are divided into intramedullary, extramedullary and extradural.

Intramedullary inflammatory diseases include, first of all, transverse myelitis. Transverse myelitis has, as a rule, a polyetiological origin: viral infection, acute disseminated encephalomyelitis, spinal cord sarcoidosis.

Native MR: fusiform expansion of the spinal cord with a decrease in the intensity of the MR signal on T1-WI and an increase on T2-WI.

Contrast MR: Moderate increase in MR signal intensity on T1-post-contrast WI, characteristic of inflammatory tissue.

Intradural extramedullary inflammatory diseases include: arachnoiditis, acute and subacute leptomeningeal infections.

Arachnoiditis

In the classic version, it is characterized by the presence of inflammatory adhesions, which involve the nerve roots and spinal cord.

MRI: compression, deformation of the roots of the nutria of the subarachnoid space, thickening of the membranes of the spinal cord, narrowing and heterogeneity of the structure of the subarachnoid space.

The most informative is the axial scanning plane with T2-VI.

Extradural inflammatory diseases include: specific and nonspecific spondylitis, osteomyelitis and discitis.