CHAPTER 8. IMAGING OF GASTROINTESTINAL TRACT AND ITS ACCESSORY DIGESTIVE ORGANS

8.1. Radiological examination of gastrointestinal tract

Radiological methods take leading positions in many-stage process of diagnosing digestive diseases. Among investigation techniques of the gastrointestinal tract (GT) x-ray examinations are still important in detection of morphological and functional changes in digestive systems.

Primary methods of diagnostics of gastrointestinal diseases are *radiographic contrast study* and endoscopy. Ultrasound, CT, MRI are additional methods.

The basic peculiarities of x-ray examination of GT:

1. Unlike examinations of bones and lungs, where most important information is provided with the help of radiography, detecting of GT diseases is based on the combination of fluoroscopy and filming.

Advantage of fluoroscopy:

- study of motor function of GT;
- choice of optimal projection, of the moment of filling and motor activity, and degree of compression for target images.

The fluoroscopy always supplemented by radiography for:

- visualization of shallow morphological details (1-4 mm);
- documenting of the detected modifications, including, rigidities zones of the wall.

In conditions of natural visibility, i.e. without application of contrast agents, only presence and allocation in the alimentary canal of gas, stones or foreign bodies absorbing X-rays can be estimated.

2. The basic method of roentgenological investigation of esophagus, stomach and intestine is injection of contrast agent into the cavity. Suspension of barium sulfate is used at the rate of 100 g of barium sulfate per 100 ml of boiled water.

The peroral contrast study is basic method at examination of esophagus, stomach and small bowel.

The main method of roentgenological investigation of colon and a rectum is retrograde contrast study (irrigoscopy). The peroral method is applied mainly for estimation of colon function.

Barium-containing drugs are contra-indicative for patients with suspicion of gastrointestinal perforation: getting in the abdominal cavity leads to severe peritonitis. In this case and in the early postoperative period water-soluble contrast agent is used at anastomoses imposed on the gastrointestinal tract. When there is risk of aspiration and fistulas in trachea and bronchi use nonionic contrast agent should be

used.

3. The important principle of examination of the alimentary canal is two-phase examination. The single-contrast gastrointestinal tract examination include barium filling and mucosal relief phases. The study of each department of the alimentary canal should be effected at its barium filling for definition of 1) position, 2) forms, 3) sizes, 4) contours, 5) ability to shift, and 6) functions of organ; and also at mucosal relief phase (barium-coated mucosa) – for study of mucosa folds. Sequence of these two phases is various for each department.

The preferred method for routine study is to use thicker preparation of barium and to distend the colon or stomach with gas (air-contrast or double conrast study). In the first situation, air is introduced through the rectal tube. In the second, gas-releasing preparation is ingested with the oral barium. The resulting study gives output, which is often sufficient to reveal subtle abnormalities.

4. Important condition of successful carrying out of examination is palpation and compression of organs with the help of special radiographic cones. All departments of the GT, except for esophagus and rectum, are studied with using dosed compression at various degrees of organs filling with contrast agent.

5. Another principle of GT examination is polypositional, or multiaxial. It includes the change of patient's position for definition of all walls of the investigated organ, its relationship with surrounding tissues.

CT has following priorities at GT examination:

- estimation of wall thickness of GT organs and its infiltration;
- detection of intramural and extraorganic pathological modifications.

Express procedure for CT of stomach and colon is the distension of walls by water (normal saline solution). Air, 2 % suspension of barium, water-soluble contrast agent is also applied.

Virtual colonoscopy is performed with the help of helical CT (fig. 8.1). CT can visualize invasion of a tumour to the wall of GT and condition of surrounding organs (fig. 8.2).

The angiography is applied at a gastrointestinal bleeding for define of indications for surgery treatment .

Ultrasound investigation of GT. The main purpose of transabdominal ultrasound is to identify diseases of parenchymal organs that clinically are similar to digestive diseases. It enables detection of intraperitoneal tumour, to ascertain its relations with GT, assess thickening of the stomach wall or bowel, detect metastases in the lymph nodes. Distension of stomach walls and colon with water (saline) is a special method GT ultrasound.

Anatomical layers of walls of digestive organs can be observed at intracavitary,

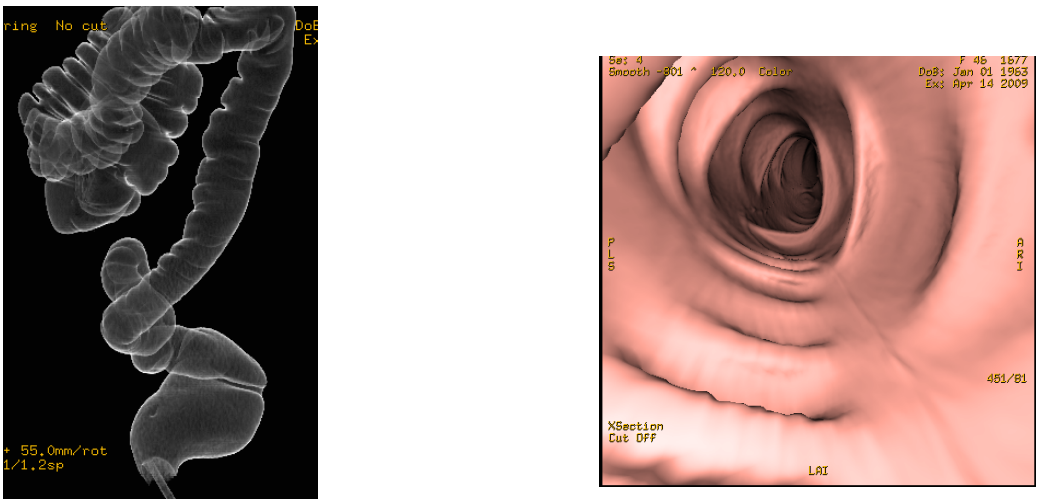

Fig. 8.1. Virtual colonoscopy. Left – 3 D reconsctruction, right – intraluminal 3 D reconsctruction. Norm

Fig. 8.2 Virtual colonoscopy. Axial slice. Narrowing of rectal lumen, non-uniform thickening of walls (arrow) with rough contours. Malignant tumour (adenocarcinoma) of rectum

transesophageal and endoscopic ultrasound unlike at CT. It is the advantage over other imaging methods in detecting of depth and extension of mural invasion.

MRI visualizes thickened wall of GT, but is worse than CT in spatial resolution.

Radionuclide methods of GT investigation. Its major area of investigation is estimation of motor-evacuation functions of a stomach. The information is represented as a series of scintigrams and the dynamic curves built from two regions of interest, usually, stomach and intestines.

Examination with the marked erythrocytes can reveal even minor gastrointestinal bleeding (0,1 ml / minute).

Radiological examination of esophagus. Diagnostics of esophageal diseases is complex. Radiological and endoscopic methods prevail.

Indications for radiologic examination of esophagus: 1) dysphagia; 2) foreign

body; 3) bleeding from the upper department of GT; 4) pain or compression mediastinal syndrome; 5) injury of mediastinal organs; 6) surgery or irradiation planning.

Examination will be carried out on an empty stomach. Survey fluoroscopy and radiography of thoracic and abdominal organs should be carried out for elimination of primary alterations in other organs. For the first stage of investigation standard fluid barium meal is used.

Radioanatomy. At examination 2-4 longitudinal parallel folds along the entire esophagus can be revealed (fig. 8.3).

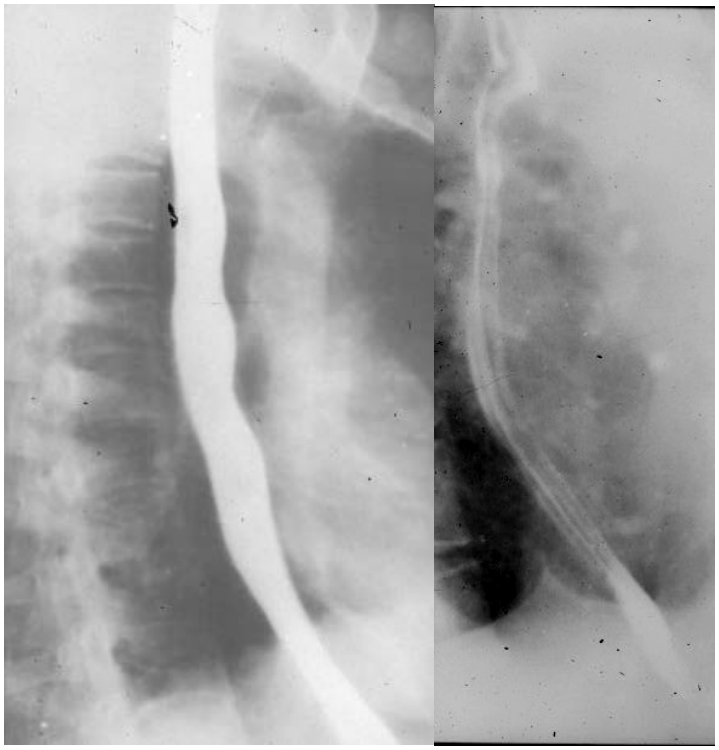

Fig. 8.3. Single-contrast esophagram. Normal esophagus. Left – barium filling. Right – barium-coated mucosa (mucosal relief)

The width of esophagus is 2 cm on average; behind the screen the following physiological strictures can be revealed:

1. Cricopharyngeal (pharyngoesophageal sphincter).
2. Aortic, which is caused by pressure of aortic arch.
3. Bronchial is caused by impression of left primary bronchus.
4. Diaphragmal is caused by esophageal compressure by cruras of diaphragm.
5. Cardial is caused by sphincter of cardiac orifice.

Velocity of fluid barium meal passing through the esophagus is 2-3 seconds, of barium paste – about 6 seconds.

The pharynx and esophagus are examined in direct, oblique and lateral positions. In direct position of the patient the cervical department of an esophagus is seen most well. In the first oblique position optimal conditions for examination of a

thoracal department of an esophagus, and in second oblique – a belly department of esophagus are created.

At esophageal examination the radiologist pays attention to:

- character of contrast mass passage;
- condition of contours and flexibility of walls along the whole length of esophagus.

In norm contours are smooth. The peristalsis is represented as surface wavy changes of esophageal contours.

At children during first 24 o'clock of their lives air fills entire GT, there is no air in GT after death.

Main radiological syndromes of diseases of alimentary canal:

1. Syndrome of organ dislocation.
2. Syndrome of alimentary canal narrowing:

а) diffuse narrowing;

б) local (limited) narrowing.

3. Syndrome of alimentary canal dilation:

а) diffuse dilation;

б) limited (local) dilation.

4. Syndrome of motor dysfunction of alimentary canal.
5. Syndrome of pathological modifications of mucosa relief.

Radiological signs of foreign bodies and diseases of esophagus.

There are the following radiological signs *of foreign body in esophagus* (fig. 8.4):

1. Shadow of a foreign body (contrast foreign bodies).
2. Filling defect (low-contrast foreign bodies).

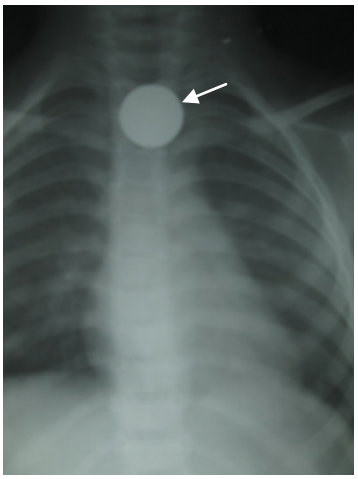

Fig. 8.4. Chest radiographs. Frontal view. Coin in upper thoracic part of esophagus (arrow) at the child aged 2,5 years. Foreign body

Diverticulums of esophagus are malformations (fig. 8.5). But there are also acquired diverticulums called traction. Local outpouching of esophageal shadow: if

the shadow is spherical, it is pulsion diverticulum; and if the apex of shadow is pointed, it is typically for traction diverticulum.

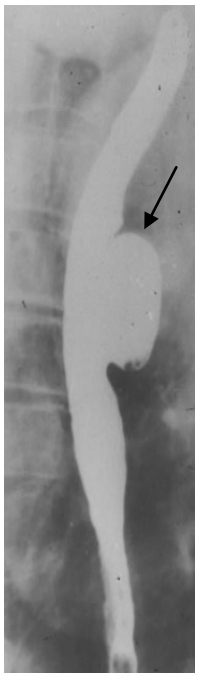

Fig. 8.5. Single-contrast esophagram. Diverticulum, esophageal. Anterior outpouching (arrow) of the esophagus with signs of posterior displacement of the esophagus

The achalasia is caused by spasm of cardiac orifice; relaxation of esophagus-gastric transition is disturbed. The radiological examination is the basis in diagnosing (fig.8.6). The sharp uniform growth of esophageal shadow, slow transition of barium into lower departments, symmetric funnel-shaped narrowing of esophagus with distinct contours is marked, which reminds of "a mouse tail" and does not open at swallowing. Disturbance of motor function can be well demonstrated with marked colloid.

Fig. 8.6. Radiograph of lower thoracic and abdominal departments of an esophagus (single contrast). Symmetric cone-shaped narrowing of abdominal department of esophagus with symmetric smooth contours, supra-stenotic enlargement is marked. Achalasia of esophagus

Cicatricical esophageal strictures are partial enlargement of shadow above narrowed area, usually found in region of physiological narrowings (fig. 8.7). In

differential diagnostics the fact of chemical burn is extremely important in anamnesis though some patients hide it.

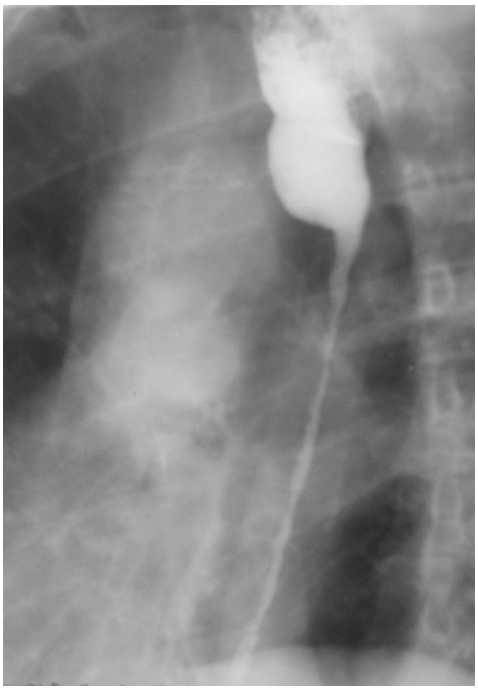

Fig. 8.7. Single-contrast esophagram in left oblique projection.There is a long, narrow stricture involving the mid and distal esophagus. Cicatrical esophageal stricture after chemical burn

The cancer of esophagus has the following radiological symptoms (fig.8.8): atypical mucosa relief, rigidity and narrowing of esophageal tube; defect of filling and unevenness, wavy contours; defect of filling and a niche; suprastenotic enlargement; regurgitation (reverse transport of contrast agent into higher departments). The most accurate methods for detecting stage of esophageal cancer are CT and endoscopic US, because the depth of involvement and enlargement of lymph nodes can be demonstrated.

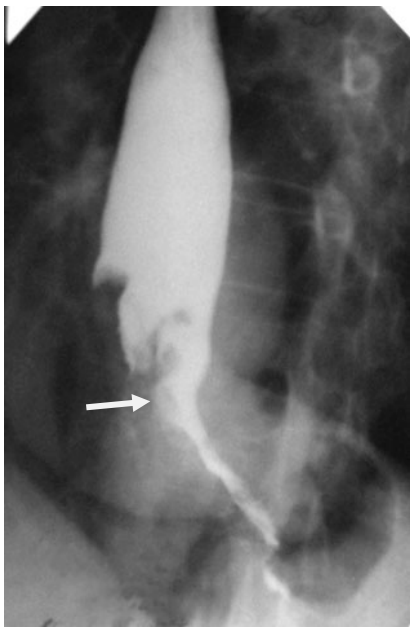

Fig. 8.8. Single-contrast esophagram in left oblique projection. Boundary filling defect is detected beginning from the bottom third of thoracic department of esophagus with rough contours (arrow), passing in circular narrowing in abdominal department. Suprastenotic dilation of esophagus. Cancer of oesophagus

Esophageal hiatal hernia. A hiatal hernia occurs when part of stomach pushes upward through diaphragm. Hiatal hernia is a kind of diaphragmatic hernia. Diaphragmatic hernia is a defect or hole in the diaphragm that allows the abdominal contents to move into the chest cavity. Diaphragm normally has a small opening (hiatus) through which esophagus passes on its way to connect to stomach. The stomach can push up through this opening and cause a hiatal hernia (fig.8.9).

Hiatal hernias are identified after detection of part of stomach or organ in thoracic cavity, above diaphragm. They present prolapse of stomach through esophageal foramen in posterior mediastinum. The main symptom of axial hernia is typical folds of mucous coat of stomach in the area of esophageal foramen of diaphragm which extend towards folds of subphrenic part of stomach. Another important symptom of axial hernia is shift of cardia section of stomach above the diaphragm. At acute hernia strangulation the x-ray usually is not carried out mainly because of grave condition of the patient. When strangulation of hernia of esophageal foramen is suspected, radiological examination should be carried out with the water-soluble contrast agent considering probable perforation of abdominal or esophageal wall.

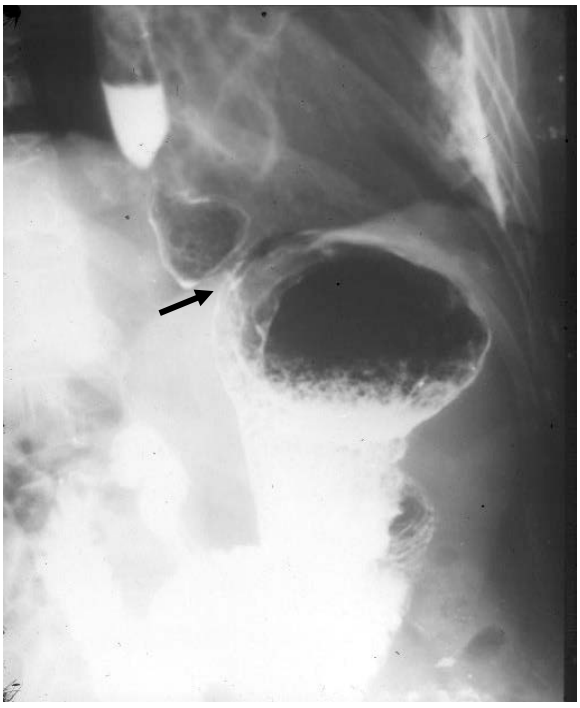

Fig. 8.9. Single-contrast esophagram. Penetration of stomach through hiatus esophagus in posterior mediastinumn (arrow)

Radiological examination of stomach. Indications: complaints about gastric discomfort.

Technique of examination. For roentgenological examination special preparation of patients is necessary, including the following steps: the day before examination for lunch the patient eats twice less than usually at the expense of

carbohydrates, but caloric value should be preserved. The supper should be also in usual time and it should include one glass of tea or coffee and a piece of bread and butter. Cleansing enemas are not necessary. In day of examination the patient should not eat, drink and especially smoke since nicotine produces abundant mucus discharge.

Examination of stomach begins after survey fluoroscopy of thoracic and abdominal cavities. Single-contrast study:

1. Mucosal relief. The folds can be: a) longitudinal – folds locating along lesser curvature; b) plexiform – short, sinuous, skew folds. The width of folds comprises 0,3-2,0 cm.

2. Barium-filled stomach (fig. 8.10.). The stomach can be shaped as a fishing hook or a horn.

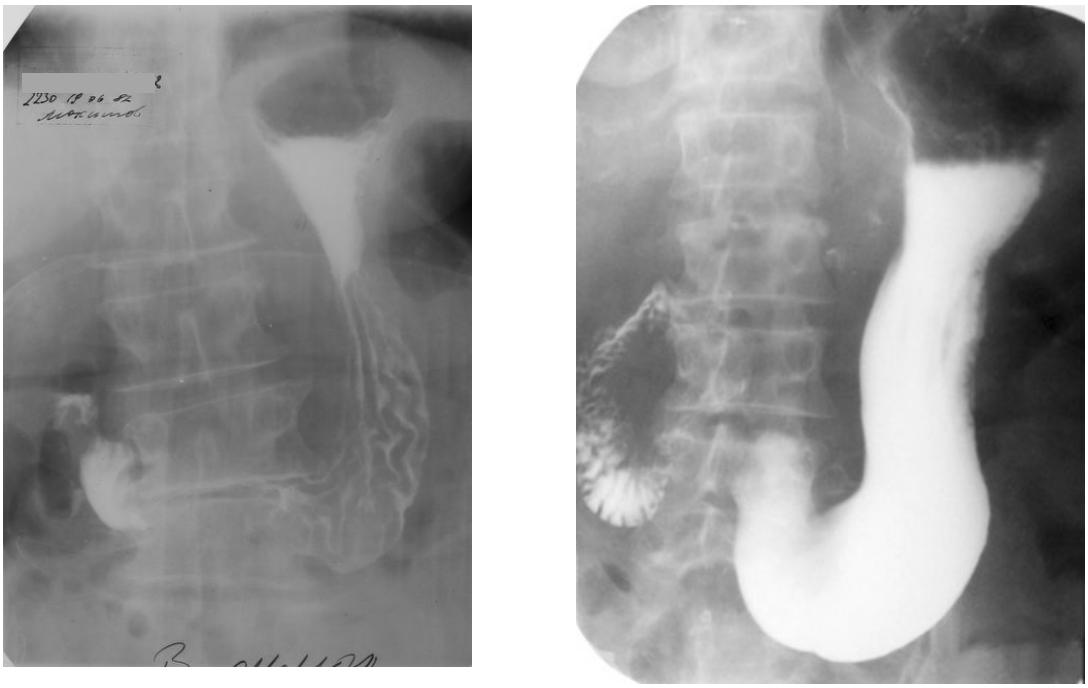

Fig. 8.10. Normal stomach. Left – barium-coated mucosa; right – barium-filled stomach

Position of stomach. Three quarters of stomach are in the left half of abdominal cavity, one quarter – in the right one. The inferior contour of stomach shadow at men ranges at the level of crista iliaca line or 3 - 4 cm higher; at women it is 3 - 4 cm lower than this line.

Image of stomach shadow. The shadow of the stomach filled with contrast mass is, as a rule, homogeneous. In its superior department gastric air bubble with distinct contours is usually visualized.

Contours of stomach shadow. Contours of lesser curvature should be always even, and those of greater curvature, as a rule, should be notched, which is stipulated

by transferring of mucosa folds from posterior wall to the anterior one.

Displaceability of stomach. The normal stomach easily displaces at deep abdominal breathing and it is revealed by changing of location, shapes and sizes. All this testifies preserved flexibility of walls and "loose" location in abdominal cavity.

Evacuation from stomach. The contrast mass from stomach, on the average, is evacuated in 1,5 - 2 hours; in 4 hours the stomach becomes completely free from contents. If barium meal is found in stomach in 6 - 8 hours, they speak about delayed evacuation; in 12 clocks there is a suspicion on pyloric stenosis; in 24 hours it testifies stenosis, 48-hour and longer presence of contrast mass in stomach means organic pyloric stenosis.

Stomach tone. Tone is a status of contracture abilities of muscular parts of organ, which defines sizes of its lumen. Walls of considerable part of alimentary canal close when empty, consequently the lumen of organ is represented as narrow chink. At food or barium meal transition the walls of the examined organ put up some resistance. In particular, normal (orthotonus), increased (hypersthenia), low (hypotonia) and lack of tone (atony) are distinguished.

Radiological indications of increased tone are: slow movement of contrast agent, reduced shadow of the investigated organ due to decrease of the cavity following the contracted status of a muscular wall.

Signs of the low tone, on the contrary, are connected with relaxation of muscles of walls of the investigated organ. These factors consist in fast movement of the barium meal through the cavity, and augmentation of shadow of the investigated organ connected with dilating (increasing) of its sizes or of the lumen.

Peristalsis. Peristalsis of GT consists in contractions of circular muscles of the organ’s wall which are rhythmic, and follow each other at equal intervals. The peristalsis of each organ is a part of those wavy contractions of shadow contours. The following notions are distinguished: 1) rhythm, 2) duration of single peristaltic wave, and 3) amplitude of peristaltic contractions.

Signs of normal stomach peristalsis:

1. Appearance. Single rhythmic contractions in the upper part of the body, directed towards the pylorus.
2. Peristaltic waves follow one another with average intervals of 21 seconds. Closing and opening of the pylorus is caused by reflex action.

Duodenum is direct extension of pylorus the canal is. It is divided in 3 parts: upper horizontal, descending and lower horizontal. Upper part includes a bulb with 4 walls: front, back, medial, lateral. Contours of the bulb are distinct, even; commonly it is triangular-shaped with the base turned to stomach. The descending department is located to the right of backbone, goes parallel to its edge and forms small camber to

skirt the head of pancreas. The inferior department of duodenum has an oblique direction to the right from below, to the left upwards, and then passes into lexura duodeno-jejunalis, situated behind the stomach at the level of the upper edge of 3 lumbar vertebra. Width of duodenum is 4 - 6 cm; in distant departments it is bigger. Bulb mucosa is extension of stomach mucosa and is represented by folds with longitudinal direction, converging at the bulb top. In other departments of a duodenum they have a cross-section direction

Motor function of duodenum. It is expressed differently in different departments. The whole bulb usually contracts and as though squeezes out contrast agent in distal direction. However minor peristaltic walls contractions can be also observed. In the area of descending department wavy contractions, sometimes more expressed segmentations can be observed accompanied by tonic contraction of walls.

Radiological signs of stomach and duodenum diseases.

Chronic gastritis. In gastritis diagnosing the results of mucosa microrelief investigation (sizes and pattern of gastric areas) have crucial importance.

They can be revealed only on the enlargement images of stomach made at pressure on the anterior abdominal wal

l. At patients with superficial gastritis image is uniform – gastric areas of irregular spherical or polygonal shape, 2-3 mm on the average in diameter, separated one from another by very thin intervals of barium. Deep gastritis is characterized by uniform granular image with high roundish or oval areolas, from 2-3 up to 5 mm in diameter. At atrophic gastritis image of gastric areas is rugged, irregular and of different shapes and sizes (maximal diameter of alveoluses is more than 5 mm) (fig. 8.11).

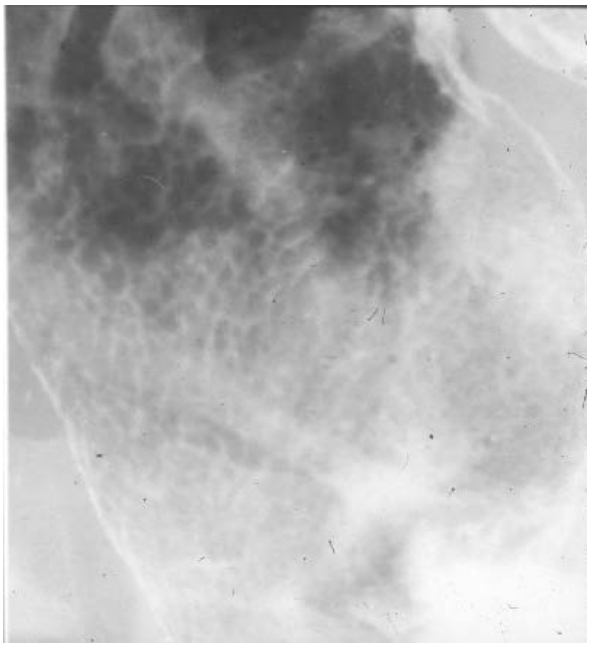

Fig. 8.11. Stomach. Barium-coated mucosa: increase of gastric areas. Chronic gastritis

Mucous membrane folds thicken as well. Ultrasound at erosive gastritis reveals irregularities of contour of mucosa wall, its local thickening, sign of "dissection" of abdominal wall which is connected with exudative inflammation of the wall.

Gastric and duodenal ulcers. Direct radiological symptoms:

1. Niche. 2. Changes of tissues around ulcer.

Niche (ulcer crater) is the result of ulceration of the organ's wall. Its depth of over 1-1,5 cm and its trilaminar contents (barium sulfate, fluid and air) can serve as indications of ulcer penetration (dissemination on adjacent organs). Depending on conditions of projections two types of niche are distinguished: niche within contour and niche within relief.

Niche within contour (Haudek's niche) is identified at barium-filled stomach and presents local enlargement of shadows (fig.8.12).

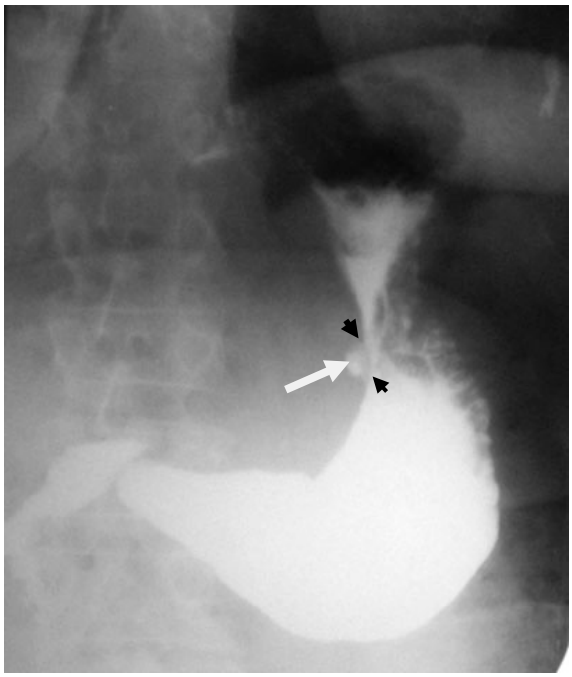

Fig. 8.12. Barium examination of the stomach (single contrast) shows a cm-sized ulcer crater (arrow) on the lesser curvature of the stomach. Radiolucent line seen across the neck of a gastric ulcer – Hampton's line (black arrows)

Niche on mucosa folds looks like irregular-shaped spherical persistent spot corresponding to the accumulation of barium sulfate in ulcerous defect (fig. 8.13.). It can be revealed with the help of small amounts of contrast agents. Infiltrative swell within the contour is observed either as protuberances on edges of niche, or as narrowing of niche orifice.

Changes of tissues around ulcer may be seen as:

- Hampton's line-radiolucent line seen across the neck of a gastric ulcer filled with barium sulphate during a barium meal. It is a sign of mucosal edema;
- ulcer collar-smooth, thick, lucent band at neck of ulcer in profile view representing thicker rim of edematous gastric wall;

- ulcer mound-smooth, sharply delineated tissue mass surrounding a benign ulcer;
- ring shadow-thin rim of contrast which represents an ulcer on the non-dependent surface of an air-contrast study;
- thickened folds radiating directly to the base of the ulcer en face.

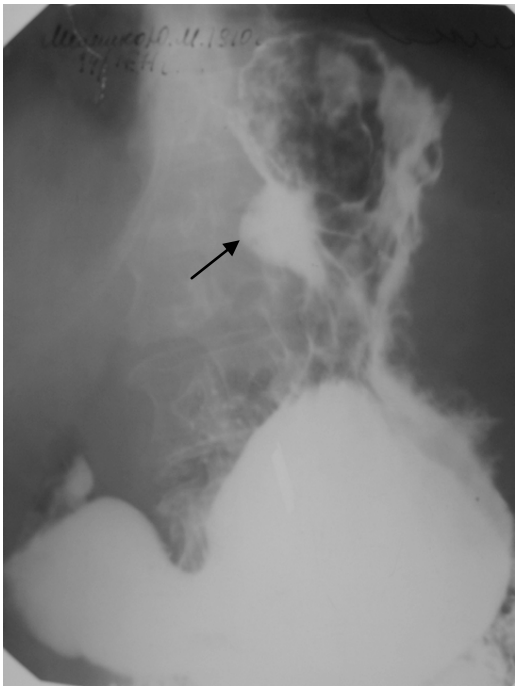

Fig. 8.13. Radiograph of stomach in direct projection with barium sulphate (single contrast). On the lesser curvature a big niche is identified (arrow) in the top third of stomach with thickened folds radiating directly to the base of the ulcer. Gastric ulcer

Functional symptoms: 1. Hypersecretion. 2. Hypertension or atony. 3. Hyperperistalsis. 4. Limited spasm as penetration on the greater curvature, often corresponding to the level of ulceration on the opposite side. 5. The evacuation is accelerated or slowed down. 6. Local pain sensitivity.

Stomach cancer. Radiological signs:

1) infiltration, rectification and rigidity of mucosa folds;
2) destruction of mucosa folds, their substitution with tumoral masses;
3) rectification and irregularity of contour of organ's shadow;
4) narrowing of organ's lumen;
5) filling defect, a niche;
6) lack of peristalsis and rigidity (immobility) of contour in affected region.

Non-uniform reduction of shadow of contrast agent in the cavity of investigated organ is an indication of presence of additional tissue (fig. 8.14).

Filling defect can be boundary (when barrier for contrast agent dissemination is located on the border of organ) or central.

In the latter case multiaxial radiography should be carried out to reveal what wall, front or back, has the defect.

For malignant tumor the following aspects are typical:

1) boundary location of filling defect;
2) broad connection with wall;
3) rigid or corroded contours;
4) surrounding mucosa has atypical folds.

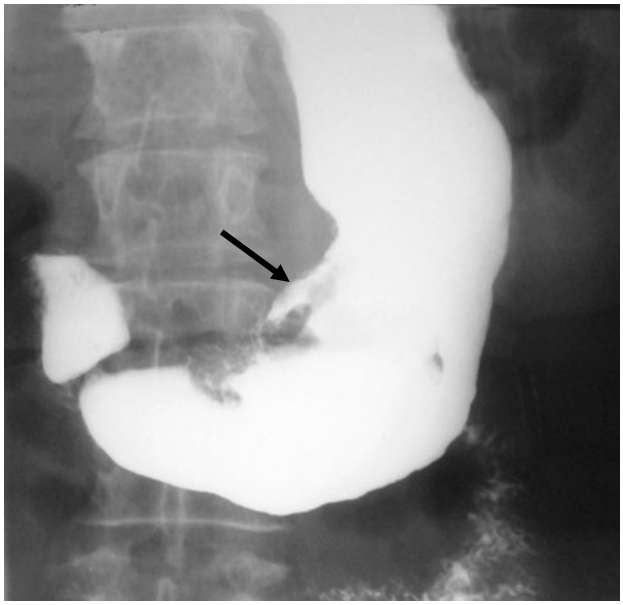

Fig. 8.14. Barium contrast study (single contrast) reveals filling defect with irregular contour involving the lesser curvature of the stomach (arrow). Stomach cancer

Polyps are benign tumours, characterized by central location of filling defects, with smooth contours. Mucosa folds are not changed (fig. 8.15).

Fig. 8.15. Radiograph of stomach in direct projection. Single contrast with barium sulphate. In distal part of stomach there is centrally located filling defect with smooth polycyclic contours (arrow). Stomach polyp

Thus CT and ultrasound have the following capabilities:

- they reveal intramural growth;
- visualize extragastral growth;
- reveal involvement of other organs and lymph nodes into the process.

Radiological examination of intestine.

Indications for radiological examination of intestine:

1. Chronic enteritises and colitises;
2. Prolonged constipation, diarrhea;
3. Enterorrhagia;
4. Intestinal obstruction;
5. Tumours;
6. Diverticulums.

Small intestine. Small intestine is better to study in 40 - 60 minutes after examination of stomach and duodenum. In most cases all this time small intestine is filled with contrast agent. Position, form of intestinal loops, their sizes (width), peristalsis and evacuation of contents are to be mentioned.

Loops of jejunum are located in the middle department of abdominal cavity, and ileum − in the lower right department, as well as in small pelvis. Intestinal loops can have small notches and it is caused by cross-section of folds. These folds in the relief phase form a specific fleecy image (fig.8.16). The width of loops varies about 2 cm. In small intestine dual movements are distinguished: peristaltic and pendulous. The first are stipulated by function of circular musculation, second – by function of longitudinal musculation. The evacuation of contents from the upper department of small intestine takes place in 2 - 3 hours, from the inferior department – in 6 hours.

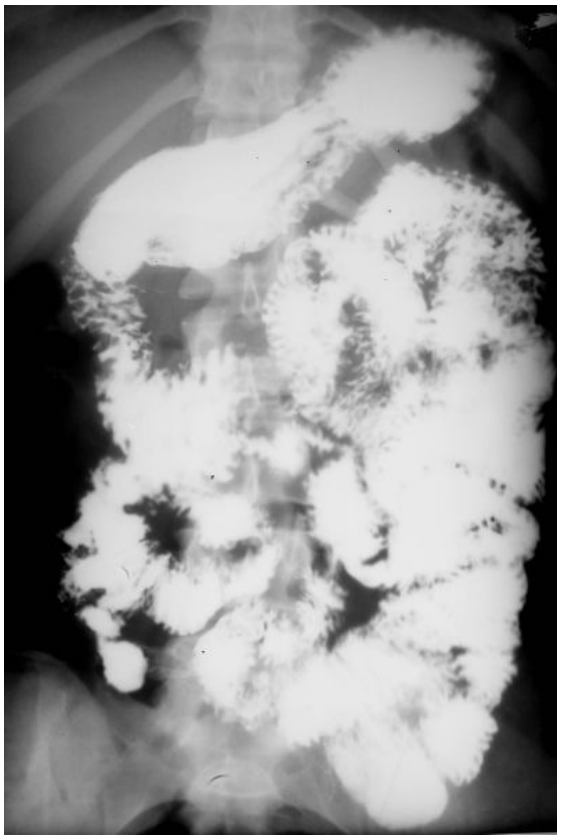

Fig. 8.16. Small intestine. Single contrast with barium sulfate. Norm

In 1 hour loops of a jejunum are filled, in 3 hours all contrast mass in ileum

starts to move towards caecum, and in 7 - 8 hours the small intestine is completely emptied.

The most precise research technique of small intestine is x-ray examination after injection of barium directly into small intestine. Barium is introduced into small intestine directly through the intestinal tube in order to stretch the intestine maximally.

Radiological symptoms of diseases of small intestine.

Enteritises. Hypertonia and hyperkinesia of small intestine is typical for patients with severe enteritises. As a result of reinforced exudation, fermentation and disorders of adsorption, gas and minor fluid levels appear in small intestine. Deformation of mucosa relief is marked: folds are thickened non-uniformly, high, become even, quite often change their direction. Important indication of chronic enteritis are single small patches on the mucosa relief (grainy-nodular relief), testifying focal edema of mucosa, occlusion and swelling of single segments, hypertrophy of solitary follicles (fig. 8.17).

Fig. 8.17. Small bowel. Single contrast with barium sulhate. Small spherical formations on mucosa relief. Enteritis

Regional enteritis (Crohn's disease). Can be of two forms. The first one is superficial non-sclerosing ileitis. The hyperplasia of lymphoid apparatus, similar pseudopolypous changes of mucosa is discovered in children and teenagers with edema of intestinal wall. It is revealed by formation of cellular image of mucosa

relief and irregular intestinal contours. Intestine narrowing is not observed.

The second form is characterized by acute inflammatory infiltration, edema of all intestinal wall layers and ulcer formation on mucosa. Expansion of process on large intestine is possible. At an x-ray examination irregular narrowing and obstruction as well as enteroenteric fistulas and enterocutaneous fistulas can be observed.The mucosa relief becomes acinose, polyps shapes, ulcers cause niche sign (fig. 8.18.).

Fig. 8.18. Terminal ileal Crohn's disease. Note long, narrowed "string" like terminal ileum which has shallow ulcers [101]

Ultrasonic and CT allow in addition to an x-ray inspection at diseases of a small bowel:

- to visualize a thickening wall of an intestine;
- to spot an expansion extraintestinal lesions;
- to reveal complications: fistulas, abscesses.

Cancer of small intestine. X-ray investigation reveals filling defect of irregular shape and rough contours, narrowing of lumen. The deformation of mucosa relief in the region of edema is detected, break of mucosa folds. The peristalsis in the area of the swelling is not detected. At CT the thickening of intestinal wall and of metastasises into lymph nodes is visualized.

*Radiological examination of large intestine.*The basic research technique of large intestine is irrigoscopy – examination of colon with preliminary injection of contrast agent through the rectum.

Examination of colon after introduction of baric suspension per os should be carried out only to study its function status (emptying), and also at intentional examination of terminal department of small intestine together with caecum (ileocecal angle).

Proctosigmoidoscopy should be carried out beforehand.

Preparation of patients. Before examination patients do not have supper. In the evening they are given two purgative enemas with pure water with an interval of 1 hour. In the morning 2 hours prior to examination the patient is given two cleansing enemas with an interval of 30 min.

Contrast agents. Barium enema is prepared at the rate of 1 part of barium sulfate per 4 parts of water with adding of 4,0 g tanninum per 1 litre of contrast agent. To fill rectum and colon 600-800 ml of a contrast agent are commonly sufficient.

Procedure of examination. The enema with barium is introduced gradually under monitoring, until the contrast mass reaches caecum and fills it. Sizes, positions of loops, condition of contours, and progression of contrast mass are investigated. Suspicious fields (changes) should be registered on the film. When the entire large intestine is filled one survey image on film 30 × 40 cm is made, and the first investigation phase is considered finished (fig. 8.19).

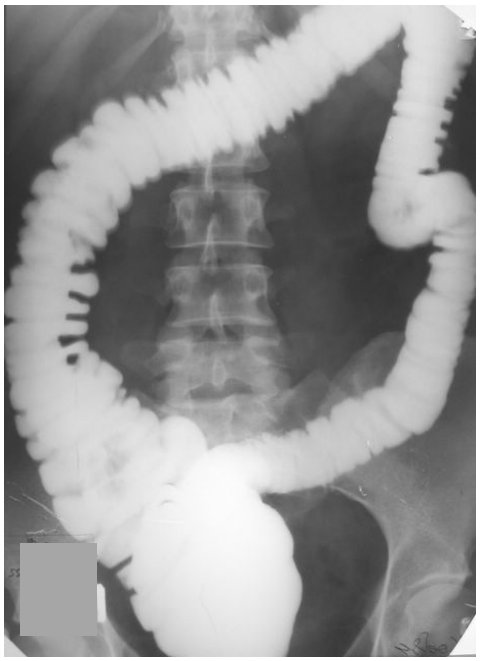

Fig. 8.19. Single contrast-barium filling of colon. Sizes, positions of loops, condition of contours, progression of contrast mass. Norm

Fig. 8.20. The second stage − examination of colon mucosa relief is carried out after bowel emptying. Norm.

The second stage – examination of mucosa relief is carried out after bowel emptying (fig. 8.20). Under screen monitoring in conditions of dosed compression mucosa folds of all intestinal departments are investigated (target images of suspicious fields are obligatory). Closing methodical technique is examination by double contrasting which is rather important at suspicion of neoplasm. Under screen

monitoring inflation of large intestine is carried out; changed and suspicious fields are subject to radiography (target imaging), and the last diagnostic technique is survey imaging on 30 × 40 cm film of intestinal all loops in status of double contrast (fig. 8.21).

Nowaday double contrast study of colon is recommended.

Contraindications to irrigoscopy:

- toxic dilation of intestine;
- suspicion of perforation;
- deep biopsy carried out within last week before examination (superficial biopsy of mucosa is not an contraindication).

Fig. 8.21. Double contrast examination of colon. Norm

Additional contraindications to contrast enema with double contrasting:

- intestinal obstruction;
- severe acute colitis;
- technical difficulties (not-mobile patient).

In rectum contours, as a rule, are smooth. The width of lumen is bigger on the right. Haustration is a criteria of assessment of colon tone. At high tone haustras are high, narrow and frequent. At low tone the intestine is wider, haustration is barely marked and visible.

Radiological signs of diseases of large intestine.

The cancer of large intestine can be identified by filling defect (boundary or

central), atypical mucosa relief change and defect on folds, intestine narrowing, irregularity of contours, dilation of intestine higher and lower than the tumour affected fragment. Ultrasound and CT play the leading part in differentiation of cancer of large intestine from its invasion from the outside at cancer of gallblader and urinary bladder, prostate gland and female generative organs (fig. 8.22).

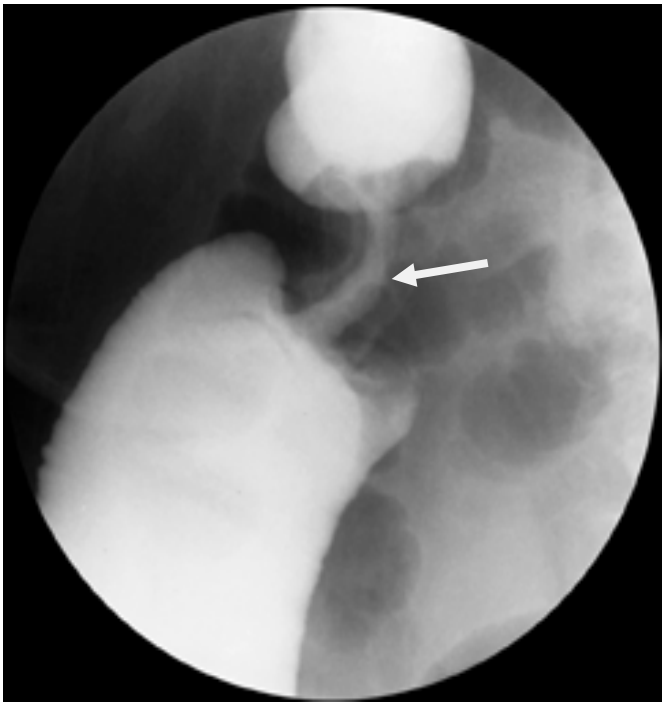

Fig. 8.22. Barium study (single contrast) demonstrating narrowing of the lumen of the proximal part of sigmoid colon with overhanging edges (arrow). The cancer of the large intestine

Diverticulosis of large intestine is local augmentation of intestinal lumen as a round shadow. Usually multiple (fig. 8.23). Can be complicated by inflammation, bleeding, perforation. Ultrasound visualizes the thickened intestinal wall, abscesses.

CT visualizes thickening of wall (more often than ultrasound), infiltration of peridiverticulitis adipose tissue, perienteric abscesses, fistulas.

Fig. 8.23. Double contrast barium enema. Dolichosigmoideum. Numerous diverticulae of the sigmoid and the descending colon [101]

Nonspecific ulcerous colitis. Rectum, left half of large intestine is affected more often; sometimes total affection takes place. Main radiological indications: superficial and deep ulcerations (fig. 8.24), thickened folds with wrong direction, indistinct contours of large intestine, cellular image of mucosa, healthy parts of mucosa relief alternating with the affected ones creating a pattern of “tortoise shell”.

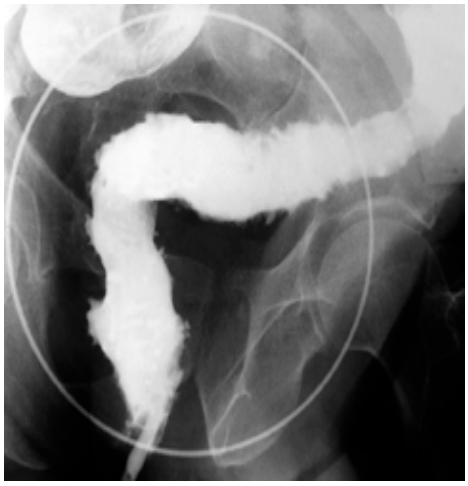

Fig. 8.24. Barium enema, revealing numerous superficial and deep ulcerations of the rectosigmoid, visible as barium outpouchings of various size and shape

Tuberculosis of large intestine. Ileocecal region is the main localization. Arises for the second time as a result of lymphogenous and hematogenous diffusion at pulmonary tuberculosis. Localization in the terminal department of ileal intestine and in proximal departments of large intestine is typical. Disorders of tone in the form of atonic and spasmodic changes, considerable atypical mucosa relief differentiates it from tumoral atypical malignant relief. Key factors of difference of this process from tumoral is its typical localization with involvement of terminal department of ileal intestine, pulmonary tuberculosis.

X-ray indications at acute abdominal catastrophes.

Radiological signs of perforated stomach ulcer (fig. 8.25):

- gas accumulation in the abdominal cavity (pneumoperitoneum – chest and abdominal films visualizes air below the diafragm);
- high position of the left cupula of diaphragm and limitation of its motility;
- (in several hours) signs of paralytic bowel obstruction, connected with developing peritonitis: expressed meteorism, sometimes presence of separate gas bladders with horizontal fluid levels.

Acute intestine obstruction: on survey image of abdomen cavity a lot of gas bladders with horizontal fluid level are discovered (fig. 8.26).

More distantly places of obstruction of intestinal loop are dissipated and do not contain any gas and fluid. This indication enables to distinguish mechanical

obstruction of intestine from the dynamic one. At dynamic obstruction the peristalsis of intestine is not observed either.

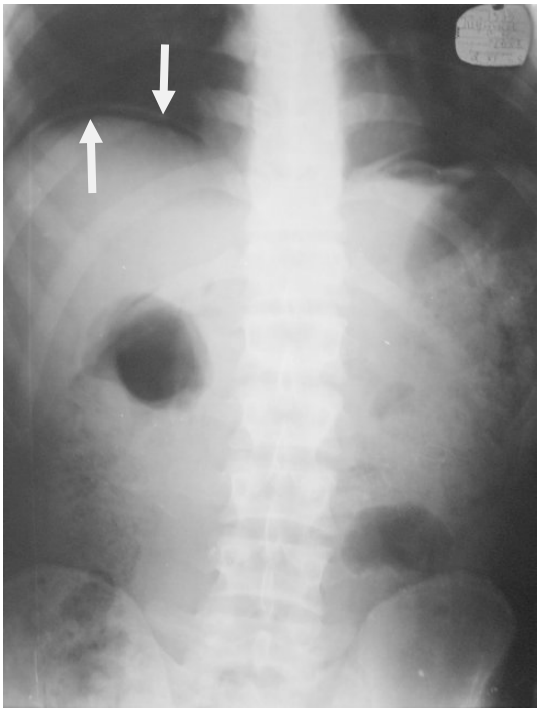

Fig. 8.25. Abdominal plain film. Frontal view. Gas accumulation in abdominal cavity (pneumoperitoneum – chest and abdominal films visualizes air below the diaphragm). Pneumoperitoneum

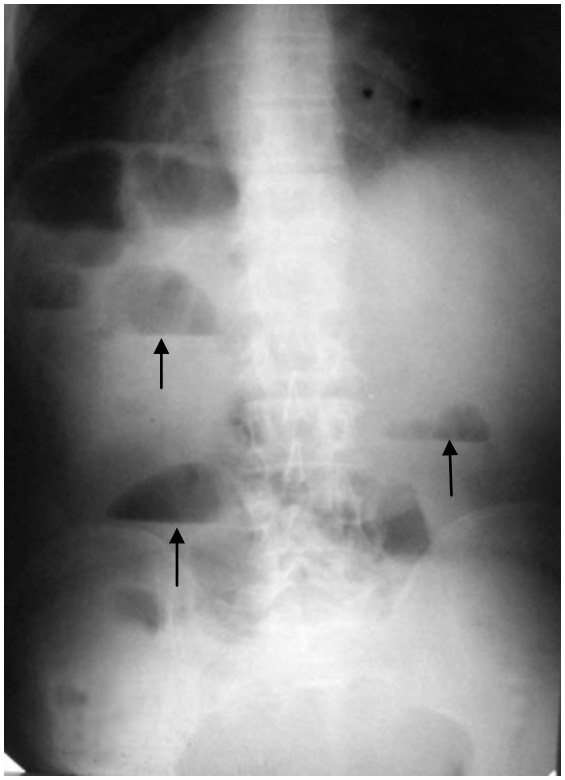

Fig. 8.26. Abdominal plain film. Air-fluid levels in patients with small bowel obstruction. Note the dilataition of the air-filled loops

8.2. Radologycal examination of liver and biliary tract

Primary method of visualization is ultrasound.

Ultrasound investigation of liver and biliary tract.

Indications to ultrasound of liver:

1. Hepatomegaly; purpose is to define sizes, form, structure of parenchyma, condition of intrahepatic vessels and determine the cause of this pathology.
2. Chronic diffuse diseases; the purpose is to determine volume of affection, identify type of disease.
3. Suspicion of tumour of liver; demonstration of changed of liver form and its echostructure, definition of precise localization of tumour for puncture.
4. Suspicion of cyst; determination of precise cyst localization.
5. Jaundice – assessment of the nature of disease, visualization of enlarged bile ducts, gallbladder, determination of pathological changes in liver and pancreas.
6. Trauma and posttraumatic conditions; visualization of place of blood accumulation; assessment of condition of posttraumatic cicatrice, as well as volume of affection of the liver.
7. Decompensated heart diseases causing overload of its right departments –with the purpose of assessment of an extent of parenchyma injury and assessment of condition of hepatic veins.
8. Acute and chronic cholecystitis.
9. Cholelithiasis (formation of gallstones).
10. Cancer of gallbladder and bile ducts.

In general, clinical signs of possible liver and bile ducts damage are the indications to ultrasound.

Preparation for ultrasound of liver: three-day diet and intake of the pharmaceuticals decreasing meteorism. If the patient has constipations, on day prior to examination it is necessary to give laxative in the evening or to make cleansing enema.

Ultrasound criteria of normal liver condition (fig. 8.27):

1. Distinct contour of liver borders.
2. Homogeneous parenchyma with low-amplitude echo signals.
3. Visualization of portal vein with its branchings of II and III order, hepatic veins and their inflow into inferior vena cava.
4. In norm intrahepatic bile ducts are not visible, as well as intrahepatic branches of hepatic arteria.

The height of right hepatic lobe by 5 years is 4 cm, by 12 years it is doubled, by 15 years – 10 cm. At adults the vertical sizes of the right lobe of a liver in norm are equal 9-12 cm, left − 8-10 cm.

Ultrasound of gallblader determines: 1) position; 2) form; 3) condition of walls; 4) content; 5) function of gallblader. Gallblader in norm has anechogenic

contents, wall thickness of 2-3 mm, average sizes: length - 7-10 cm (less than 13 cm), diameter - 3 cm (less than 4 cm) (fig. 8.28). On empty stomach bile bladder rarely exceeds the sizes of 4 × 10 cm.

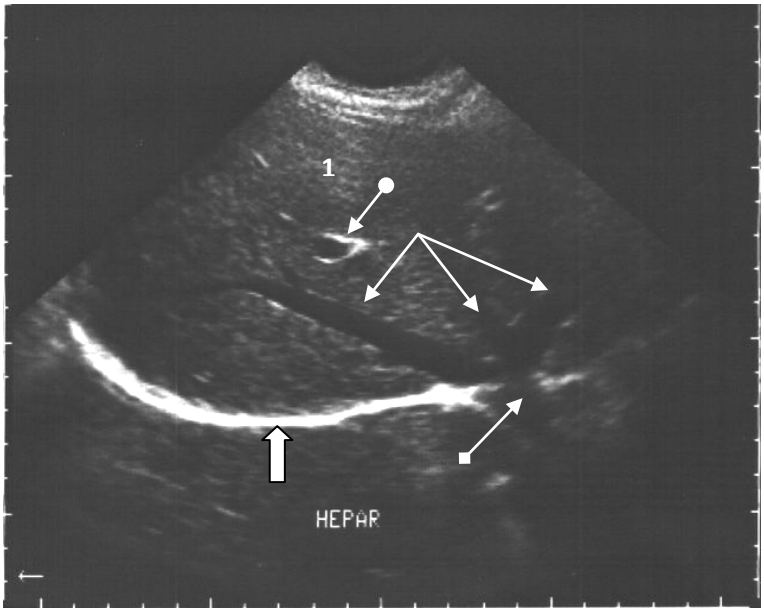

Fig. 8.27. B – mode. Normal liver ultrasound. Longitudinal scan. Against parenchyma of liver (1), branches of the hepatic veins (white arrows) running into the vena cava inferior (arrow with rombus) are visible. Unlike hepatic veins vena portae hepatis has thicker and hyperechoic a walls (arrow with sphere).
The diafragm produces the hyperechoic curved line posteriorly (figured arrow).

Visualization of small bile ducts inside liver is an indication of pathological process. At 95 % of patients the diameter of normal common bile duct is 0,4 cm and fewer.

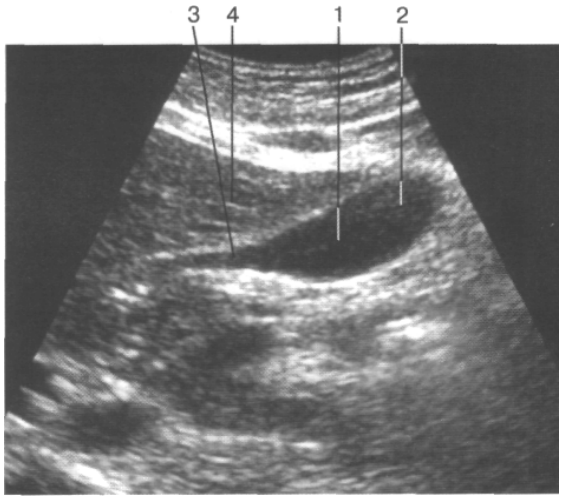

Fig. 8.28. Normal gallbladder ultrasound.
The gallbladder appears as organ with anechogenic content: 1– body of gallbladder; 2 – fundus of gallbladder; 3 – neck of gallbladder; 4 – liver [34]

Computed tomography of abdomen and retroperitoneal space. Indications:

I. 1. Trauma of abdomen with suspicion of internal injury (liver, kidney).
2. Focal and diffuse liver diseases:
a) cysts of liver (congenital and parasitogenic);
b) primary tumours of liver;
c) metastasises;

d) abscesses of liver (of various etiology);

e) cirrhosis of liver;

f) adipose degeneration.

II. 4. Diseases of gallbladder:

a) acute cholecystitis (empyema of gallbladder);

b) suspicion of chronic calculous cholecystitis at nonfunctioning gallbladder and doubtful data of ultrasound and cholecystography;

c) cancer of gallbladder;

d) choledocholithiasis.

III. 5. Obstructive jaundice.

IV.6. Diseases of a pancreas:

a) acute pancreatitis (pancreatonecrosis);

b) cyst of pancreas;

c) chronic pancreatitis;

d) tumors of pancreas.

In norm the liver has smooth distinct contours on tomogram. Its lobes separated by incisures can be easily identified. Parenchyma structure is homogeneous.

Intrahepatic bile ducts with diameter of 1-2 mm with the help of this method cannot be visualized.

Anhepatic, common bile ducts are visible without injection of contrast agents temporary, are visualized after contrasting.

Bile ducts on tomogram in norm are not visible; enlarged ducts because of low density are differentiated clearly on cuts without contrasting. CT enables to assess not only the sizes and shape of liver, but also location of surrounding organs.

Cholecystography (oral cholecystography). Bile ducts on common images are not displayed. Artificial contrasting is used. The media in common use are sodium ipodate and calcium ipodate. The fluoroscopy and radiography in 13-14 hours after introduction of contrast agent is carried out. Gallbladder to the right of center line: length is 5-8 cm, and diameter is 2,5-3,5 cm. Contours are distinct, arched, the shadow is intensive and homogeneus.

Indications: cholelithiasis, dyskinesia of gallbladder. Contraindications: idiosyncrasy to iodide drugs, thyrotoxicosis, cardiovascular decompensation, renal and hepatic failure.

Cholegraphy (intravenous cholangiography). Hepatotropic iodine contrast agent is introduced intravenously. The contrast media in use are ioglycacamide and itroximate. After injection bile ducts (common bile duct, hepatic and gallbladder ducts and their branchings) and gallbladder are contrasted. Indications: exacerbation

of chronic cholecystitis, cholelithiasis, condition after a cholecystectomia, negative results of cholecystography.

Contraindications: idiosyncrasy to iodine, severe diseases of liver, kidney, thyroid gland; decompensation of cardiac activity.

The role of cholecystography and cholegraphy essentially decreased in connection with development of other methods of visualization, first of all – ultrasound. Cholecystography and cholegraphy are carried out only when ultrasound results are doubtful.

Endoscopic retrograde cholangiopancreatography (ERCP) is carried out by cannulation of major duodenal papilla with the subsequent injection of the water-soluble iodine contrast agent into bile ducts. The procedure enables to estimate the condition of duodenal papilla, bile ducts and pancreatic duct. Indications: differential diagnosis of mechanical and hepatic icteruses. Contraindication: intolerance of iodide drugs, breaking of coagulating system of blood, acute pancreatitis, acute cholangitis and cholecystitis, common grave condition of the patient, contraindication to introduction of endoscope.

Percutaneous transhepatic cholangiography (PTC). Indications: differential diagnosis of mechanical and hepatic icteruses, clarification of localization, nature and character of occlusion of bile ducts.

Contraindications: intolerance to iodide drugs, hemorrhagic diathesis, acute breaking of coagulating system of blood, echinococcus or polycystosis of liver. As a contrast agent 50 % solution of Hypaque is applied. Complications: bleedings, outflow of bile in abdominal cavity, shock.

Operative cholangiography. At this method contrast agent is introduced directly into bile ducts during operation (fig. 8.29). Indications: stones in bile ducts or suspicion of them, dilating bile ducts, augmentation of the head of pancreas. Contraindications: no absolute contraindications, among relative ones – acute cholangitis.

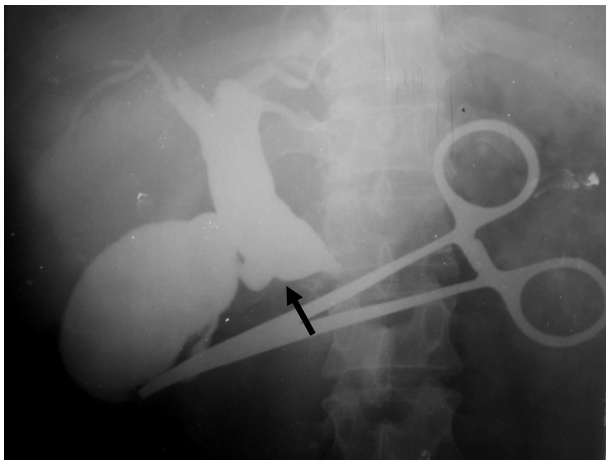

Fig. 8.29. Operative cholangiogram. The contrast agent is introduced into bile ducts. Massive dilatation of the common bile duct and hepatic ducts, gallblader. Obstruction of common bile duct, with rough contours (arrow). Contrast agent does not reach the duodenum. Cancer of the common bile duct

On cholegrams width of shadow of normal common bile duct comprises up to 0,7 cm, on cholangiograms normal common bile duct can reach 1,5 cm.

Angiography. For study of blood flow and condition of blood vessels, which supply liver, selective catheterization of truncus coeliacus (arteriography) became the most popular. Thus analysis of the image of arteriography is grounded on study of three serial phases: arterial, parenchymatous and venous. Data obtained can enable to diagnose affection of hepatic vascular system and disorders in its hemodynamics as well as malformations of liver and character of focal lesions can be specified.

Radionuclid methods of liver visualization. The study of function state of polygonal cells of liver is possible at dynamic scintigraphy.

Dynamic hepatobiliary scintigraphy with usage of the – ^{99m}Tc-labeled imidodiacetic acid (hepatotropic derivants) provides determination of the parameters describing secretory and excretory functions of liver, patency of bile ducts, accumulative and motorial functions of gallbladder, basic anatomical parameters (position, shape, sizes) of liver, gallbladder and intestines.

A number of scintigrams enable to assess absorption and excretory functions of liver visually, time and degree of gallbladder contrasting, motor function of gallbladder, patency of bile ducts, some anatomy-topographical peculiarities of liver and gallbladder. The obtained information is reproduced on the display of the computer; and four zones of interest are distinguished: heart, liver, gallbladder, small intestine. After choosing these zones, the information is integrated and activity curve is made – time from the chosen zones of interest.

Mechanical jaundice (icterus) causes substantial growth of time of maximal accumulation of drug in liver, clearance of blood does not change significantly, and drug is practically not removed into the small intestine.

Parenchymatous jaundice is accompanied by abrupt disorders in functional state of liver with the most typical decrease of parameters of blood clearance and retardation of liver clearing of injected drug.

For hemolytic jaundice is usually not characterized by sharp changes in functional hepatocytes.

Concentrational function of gallbladder is calculated under the attitude of count rate in the gallbladder region to count rate in the liver region.

Static scintigraphy of liver. Main diagnostic problems of static scintigraphy of liver are:

- anatomical peculiarities of organ (sizes, shape, position relative to other anatomical structures);
- character of lesion (diffuse, focal);
- gravity of lesion and syndrome of portal hypertension (acute and chronic

hepatitis, liver cirrhosis, etc.);

- focal lesion of liver.

Adequate solutions of the problems mentioned above are made with methods of scintigraphy with usage of colloidal radiopharmaceutical marked ^{198}Au, ^{99m}Tc, ^{113m}In which create high concentration in liver.

Colloid particles stay for a long time in the system of mononuclear phagocytes of liver therefore it is possible to conduct repetitive examination in various regimes and projections. At liver cirrhosis examination with radiocolloids provides with additional information on the state of lien.

Principle of analysis of the obtained information at static scintigraphy of liver. Position, shape, distribution in liver and lien, staining and degree of colloid accumulation, character of contours and presence of typical incisures, character of colloid allocation, presence of the loci of no radiocolloid allocation, degree of anhepatic accumulations of radioactive nuclide.

Scintigraphy liver imaging (fig.8.30). Liver imaging in direct projection has a triangle shape with its base turned towards the abdominal cavity. Contours of organ are distinct. Relative metrical values are used. Among them: ratio of maximal heights of left and right lobes (in norm no more than 20 %). It is necessary to emphasize, that the edge of the liver image can be visualized on half-clavicle lines on 0,5-2 cm, on line of processus xiphoideus 2-4 cm below marked costal margin.

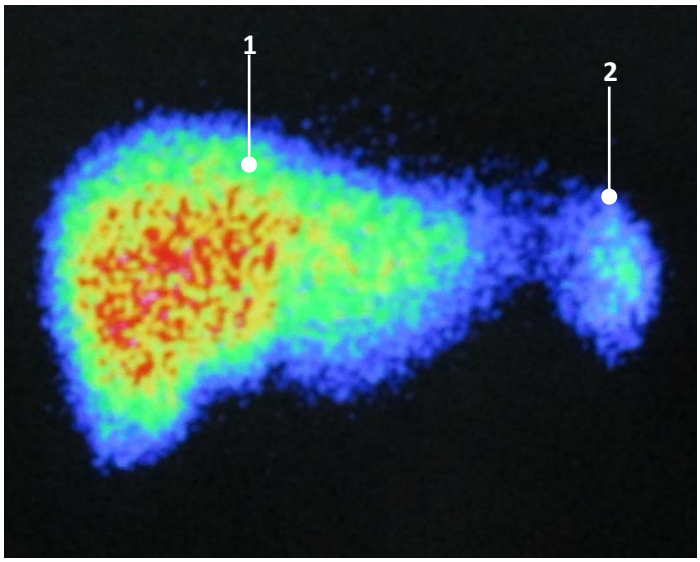

Fig. 8.30. Static scintigraphy of liver. Normal distribution of ^{99m}Tc-labeled colloid in liver (1) and spleen (2)

The image of lien in direct projection is always visualized on scintigram. Accumulation of radiocolloid by a lien in a front projection does not exceed 4-5 % concerning a common radioactivity of a liver and a lien. The bone marrow in norm is not visualized.

The scintigraphy of a liver is concedes to other methods of visualization in

diagnostics of focal lesions of liver (locuses of lesion with sizes not less than 3 cm are detected).

Signs of local decrease or lack of radiocolloid accumulation are typical. In some cases it is more informative than other methods of visualization (for example, malignant lymphatic system diseases).

Thus, radionuclid examination of liver and bile ducts yields very important diagnostic information on function and anatomical-topographical state of liver, intrahepatic bile ducts, gallbladder, common bile duct.

MRI. Capabilities of MRI are similar with those of CT, but at MRI image can be obtained in all projections, it is possible to obtain the image of hepatic vessels (MR - angiography), bile ducts and pancreatic ducts (MR - cholangiography).

Radiological symptoms of diseases of liver.

Hepatitis. Decrease of liver echogenicity is typical for severe cases of acute hepatitis, elements of portal vein are more bright against this background, hepatomegaly is detected, gallblader can diminish (fig. 8.31).

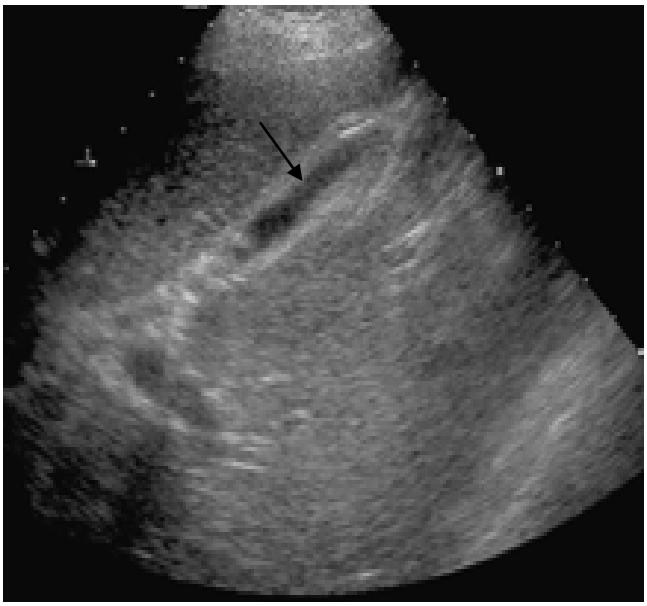

Fig. 8.31. Gallbladder affected by acute hepatitis. Ultrasound examination, demonstrating small volume of gallbladder (arrow) which reveals markedly thickened wall [101]

On MRI at an acute hepatitis the inflammation site is defined as a zone with more intensive signal on T2-WI (fig. 8.32). At chronic hepatitises echogenicity is often increased.

As a rule, at diffuse lesions of liver radionuclid technologies have more diagnostic capabilities than other imaging methods.

The chronic hepatitis – distribution of radiocolloid has irregular character at 50-60 % of patients. One of indications is shift of the area of maximal radiocolloid accumulation from the central right lobe. At 50-60 % of patients the sizes of lien increase, accumulation of radiocolloid increases (10-15 %), and at active chronic

hepatitis radiocolloid accumulation exceeds 15% in 30 % of cases (fig. 8.33).

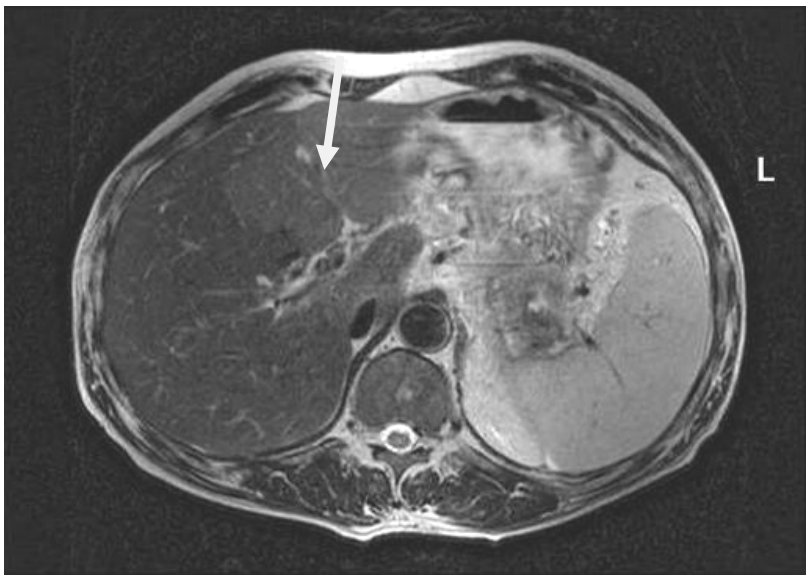

Fig. 8.32. MRI of liver. T2-WI. Inflammation with more intensive signal (arrow) is defined in liver tissue. Acute hepatitis.

Liver cirrhosis. Ultrasound reveals changing of liver sizes at cirrhosis, roughness of contours of the organ, increase and heterogeneity of liver echogenicity, augmentation of lien, dilation of portal vein (norm – less than 1,5 cm), splenic vein (norm – less than 1,0 cm), ascites (fig. 8.34).

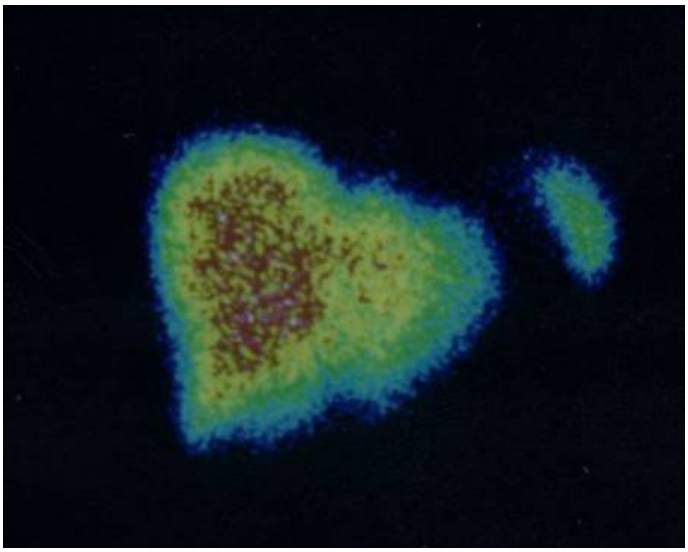

Fig. 8.33. Static scintigraphy of liver with ^{99m}Tc-tehnefit (^{99m}Tc-labeled colloid). Increasing of the liver, decrease in ^{99m}Tc-labeled colloid accumulation, mainly in the field of the left lobe. Increase of ^{99m}Tc-labeled colloid capture by spleen (more than 10 %). Diffusion changes of liver parenchyma, typical for chronic hepatitis.

High performance of ultrasound at ascites diagnostics should be mentioned. Minimum quantity of fluid that can be revealed by ultrasound is 50 ml. In this respect ultrasound is second to laparoscopy.

CT and MRI reveal the loci of regeneration and liver cirrhosis, dilation of portal and splenic veins, effusion in the abdominal cavity (fig. 8.35). The x-ray examination of esophagus detecting esophageal varicose phlebectasia is indicated.

Fig 8.34. Ultrasound examination. The irregularity of the liver contour (arrows) is clearly visible because of the presence of a considerable amount of ascites. Cirrhosis of liver [101]

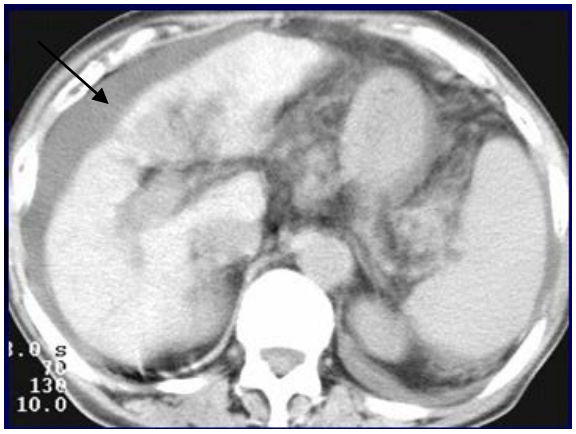

Fig. 8.35. CT also shows heterogeneity of hepatic frame, roughness of contours, presence of ascites (arrow). Cirrhosis of liver

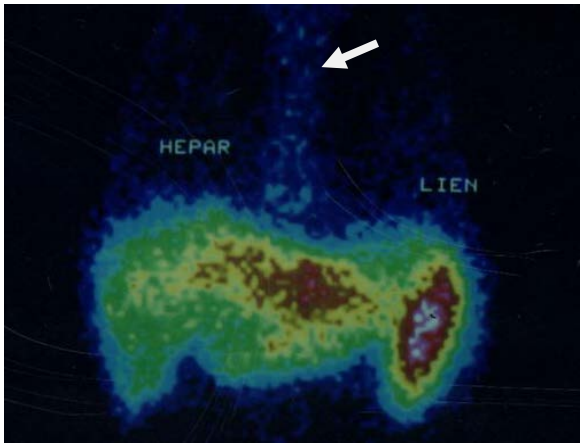

Fig. 8.36. Static scintigraphy of liver. Heterogenous distribution and decreased accumulation of radiocolloid. Anhepatic hyperfixation of radiocolloid shows high accumulation in the lien area (up to 40-50 %) and bone marrow (arrow). Cirrhosis of liver

At static scintigraphy changes are alike chronic hepatitis. As blood flow decreases, the image contrast decreases as well, there appears heterogeneity of radiocolloid distribution. Anhepatic hyperfixation of radiocolloid reveales high accumulation in the lien region (up to 40-50 %) and bone marrow (fig. 8.36).

Liver cancer is diagnosed when there are changes of echogenicity of hepatic parenchyma, its shape and sizes (fig. 8.37). Tumoral clusters can be solitary or multiple. At CT decrease of hepatoma density is registered, at MRI – alteration of

MR-signal intensity. As a rule, regardless of growth form dilation of intrahepatic bile ducts is observed. These data can be received at ultrasound, CT and MRI.

Metastatic liver lesions at ultrasound can be of different echogenicity, either diffuse or focal. Homoechogenic metastasises are revealed by indirect indications (deformation of vascular pattern, local protrusions of contour). They can reach the sizes of more than 1-2 cm. Total sensitivity of contemporary ultrasound at detection of focal hepatic alterations is 60-75 %. At native CT the loci less than 1 cm, some larger loci, cannot be visualized. Standard CT infrequently supplements ultrasound on sensitivity and specificity. CT at metastasis reveals spherical or irregular-shaped areas of low density against the background of parenchyma (fig. 8.38).

Fig. 8.37. Ultrasound examination of the liver, revealing a hyperechoic lesion (diameter 3.5 cm) with irregular configuration and unsharp borders

Diffuse liver lesions are more difficult to diagnose with help of CT, unlike the local ones. Sometimes radionuclide diagnostics is preferable at such changes.

Capabilities of modern MRI at diagnostics of metastasis in liver can be compared with CT.

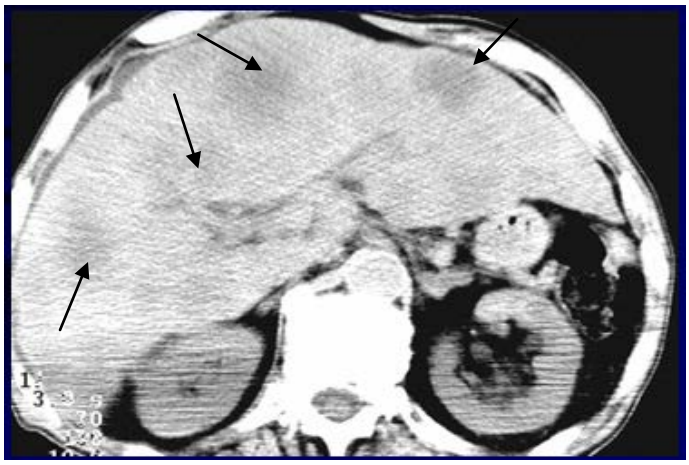

Fig. 8.38. CT at metastasises in liver reveals spherical or irregular-shaped areas of low density against the background of parenchyma (arrows)

Liver cysts. At ultrasound cysts are detected as spherical non-echoes formations. They have distinct, sleek contours and high intensifying echoes behind them. CT and MRI visualize cysts as fluid formations with distinct contours.

Liver abscess. At ultrasound the abscess is detected as hypoechoic or non-echoic zone with rough contours, behind the abscess acoustic intensification is observed. The liver around the abscess can be hypoechoic. CT shows lesser density decrease at abscess if compared with cysts.

Acute cholecystitis. US indications of acute cholecystitis (fig. 8.39):

- uneven thickening of gallbladder wall (more than 3 mm) with its inhomogeneity, lamination and sometimes indistinct border with liver due to edema of tissue around gallbladder.
- Exact correspondence of the pain caused by transduser pressure to the location of gallbladder (Murphy's sign).

CT is indicated at complications, when ultrasound is insufficiently informative. It detects gas bubbles in lumen and in the wall of gallbladder at cholecystitis, changes of tissues around gallbladder better than ultrasound.

Fig. 8.39. Ultrasound indications: uneven thickening of wall of gallbladder (more than 3 mm) with its inhomogeneity (arrow). Edema of tissue around gallbladder. Acute cholecstitis

Chronic cholecystitis. Ultrasound indications of chronic cholecystitis:

- thickening of walls is not typical and can be interpreted as chronic cholecystitis only in view of anamnestic indications;
- contraction of bladder, rough cicatrical alterations;
- disorders in gallbladder emptying.

Cholelithiasis. Chronic acalculous cholecystitis is a rare form, calculous cholecystitis is more common.

Ultrasound is primary imaging method. One of its advantages is a possibility to

change position of the patient that enables identification of stones. Sensitivity of ultrasound comprises 95-99 %. Stones on sonogram look like hyperechoic formation with acoustic shadow behind it (acoustic track) (fig. 8.40).

The causes of false-negative ultrasound results are:

- small stones in gallbladder neck;
- stone is located deep behind a rib arc.

Cholecystography may help in such cases.

Gallbladder cancer. Ultrasound is the primary method. If cancer is suspected, CT is indicated. Pattern of early cancer forms is not typical. Tumoural thickening of gallbladder wall is difficult to differentiate from cholecystitis. Tumors substituting gallbladder and extending into liver (50 % of gallbladder tumors) are usually detected better.

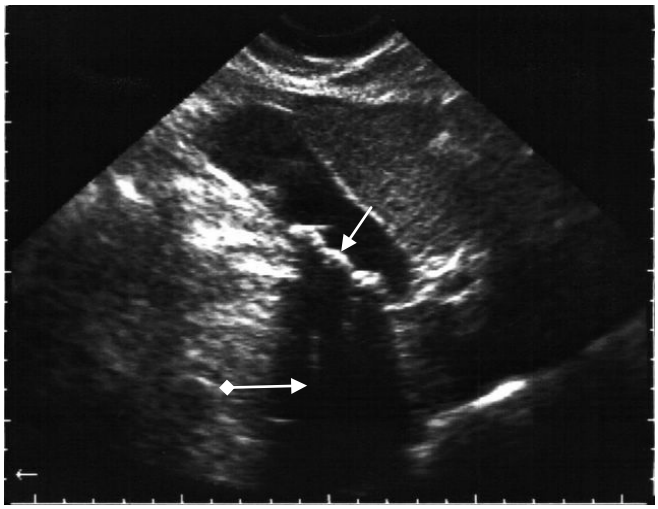

Fig. 8.40. Ultrasound of gallbladder. Stones on sonogram look like highly reflective echogenic focus within gallbladder lumen (arrow) with prominent posterior acoustic shadow (arrow with rhombus). Cholelithiasis

Cholangiocarcinoma. Common radiological sign of cholangiocarcinoma is dilation of bile ducts above tumoural lesion, gallbladder increases, mechanical jaundice develops, which is revealed by ultrasound, CT, MRI.

Visualization plays the leading role in diagnosing *mechanical jaundice.* Its tasks: to determine presence of obstruction, level of expansion and cause. Ultrasound is primary method. It determines dilation of bile ducts as distinctive feature of mechanical jaundice (fig. 8.41). During acute period dilation of ducts has no time to develop (when bilirubin indicators suggest mechanical jaundice, repetitive ultrasound, dynamic hepatobiliary scintigraphy, cholangiography is performed).

CT with intensifying enables to identify better than ultrasound, dilation of intrahepatic ducts, and the intrapancreatic part of choledochus is better visualized. CT is better than ultrasound in visualizing distant obstruction of choledochus. CT limitation: gallstones identical in densities with bile are not visualized. CT-cholangiography is a method providing imaging (on the basis of spiral CT) of all

contrasted enhanced a biliary tree as opposed to separated into layers at common CT. It is similar with percutaneous transhepatic cholangiography (PTC), endoscope pancreatic cholangiography (EPC) in visualizing the majority of stones in bile ducts and, as a rule, acknowledging or excluding biliary obstruction.

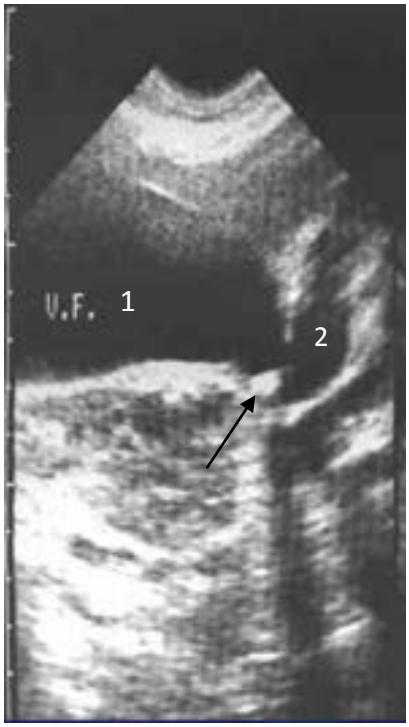

Fig. 8.41. Ultrasound of gallbleadder. Increased gallbladder (1) and choledochus (2). In the field of a neck of a galldladder stone (arrow), giving an acoustic shadow

The greatest attention attracts MR-cholangiopancreatography which provides with excellent imaging of all biliary tree. In 80-90 % of cases – a pancreatic duct and its leading branchs without injection contrast agents. MR-cholangiopancreatography is second to direct cholangiography in visualization of ducts and assessment of malignant strictures. But its advantage is in its possibility to visualize both sides of place of obstruction (fig. 8.42).

Fig. 8.42. MR – cholangiography. T2-WI. In the choledochus a stone in the form of hypointensive formation (arrow)

Alternating, or incomplete obstruction of ducts (cholelithiasis), will better be recognized at direct cholangiography and at dynamic scintygraphy with ^{99m}Tc-labeled imidodiacetic acid.

The best methods of detection of bile ducts narrowings are direct cholangiography: endoscope pancreatic-cholangiography (EPC) and percutaneous transhepatic cholangiography (PTC).

Indications to direct cholangiography:

• non-informative data of ultrasound and CT; however it does not visualize changes outside the duct lumens unlike these methods;

• differential diagnostics of obstructions with steep duct rupture and non-visualizing at ultrasound and CT tumours or stones.

8.3. Radiological examinations of pancreas

Examinations of pancreas usually start with ultrasound; however CT and MRI has its advantages. The angiography is applied when CT detected negative or doubtful results. The radiography and fluoroscopy are seldom carried out, as there are more informative methods of visualization.

Pancreas ultrasound. Examination is carried out in the morning (as in mornings not much gas is swallowed, therefore less gas in intestine prevent from performing ultrasound). The tissue of pancreas has homogeneos echostructure. Echogenicity is the same as in liver or a little bit higher. A duct of pancreas in norm is no more than 1,5-3 mm in width. Average thickness of pancreas at adults (the front-back dimension): head of 2,5-3,5 cm; body – 1,75-2,5 cm; tail 1,5-3,0 see. At children: in 3 years of the head of – 8 mm; body –5 mm; tail –5 mm; in 13 years: head of 2 cm; body – 1,5 cm; tail – 1,5 cm (fig. 8.43).

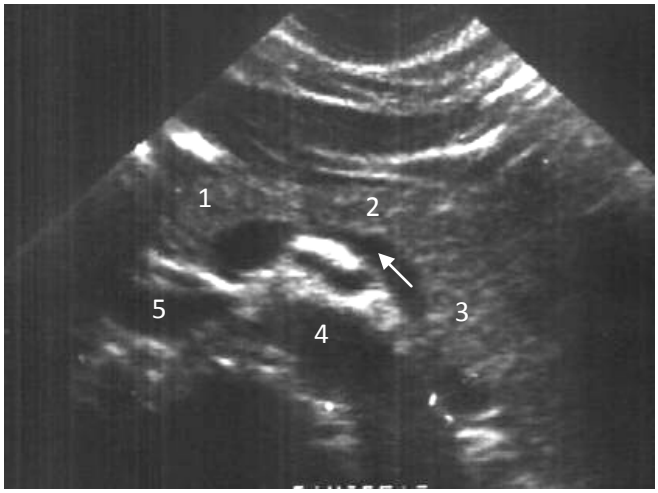

Fig. 8.43. Ultrasound of the pancreas. 1 - head of pancreas, 2 - body of pancreas, 3 tail of pancreas, splenic vein (arrow), 4 - aorta, 5 - inferior vena cava. Norm

Spatial resolution of ultrasound at focal lesions of pancreas is 1 cm.

CT. Advantage of CT over ultrasound lies in its better resolving power (3-4 mm). Besides if compared with ultrasound, CT can visualize pancreas at meteorism. CT also visualizes better structures surrounding pancreas (fig. 8.44).

Fig. 8.44. CT-scan pancreas in norm:
1-head of pancreas;
2- body of pancreas;
3-tail of pancreas

MRI is very accurate in the diagnosis of pancreatic duct abnormalites and pancreatic tumour.

Endoscopic pancreatic cholangiography (EPC). The procedure enables to estimate the status of pancreatic duct and its branches. Indications: making decision on the possibility of surgery at pancreatic cancer, connections of pancreatic ducts with cystic formations.

Radiological signs of pancreatic diseases.

Acute pancreatitis. In mild cases ultrasound image of the pancreas can look normal. In heavier cases edema of organ and related to it enlargement and echogenicity dicrease are detected. Wirsung duct can be enlarged. Fluid is identified at abscess, necrosis, marked exudation (fig. 8.45).

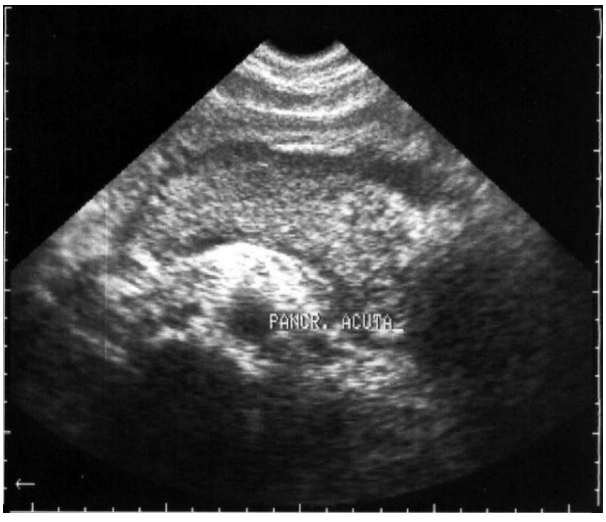

Fig. 8.45. Sonogram of pancreas. Diffusely enlarged and relatively hypoechoic if compared to the liver, owing to interstitial oedema. Acute pancreatitis

CT is indicated for the patients with non-informative ultrasound because of abdominal distention (fig. 8.46), which frequently accompanies acute pancreatitis (up to 1/4 patients), the patient with clinical presentation, suspicious of the necrotic or complicated pancreatitis.

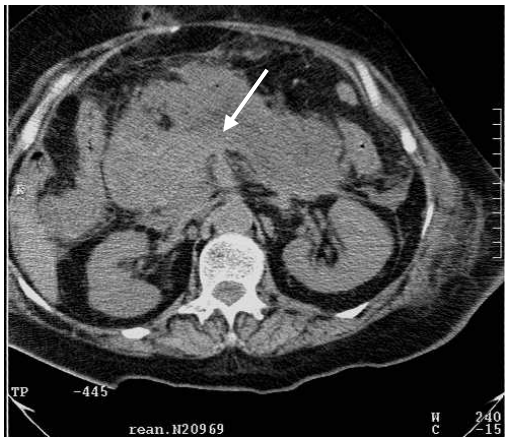

Fig. 8.46. CT. The pancreas enlarged with ill-define borders (arrow). Acute pancreatitis

Advantages of CT over ultrasound:

• necrotic form can be differentiated more precisely from hydropic one: areas of necrosis do not increase unlike edematous tissue of pancreas;

• is better than ultrasound in assessing peripancreatic dissemination of inflammatory exudate and differentiating fluid aggregations from the phlegmonous infiltrate, consisting from edematous and necrotic tissues of pancreas and retroperitoneal space;

• massive hemorrhage at erosions of vascular walls is recognized more precisely.

CT with intravenous contrasting can confirm abscess suspected by clinical presentation or ultrasound data, by demonstrating its surrounding ring of contrast intensifying. But puncture with aspiration under ultrasound or CT control can detect infection and abscess formation more precisely.

MRI also it is accurate in identifying of pancreatonecrosis and can be alternative to CT with contrasting.

Chronic pancreatitis. The calcification of pancreas is frequently detected at radiography. Ultrasonic at early stages of disease can reveal unchanged or not-enlarged, hypoechoic with duct dilation pancreas. At the fibrous form of a chronic pancreatitis the sizes of a pancreas decrease, appears strengthened and nonhomogeneous echoes of pancreatic tissue. The pancreatic duct may have areas of dilations and narrowings because of stenoses. Concrements and calcifications are revealed. They produce focuses of hyperechogenicity with distal acoustic shadow.

CT specifies pathomorphology of affection, especially one of the most important signs – calcifications in pancreas (fig. 8.47).

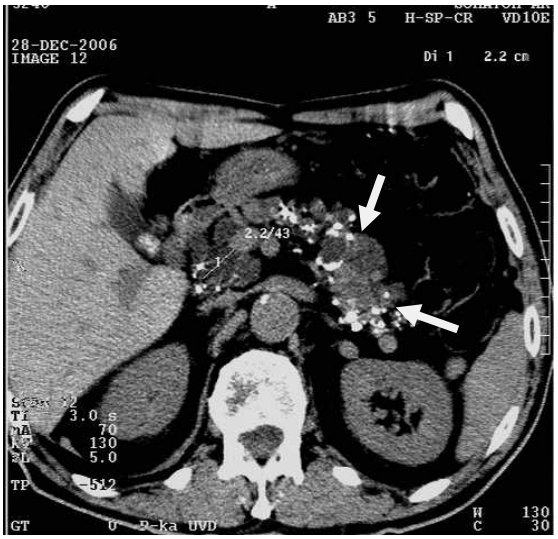

Fig. 8.47. CT. The pancreas is deformed. Its structure non-uniform. Calcifications in pancreas (arrows are specified separate calcifications). A chronic pancreatitis

Pancreatic cancer. Ultrasound enables to recognize the majority of tumours of the head (fig. 8.48) and surrounding departments of pancreas body and their influence on pancreatic and common bile ducts; it is less informative at cancer of tail part and caudal department of body and it is not enough for setting surgical treatment. The most common pancreatic cancer indication is enlargement of its departments. In 70 % of cases the tumour is localized in the area of pancreatic head. Usually cancer is revealed by heterogenous echostructure. Wirsung duct gets bigger. The choledochus dilates as well at cancer in the area of the head of pancreas.

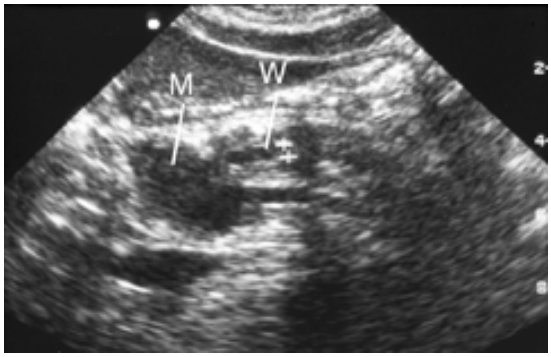

Fig. 8.48. Carcinoma of the head of the pancreas. Transverse sonography upper abdomen demonstrates a hypoechoic mass (M) in head of pancreas and moderate dilatation of Wirsungian duct (W) [101]

Capabilities of CT in diagnosing pancreatic cancer (fig. 8.49):

- native CT is not enough sensitive to small tumors;
- method of a choice is CT with intravenous contrasting, providing more precise cancer detection and more reliable estimation of its local diffusion if compared to ultrasound;
- diagnostics of cancer in earlier stage (pancreaticoduodenal resection is

possible) are improved by CT with contrasting, at which false-negative results compound only 1-3 %. The images received at the moment of maximal contrast between intensifyed parenchyma and low-vascularized tumour, enable to detect tumoir sized up to 1-2 cm and specify their borders; pancreatic duct can be visualized better.

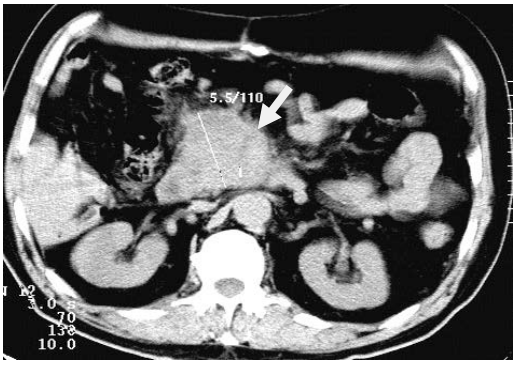

Fig. 8.49. CT-scan. Carcinoma of the head of the pancreas. Large irregular mass originating in the pancreatic head with lower and heterogenic attenuation (arrow)

MRI can serve as an alternative to CT (fig. 8.50).

Fig. 8.50. MRI of the abdomen at the level L 2. T2-weighted image. Increase deformation and contours of the pancreas (arrow). Cancer of the pancreatic head