URINARY TRACT IMAGING

Radiological researches are appointed to each patient at whom assume diseases or damages of kidneys, ureters, urinary bladder.

Assignments are carried out by the attending physician, formulating the primary goal of research. In contact to a radiologist the order and volume of radiological researches is established.

<u>Ultrasonic scanning of kidneys.</u>

In connection with harmlessness and high information ultrasound in most cases is the first method with which research in urological clinic begins.

For ultrasound kidneys of the patient does not require special preparation, however at exception of the products causing a bulging of intestines, ultrasonic diagnostics becomes more exact.

Detection of kidneys at ultrasonic comes nearer to 100 %. However at patients with adiposity III-IV of a degree (much adeps absorbing a significant part of ultrasonic energy), at hypoplasia, dislocation, fatty or amiloid regeneration of a kidney they define hardly.

Ultrasonography it is carried out both on the part of a back, and on the part of an abdominal cavity.

At inspection on the part of an abdominal cavity the right kidney define through a liver. The left kidney at such position of a body of the patient define hardly because the intestines present. Researches of kidneys are carried out through the right and left side in a prone position and standing in various directions.

On ultrasononic scan in longitudinal direction the normal kidney has the oval form, precise contours. The size of it on the average at the adult makes 7,5-12,5 cm, width of 4,5-6,5 cm, thickness 3,5-5 cm. Distinction in length of kidneys does not exceed 1,5-2 cm. The kidney at newborns proportionally is more on volume and weight, than at the adult. The parity of thickness and and lengths of kidneys at newborn makes width 1:1,5:2; at the adult - 1:1,5:3. At newborn the length of a kidney is 4-4,5 cm, width - 2,5-2,7 cm and thickness - 2-2,3 cm. The kidney is covered connective tissue with a capsule appearing as a continuous light strip in width in 1-1,5 mm. ***Renal cortex and the medullary substance causes dark area (almost free from echoes – hypoechoec) width ≈15 mm (up to 25 mm). This peripheral zone represents parenchyma. Normal corticate the substance of kidneys has smaller echoes, than a spleen or a liver. The central zone defines as a congestion echoes with non-uniform reflection, corresponds renal pelvis, major and minor renal calices. In norm the front-back size renal pelvis does not exceed 1,0 cm. In norm the ureters almost not defines, except for the top third.***

Owing to low selfdescriptiveness ultrasonic of ureters and vessels of kidneys except for rare cases of the big practical value has no.

Opportunities of ultrasonic as method of initial visualization:

• allows to estimate position of kidneys, dislocation at breath, the sizes, the form, outlines, a differentiation of parenchyma on a renal cortex and renal medulla; renal sinus with renal pelvis and calix and perirenal tissues;

• focuss concerning character of disease, necessity of the further visualization and a choice of its method;

• the majority of stones in kidney and urinary tract is visualized;

• the method is high-sensitivity to obstruction of urinary tract;

• allows to reveal diffuse and focal changes the parenchyma of kidneys.

Lacks:

• does not give the information on function of kidneys;

• are badly visualized uretes.

<u>Ultrasonic of the urinary bladder.</u>

Safety and informatively enough. Probably only at well filled bladder urine or a disinfectant solution. The sizes depend on a degree of its filling (average capacity 250-300 ml). The filled bladder in norm is free from echoes, has precise contours, is located in a cavity of a small pelvis, behind symphysis pubica. More often the oval or pear-shaped form. Thickness of a wall of a bladder in norm at its filling makes 3-6 mm, and a mucous membrane - less than 2 mm.

Prostate appears directly behind of a bladder and in norm has equal outlines. The tissue of prostate is submitted by continuous alternation hypoehoic sites and fine dot and linear structures. Length prostate is 2,5-4 cm, front-back the size - 1,8-2,5 cm, cross - 2,7-4,2 cm.

At research through urethra, or, that is more often, through rectum, it is possible to receive images of a top, an average part and the basis prostate.

Now ultrasonic has taken the central place in research of urinogenital system since has the big diagnostic value, is simple, cheap and harmless. Usual ultrasonic gives the information on morphology, but not about function. ***Ultrasonic - an excellent auxiliary method at various intervention procedures, such as nephrostomy, biopsy and drainage.***

X-ray researches

Include, first of all, a survey film. Preparation - to clear intestines on the eve in the evening and in the morning in day of research. In a x-ray study the patient should be on an empty stomach. Exception: patients with sharp renal colic. Perform a survey a film 30×40 cm. It should cover area of all urinary tract, starting from X thoracal vertebra and finishing the symphysis pubica.

Interpretation of survey film includes a rating of quality of an image, definition of correctness of a projection, studying of a shadow picture of soft tissues, a bone skeleton, organs of GT, kidneys, ureters, a bladder.

Kidneys are located as bean shaped shadows at a level of XII chest - II lumbar vertebraes at the left and I lumbar - III on the right. Top polies are located closer to a median line, than bottom. Contours of shadows of kidneys in norm equal also look like arched lines, convex in lateral the side.

Size of kidneys at radiological research at adults: length of 11,5-13,7 cm, width - 5,1 - 6,7 cm. Normal ureters in a survey film are not visible. The emptied bladder in a usual film is not seen. Survey radiography of kidneys and a bladder in a direct projection helps to reveal stones and gas. It is a general part of all usual radiological researches of urinary tract which should precede researches with use contrast agents.

Intravenous urography (IU). The IU is impotant mode of research of kidneys. Opportunities of its application concern to advantages of IU in children's practice, at narrowings of urethra , at traumas of kidneys and renal bleedings.

At intravenously enter contrast substance (on 1 kg of weight - 1 ml of the solution containing 300 mg of iodine per/ml).

Contra-indications to research: the increased sensitivity preparations of iodine and a bad status of the patient.

Films are made during the first 60 second, that allows to see kidneys during time nephrography phase, but are more often trough 5-7 min. and 20-25 min. In nephrography phase there is a distinct shadow of all renal parenchyma, containing contrast substance, which arrives in renal calyx and pelvis. At the healthy person the shadow renal parenchyma is homogeneous. Further there are an image pelvises. Displacement renal pelvis lower than III lumbar vertebra - the abnormal phenomenon. Kidneys are mobile at breath; their excursion in vertical a direction can achieve 10 cm. At research in horizontal and vertical position of the patient displacement of a kidney in identical conditions of a respiratory pause should not be more than 1,5 vertebraes. Renal pelvis usually settles down within the limits of a kidney, but can settle and extrarenal. The shortest distance from a contour pelvis up to lateral a contour of a shadow of a kidney in norm - 2-3 cm. The form renal pelvis is various, but the basis it is more often triangular, a longitudinal axis of a body. Top and external borders of pelvis convex, bottom - concave. The capacity of it on the average 6-7 cm^3. Are available major and major and minor renal calices. The major renal calices usually 3, they connect pelvis to major and minor renal calices. In each major renal calix distinguish the basis - its junction with pelvis, neck - an average part of major renal calix as the lengthened tubule and top from which one or several small calices depart. Number of minor renal calices - from 4 up to 20. In each minor renal calix distinguish three parts: neck - the narrowest part in a place of begin minor renal calix from major renal calix, actually a calix and the arch which surrounds cone shaped papilla. As minor renal calices settle down in different planes, to receive the image of each of them not always it is possible, therefore in many cases it is necessary to resort to multiprojective research.

During consideration IU it is possible to observe various phases of bleeding the top urinary tract, since calices and pelvis and finishing terminal departments of ureter. As bleeding of calices occur during different time on normal IU one calix appear filled with contrast substance, others do not contain it, as are in a phase of reduction. Similar phases of a systole and diastole come to light on a series films.

Normal ureter on IU it does not happen, it is in regular intervals filled with contrast substance on all an extent and it ***is represented as shank shaped shadows which correspond to filling by contrast substance separate segments in a phase of a systole and diastole.***

At the majority of people segments it happens 3, less often – 2. Ureters with contrast substance are visible as rod in the width from 3 up to 10 mm. IU allows to make also radiological research of a bladder (descending cystogram).

Advantages IU:

1) Fast research of all uric ways;

2) An opportunity to reveal structure renal pelvis and calices;

3) Detection of stones, is especial in ureters;

4) Exact diagnostics of obstruction.

Lacks of a method:

1) Dependence on functional ability of kidneys;

2) A unsatisfactory opportunity to estimate structure of renal parenchyma for presence cysts or solid formations;

3) All kidney contours to find out difficultly, frequently it is not possible to find out the formations which are starting with forward or back departments of a kidney;

4) Impossibility to estimate perirenal space;

5) Necessity to use contrast agents and radiation;

6) Impossibility to investigate a level of glomerular filtration. However last can be estimated if to take blood of the patient through 3-4 ч after introduction of contrast substance and to investigate it on the contents of iodine.

Ability of urography to show detailed anatomy renal pelvis and calices is important for diagnostics necrosis of papilla, tumours of renal pelvis and a urinogenital tuberculosis. The method is exact in diagnostics stones in urinary tract, but on sensitivity concedes CT.

Its role at obstruction of uric ways is discussed; the combination of a survey film, ultrasonic and scintigraphy represents alternative, but ***at presence of acute obstruction IU is the important diagnostic method. Congenital developmental anomalies, for example, adnation kidneys, rotation, variants of a structure renal pelvis and calicces, are very well visible with IU. At traumas when the minimal damage of a kidney is supposed, the urography enables fast and effective inspection.***

<u>Retrograde ureteropyelography.</u> The retrograde ureteropyelography is a direct introduction of contrast agent (75-100 mg of iodine / of ml, 7-8 ml) in a lumen of the top urinaty tract. The preparation can be entered through catheter, established in ureter at cystoscopy. Ureter filling defect seen on intravenous urography or retrograde ureteropyelography which may have many causes. Most commonly these are stones or less usually polyps or small urethelial tumours arising from the ureteric wall, or rarely blood clot.

The method is demonstrative for diagnostics:

1) Little changes mucous;

2) Diverticulums and cavities;

3) The various processes including and obstruction, when intravenous urography not was information;

4) Absence of the image of the top urinary tract at intravenous urography (in obvious cases, for example, at the big tumour, it it is more preferable CT);

5) At patients with risk of intravenous introduction iodine content contrast agent, limiting application IU;

The method is contra-indicated at acute inflammatory processes in kidneys and urinary tract and at macrohematuria.

Retrograde ureteropyelography almost is completely superseded by application CT and MRI.

<u>Angiography</u>: in this method catheter enter in venous or arterial systems. The end of catheter under the fluoroscopy control establish in a vessel included in researched area or leaving it. Renal angiography for revealing and differential diagnostics of volumetric formations it is used now seldom in connection with application of ultrasonic and, especially, CT. Angiograhy can be used in case of scheduled operation concerning an abnormal kidney or in case of a resection of a kidney. Other indications to renal angiograhy

include suspicion on a stenosis renal arterie, to an aneurysm. Angiograhy it is necessary before vascular operations, such as embolisation, an establishment stent or balloon dilating of renal arterie.

On a series of films in the beginning receive the image of an aorta and large branches departing from it, including, renal arteries (an early arterial phase), then a shadow fine arteries (a late arterial phase), further the common increase of intensity of a shadow of kidneys (nephrography a phase), a weak shadow renal veins and, at last, the image of pelvis and calices since the contrast substance is allocated from blood with urine. Renal arteries depart from an aorta almost under a directly angle at level I lumbar vertebra or a disk between it and II lumbar vertebra. Diameter trunk parts renal arteries makes 1/3-1/4 diameters of an aorta at this level. Length of the right artery of 5-7 cm, and left 3-6 cm. Contours equal and smooth, a shadow homogeneous and intensive. Diameter renal veins 1-1,5 cm, diameter vena cava inferior at a level of a gate of kidneys no more than 2,5 cm.

***Cystography.* Films at IU usually make for research of a bladder through 0,5 - 1 hour after introduction in blood of contrast agent. Considerably more precise image is achieved by means of ascending cystography, carried out with liquid or gaseous contrast substances. The normal bladder has oval, spherical or the pyramidal form. The bottom border of it settles down at a level of symphysis pubica, top achieves a level III sacrum vertebra. At insignificant filling a bladder by contrast substance the normal bladder gets the saddle form dependent on pressure of a uterus from women. Contours equal are smooth.**

More often cystography make for diagnostics posttraumatic or postoperative extra bleeding, revealings diverticulum and bladder-ureter a reflux.

***Urethrography.* It can be made ascending (at urination) or retrograde. The image during time of urination gives the information on a back urethra, and the forward department of a urethra is visible not so well. Retrograde urethrography gives more information on a forward department of a urethra, than about back.**

***Computerized tomography.* CT - an excellent method for revealing and diagnostics volumetric formations of kidneys, and also for definition of a stage of malignant tumours of a kidney. The method is very informative in diagnostics stones. CT surpasses ultrasonic in revealing perirenal, periureter and pelvic the processes touching urinary tract. CT is a method of a choice for a rating of consequences of a trauma of kidneys when suspect heavy damage of body. CT - the best method of visualization of adrenal glands and a method of a choice in diagnostics of these diseases. To new ways of visualization renal pelvis and calices carry it computerized tomography urography (at presence of a spiral tomograph), carried out with intravenous contrast enhancement. Three-dimensional reconstruction on a spiral computer tomograph shows the image of vessels of kidneys.**

MRI.

Visualization pelvics bodies (a bladder, prostate, a uterus and genitals) is one of important fields of activity MRI. The method gives the valuable information on a stage of tumoral process, and, more precisely, than at CT, volumetric formations come to light. Now MRI kidneys it is carried out when the diagnosis is not clear after CT and ultrasonic, is indication if present intolerance of contrast preparations, at vascular defeats. MR-urography (MRU) - completely non-invasion a method; does not demand introduction contrast agent, does not depend on function of kidneys and it can be applied at patients with renal insufficiency. On the published data, MRU enables to receive the image of urinary tract comparable on quality and results with IU and even from a retrograde ureteropyelography. Expansion of uric ways is visualized, the level and, in most cases, the reason of obstruction are distinguished. MRU with paramagnetic contrast enhancement displays both anatomy of urinary tract, and function of kidneys, it is comparable with dynamic nephroscintigraphy. Advantages MRU allow to see in it a method of the future.

Radionuclide renal imaging.

Radionuclide renal imaging of kidneys in clinic were received with general distribution and a recognition.

They enable to study a functional status: 1) renal tubular cells; 2) glomerular filtration; 3) excretory phase; 4) a status of a vascular channel and parenchyma of kidneys, topography of its.

Distinguish the following kinds radionuclide researches of a status of kidneys:

1) radiorenography (studying mainly the function of renal tubular cells and excretory phase with ^{131}I-orthoiodohippuric acid);

2) dynamic nephroscintigraphy (research glomerular filtration with - ^{99m}Tc-DTPA(the pharmacological moiety is a pentavalent chelating agent);

3) angyonephroscintigraphy (research renal a blood-groove with ^{99m}Tc-DMSA. The pharmacological moiety ^{99m}Tc- DMSA is dimercaptosuccinic acid).

<u>Radiorenography</u>. The technique consists in graphic registration of changes of a radio-activity above each kidney and above heart area after intravenous introduction^{131}I-orthoiodohippuric acid. . On character elimination ^{131}I-orthoiodohippuric acid is mainly by renal tubular cells (80 % secretion by renal tubular cells, 20 % are filtered by glomerulars). Radioiodine can entered in a thyroid gland, therefore it is necessary blockade of a thyroid gland with potassium iodine.

Two curves reflect work of kidneys, and one above heart -clearence.

The first segment a curve - a quality indicator of blood supply of a kidney. Time of passage initial ^{131}I-orthoiodohippuric acid (a vascular segment) proceeds on the average 17-20 sec.

The second segment - slower rise of 2,5-4 min., it is a secretory phase. This phase is regarded as reflection, at least, three factors: accumulation of ^{131}I-orthoiodohippuric acid by renal tubular cells, removing of a preparation in a gleam tubulars and clarifications of blood from a preparation. The point of the hinge rise of a curve reflects the period of time balance between process of accumulation and excretion of ^{131}I-orthoiodohippuric acid in a kidney, it is the end of II segment.

The third segment reflects removing a preparation from a kidney. $T_{1/2}$ 8-10 min. (up to 15 min.). In norm the difference in height of amplitude of curves of the right and left kidneys does not exceed 10 %, as well as time parameters.

The third curve of radiorenography (above area of heart) - a curve clearance of ^{131}I-orthoiodohippuric acid, shows speed of clarification of blood from radiopharmaceutical. The first 3-4 min. from the beginning of research are reflected with the common delution of ^{131}I-orthoiodohippuric acid, and during later period it is a parameter of total activity of kidneys.

It is defined effective renal flow of plasma: measure a radio-activity in blood on 20 min; 40 min. also compare to the entered activity under the special formula. Norm renal flow of plasma is equal 500-800 ml /min./1,73 of m^2. Selective decrease effective renal flow of plasma is observed at an arterial hypertensia, at heart and sharp vascular insufficiency.

<u>Dynamic nephroscintigraphy</u> (research glomerular filtration with - ^{99m}Tc-DTPA (the pharmacological moiety is a pentavalent chelating agent).

The glomerular filtration agent used is ^{99m} -Tc DTPA, of which 10–15 % is extracted on first pass. Receive the image of distribution given radiopharmaceutical in parenchyma of kidneys and graphic registration of a transfer of a preparation in kidneys.

Under the special formula (computer) pays off volume functioning of parenchyma (area) in %. Norm of 100-90 %. The glomerular filtration pays off under the special formula. There are special tables depending on age. On the average $T_{1/2}$ of glomerular filtration it is equal 100-140 ml / minutes. Half-time of cleaning up of blood in norm on the average-18 minutes.

<u>Angyonephroscintigraphy.</u> The renal tubular cell uptake marker in clinical use is ^{99m}Tc- DMSA. A dose of 2.5–3.0 MBq/kg (max. 80 MBq) is injected into the patient, the radionuclide is extracted by the renal tubular cells but not excreted into the tubuli, thus marking regions of poor renal parenchymal function. This is a static imaging method and in a sense functions as a chemical microsphere (perfusion agent). It is mostly used for the detection and follow-up of pyelonephritis. The pharmacological moiety ^{99m}Tc- DMSA is dimercaptosuccinic acid. The received information with ^{99m}Tc- DMSA allows to estimate renal a blood-groove as a whole in each kidney and its separate parts. Has the big diagnostic value in revealing infringements renal blood supplies in each kidney separately, that allows to estimate presence of a stenosis renal arteries.

The parameter is used: transit time - time from occurrence of the maximal intensity of speed of the account above an aorta till the maximal speed of the account on a kidney. In norm transit time of 8-9 sec.

So, radionuclide renal imaging, nuclear imaging methods able to evaluate bilateral renal function individually. There are three types of renal examinations available in nuclear medicine. There are radiopharmaceuticals to evaluate glomerular filtration, renal excretion and renal tubular cell uptake markers. In combination with pharmacological "stressors" such as furosemide (furosemide renography and captopril (captopril renography), these methods are used for a wide range of purposes to evaluate renal function in renal disease such as the follow-up of renal function in patients with renal congenital malformations and pyelonephritis. In the adult, the tests can be used to identify renal vascular hypertension, to assess renal function prior to nephrectomy and renal transplants.

In the initial study is normal or near normal, the patient is then administered the angiotensin converting inhibitor orally and the isotope study is repeated 1 hour later following reinjection of the radionuclides. If occur the stenosis of renal artery there is virtually no function in the kidney with stenosis oa renal artery. The healthy kidney has normal curve.

Radiological diagnostics of congenital anomalies of kidneys.

Aplasia of kidneys. On survey films, as well as on IU, the shadow of one kidney is absent, and renal pelvis and ureters are not filled by contrast agent entered intravenously.

The basic ultrasonic an attribute which should guard concerning unilateral aplasia, is a definition of obviously increased kidney owing to it compensation hypertrophies. From the opposite side the kidney is not found out.

With the help aortagraphy reveal only one renal an artery. With help CT and MRI, executed both with contrast enhancement and without it, reveal only one kidney and one vascular bunch.

Hypoplasia of kidneys. Distinguish unilateral and bilateral hypoplasia. At hypoplasia kidneys considerably the smaller size, however their macrostructure remains normal. It comes to light at intravenous contrast enhancement, thus there is no deformation renal pelvis and calices and there is no infringement urinary excretion. At CT and MRI it is possible to execute precisely measurements of kidneys, and at presence contrast enhancement to be convinced in their simultaneous contrast enhancement. At ultrasonic the kidney with hypoplasia has the smaller sizes, but ultrasonic structure is not broken.

The double kidney. The double kidney - one of the most often developmental anomalies of the top urinary tract. It can be one - and bilateral. Doubling on the one hand is observed more often, than from both. In anatomy-topographical understanding the double kidney represents the uniform body consisting of the top and bottom segments. The double kidney has two pelvis, two ureters and a uniform fibrous capsule. With the help of contrast enhancement researches can be revealed in one kidney two isolated pelvis and calices. CT is less informative, taking into account the limited opportunities of reception of images ureters. Presence of two isolated pelvis and calices in one kidney come to light on CT with the help of amplification and longitudinal reconstruction, and on MRI on frontal scans. At ultrasonic on a background hypoechoic structures parenchyma the increased kidney it is possible to reveal two hyperechoic central a complex.

Radiologycal diagnostics of inflammatory defeats of kidneys

Acute pyelonephritis. ***The majority of acute inflammatory diseases of kidneys attending with increase in their sizes.***

In addition to clinical methods it is shown the ultrasonic, being by the important initial technique since helps to see stones, hydronephrosis, into kidney or perirenal abscesses. To ultrasonic attributes of an acute pyelonephritis carry increase in the sizes of a kidney (but the kidney can have and the normal sizes), decrease echoes, expansion renal pelvis and calies. Little changes renal parenchyma, connected with inflammatory process, come to light better at CT, than ultrasonic, and will consist of spotty areas, characteristic for insufficient blood supply, small dense sites, puffiness perirenal fat. Typically on CT formation of microabscesses 0,5-1 cm. The density is close to density of a liquid (8-12 HU).

Angyonephroscintigraphy with ^{99m}Tc- DMSA also it is informative, since shows the located infectious centers before they become visible on ultrasonic or CT. Research with ^{131}I-orthoiodohippuric acid shows decrease of function renal tubular cells.

IU during acute inflammatory process in a kidney, as a rule, does not give the qualitative information though regarding cases the increase in a kidney is found out, moderate expansion renal pelvis calices and ureter and decrease of function of a kidney.

The heavy pyelonephritis at inadequate treatment or tolerance of flora to antibiotics can result in chronic inflammatory process or an abscess of a kidney. IU show non well defined a contour of a lumbar muscle on the side of defeat, diffuse increase in kidney or volumetric formation at its background, deformation renal pelvis and calices. At ultrasonic the abscess is seen as hypoechoic or anechoic volumetric formation with a liquid or dense inclusions in a liquid and with increased "through transmission" beneath. Walls an abscess look as hyperehcoic a ring. CT without enhancement shows the hypodensity zone within the limits of a cavity of an

abscess. Walls of an abscess with contrast agent application are enhancement, and contents - are not present. The similar information at MRI.

The chronic pyelonephritis. Disease seldom arises at patients with not changed urinary tract. Visualization apply, mainly, to specification of expressiveness nephrosclerosis. On IU it is defined reduction of the sizes of one or both kidneys, deformation renal pelvis and calices. The intravenous urography insufficiently precisely shows shrinkage of kidneys in comparison with scintigraphy. Ultrasonic marks an atrophy parenchyma and zones of fibrosis. CT shows shrinkage and roughness of a contour of a kidney. To distinguish pyelonephritis from hypoplasia displaying change of structure of kidney symphysis pubica helps the ultrasonic. MRI shows at hypoplasia uniform reduction renal artery and its branches.

Tuberculosis of the kidney. Tuberculosis of the kidney in its early stages may produce nonspecific changes such as papillary necrosis. With progression of the disease, the more characteristic findings of stricture of a renal pelvis, caliceal amputation, and cavitation may occur. Tuberculosis also causes ureteral strictures. A combination of renal and ureteral abnormalities such as strictures should suggest the diagnosis. The end stage of renal tuberculosis is a small, shrunken, nonfunctioning kidney that othen contain calcific debris (“putty kidney”).

Changes of chronic inflammation of the bladder include thickening and irregularity of the wall secondary to muscular and mucosal hypertrophy.

Nephrological diseases of a kidney

Acute glomerulonephritis. Kidneys are increased, reduced or their sizes do not vary. Biopsy of kidneys in many cases it is necessary for an establishment of the exact diagnosis. Each patient with renal insufficiency it is necessary to subject ultrasonic.

With contrast substances (urography, CT) it is necessary to avoid researches at patients with the reduced function of kidneys as contrast preparations can promote the further decrease of function of kidneys.

To early attributes acute glomerulonephritis it is possible to reveal decrease of glomerular filtration, established with the help ^{99m}Tc-DTPA.

Urinary calculus.

Calculus, renal, stone formation in the kidneys, described since the earliest records of civilization.

Stone formation may be due to metabolic abnormality, structural disorders or recurrent urinary tract infection. ***Because approximately 90% of all urinary tract calculi are radiopaque, the plain film of the abdomen is the keystone of radiological diagnosis.*** Calculi can be obscured or easily overlooked when they overlie bony structures (transverse processes of lumbar vertebral bodies or especially the sacrum). Numerous extraurinary calcific densities that overlie the urinary tract may be confused with uroliths, the commonly encountered ones being calcified costal cartilages, gallstones and vascular calcifications. Ureteric calculi can be confused with bone islands in the sacrum and phleboliths.

An intravenous urography can localize a calculus to the kidney or ureter, and evaluate the degree of obstruction the stone is producing. After intravenous contrast administration, stones may be either completely or partially obscured by excreted contrast or appear as a filling defect. The degree of obstructive uropathy often bears no relation to the size of a ureteric calculus. Perhaps the most consistent urographic finding with a ureteric calculus is the presence of a continuous column of opacified ureter expending from the renal pelvis to the site of the calculus. Some degree of ureterectasis is usually also present if ureteric obstruction has been present for more than a few hours.

Ultrasonography can differentiate renal calculi from other causes of pyelocalyceal filling defects such as tumours or blood clots. The sonographic diagnosis of a calculus is based on the demonstration of a highly echogenic focus that produces an acoustic shadow. Stones as small as 0.5 cm can be reliably detected in this manner. This technique assumes greatest importance when faced with a nonopaque filling defect on urography. Tumours and clots lack a distal acoustic shadow.

Recently, it has become apparent that noncontrast helical CT (HCT) has major advantages over intravenous urography in the evaluation of patients with urolithiasis. Noncontrast HCT studies can be completed much more rapidly than intravenous urography, as there is no need for oral or intravenous contrast administration or other patient preparation. Virtually all types of urinary tract calculi contain enough calcium to be visibly hyperdense on noncontrast HCT. ***It has been demonstrated that stones are more accurately detected with noncontrast HCT than standard radiography, nephrotomography, intravenous urography, or sonography.*** Noncontrast HCT provides no direct functional information. ***MR imaging has not yet had a major impact in this area because stones lack mobile protons and generate no signal with standard MR imaging techniques.***

<u>Renal cell carcinoma</u>

Renal cell carcinoma, (RCC), the most common renal tumour, comprising approximately 85% of all primary malignant renal neoplasms. Renal tumours are usually solitary, although bilateral tumours are encountered in approximately 2% of patients. Histologically, the most common type of malignant renal cell cancer is clear cell adenocarcinoma. Before widespread use of cross-sectional imaging (ultrasound (US), CT, MRI), renal cell cancer often presented as an advanced disease at the time of diagnosis. Today, however, there has been a shift to a smaller size and lower stage of renal cell cancer at the time of diagnosis. ***RCC may be locally aggressive, extending into the renal veins and inferior vena cava (IVC) or invading adjacent soft tissue structures. RCC can metastasize by lymphatic and haematogenous routes.*** Common sites of haematogenous metastases include bone, liver, and lungs. Nodal metastases commonly involve pararenal and para-aortic nodes and may also include mediastinal and pulmonary hilar nodes.

Imaging. Imaging plays an important part in the detection, characterization and staging of renal cell cancer. Although the intravenous urogram (IU) is still often used as the initial study in the search for renal masses, it has been shown that in the presence of a CT-confirmed renal mass, detection by IU is only 21% when the lesion is smaller than 2 cm, 52% when the lesion is 2–3 cm, and 85% when the lesion is 3 cm or more in diameter. A normal IU, therefore, does not exclude the presence of a renal mass.

At IU characteristic attributes of a tumour can be revealed:

1) Increase in the sizes of a kidney, increase in distance between cavities of a kidney and its contour, displacement of a kidney, rotation around of a longitudinal axis;

2) Deformation renal pelvis, defect of its filling, serrated of pelvis contours;

3) Changes on the part of calices: partial or full disappearance; narrowing or expansion, and displacement of calices;

4) Change of ureter position and narrowing it in the top department due to the big tumour of the bottom pole of a kidney and metastasises in region lymph nodes.

When compared with CT, US demonstrates detection of 60% of lesions smaller than 2 cm and 83% of lesions between 2 and 3 cm in size. Lesion detection on contrast-enhanced MRI (90–97%) equals that of CT (89 – 99%). US, CT, and MRI have all been used with varying degrees of success in the characterization of renal masses. On US, the appearance of renal cell carcinoma is variable. Approximately 86% of tumours are isoechoic, 4% are hyperechoic, and the remainder are hypoechoic as compared to the adjacent renal parenchyma.

Ultrasonic is an initial method of visualization of RCC. RCC at ultrasonic it is defined as formation wrong spherical or the oval form with rough contours. In most cases the cancer of a kidney has non-uniform structure; in parenchyma appear additional echoes, caused cysts and necrosis sites, calcifications, haemorrhages. Deformation of a kidney and increase in its sizes frequently comes to visualization. Deformation, displacement or reduction renal pelvis and calices is quite often defined.

Ultrasonic as an initial method of visualization of kidneys allows:

- ***to find out the majority of cancer tumours;***
- ***to distinguish them, since the sizes of 4-5 cm, from benign tumours on not homogeneous structure;***
- ***to reveal metastasises in lymph nodes and a liver;***
- ***to exclude defeat of the second kidney;***

Colour Doppler sonography using frequency shift determinations has demonstrated some utility in differentiating benign from malignant lesions. Power Doppler sonography, which is even more sensitive to flow than conventional colour Doppler imaging, may provide additional information in characterizing renal lesions. Although US is useful in characterizing renal masses, it is inadequate in staging renal cell carcinoma.

The CT appearance of renal cell carcinoma varies with tumour size and vascularity. When large enough, these tumours appear as masses that alter renal contour or intrarenal architecture. Detection of small lesions is facilitated by rapid sequence scanning techniques during administration of contrast material because abnormal enhancement may be evident even when renal contours are normal. ***Heterogeneous enhancement is characteristic, but after administration of contrast medium, renal cell carcinomas typically appear less dense***

than surrounding renal tissue. Large intralesional vascular channels and retroperitoneal collateral vessels may also be present. Renal cell carcinomas tend to have a solid growth pattern, attenuation values of 20 Hounsfield units (HU) or higher, an increase in heterogeneous enhancement is characteristic, but renal cell carcinomas typically enhance somewhat less than surrounding renal tissue.attenuation values of at least 10 HU after administration of contrast media. Initial experience with spiral CT suggests that this technology may offer more complete CT characterization of small indeterminate renal masses.

On MRI, renal cell carcinomas demonstrate variable signal characteristics depending on the degree of tumour vascularity and the presence or absence of haemorrhage, necrosis, calcification or iron particles in the tumour cells. In the absence of haemorrhage or necrosis, RCC tends to be isointense to normal renal parenchyma on both T1- and T2-weighted images. When intratumoural haemorrhage or necrosis is present, signal intensity can be heterogeneous on both T1- and T2-weighted images. Haemorrhage from a RCC may result in deposition of iron in the kidney and lower the signal intensity of the tumour on both T1- and T2-weighted images. This effect is not specific for renal cell carcinoma and may be seen with any haemorrhagic lesion or with systemic haemolysis. The differential diagnosis for a renal lesion appearing hypointense on both T1- and T2-weighted sequences also includes a fibroma, milk of calcium cysts, and other calcified renal lesions. Intralesional calcifications are not well depicted on MR imaging. ***Renal cell carcinomas have been well depicted on postcontrast T1-weighted fat suppressed images. On gadolinium contrast-enhanced MRI scans, tumours generally enhance to a lesser degree than the surrounding renal parenchyma.*** Lesion sensitivity is increased when dynamic postcontrast scanning is employed.

Imaging plays an important role in renal cancer treatment decision. The decision as to the type of surgery (nephron sparing; simple or radical nephrectomy) that can be performed in patients with renal cell carcinoma is helped by imaging. Because surgery provides the only effective therapy and because survival depends on local and distant extent, precise staging is critical for preoperative planning and prognosis.

Although CT has been the test of choice for staging renal cell carcinoma MRI appears to have a similar accuracy. Combined transverse and sagittal MRI planes are optimal for the evaluation of venous anatomy and the normal tissue – tumour interfaces.

The particular uses of MRI staging include determination of the origin of the mass, evaluation of vascular patency, detection of perihilar lymph node metastases and evaluation of direct tumour invasion to adjacent organs. ***On CT and MRI, diagnosis of lymph node metastases is based on detection of lymph node enlargement with nodes measuring larger than 1 cm in diameter in short axis considered abnormal. Approximately 60% of nodes measuring greater than 1 cm in transverse diameter, in the setting of RCC, however, have been shown to be inflammatory or hyperplastic in nature rather than metastatic.*** Lymph node enlargement due to inflammation/hyperplasia or to metastasis cannot be distinguished on the basis of imaging findings. ***MRI is a sensitive tool for determining the presence and extent of tumour thrombus and for demonstrating invasion of the wall of the inferior vena cava (IVC).***

In the assessment of thrombus extension into the renal vein or inferior vena cava, MRI has replaced venography. In renal cell carcinoma, thrombus extends into the inferior vena cava in 4–10% of cases. Typically, tumour thrombi enlarge the renal vein and inferior vena cava and cause the density of these vessels to be heterogeneous. ***The accuracy in the determination of IVC thrombus is 100% on MR imaging compared to 88% and 78% for CT and ultrasound, respectively. MR accuracy in determination of renal vein thrombus is lower at 88%.*** On MRI tumour thrombi are usually isointense to the primary tumour.

Visualization of tumour extension to the liver, spleen and psoas muscle is also improved with MR imaging. Overall staging accuracy of 80–94% has been found with MR imaging and is similar to slightly better than that achieved with CT. The overall accuracy of CT in staging renal cell carcinoma ranges from 67–91%. When each stage is analysed separately, the accuracy of MR imaging is similar to that of CT in patients with stage I and stage II disease, but with more advanced disease (stage III and IV), particularly involving a large tumour mass, MR staging has proven superior.

Because CT is less expensive and more widely available, CT remains the preferred cross-sectional imaging procedure for the detection, characterization and staging of renal lesions. Three-dimensional imaging and display of renal tumours using spiral CT has also recently been shown to serve as a surgical aid when planning partial nephrectomy.

MRI is reserved for those cases where CT staging is inconclusive, especially with respect to vascular extension and direct tumour invasion of neighbouring tissue or in patients with renal failure, or where there are other contraindications for the use of iodinated contrast media.

Arteriography in modern practice apply at tumours of kidneys seldom: for definition of anatomy of vessels at a planned resection of a kidney and embolization before surgery treatment.

Cysts. ***Simple renal cyst most often volumetric formations of a kidney. They come to light more than at 50 % of cases of patients with 50 years old are more senior. US signs of cyst include: absence of non-uniform structure, smooth and equal walls, density of contents meets to a liquid, distal acoustic enchancement.***

In general, renal cysts appear as nonspecific space-occupying lesions at intravenous urography, a well-defined anechoic lesion with distal acoustic enhancement at US, a non-enhancing discrete fluid density lesion at CT, and a non-enhancing well-circumscribed lesion of fluid signal intensity characteristics at MRI.

Pharmacological-ultrasonic mode with application of diuretic drug – furosemidum promotes differentiation diverticulum of calices and hydrocalix (expansion after furosemidum) from cysts.

Nephroscintigraphy shows a zone of the lowered accumulation of a preparation.

Renal trauma part of a major abdominal trauma, occurring in 8–10% of all blunt and penetrating abdominal injuries. Most blunt renal injury results from blunt impact trauma. The indications for performing an imaging assessment for renal injury after blunt trauma are controversial. Most patients with major renal injury demonstrate either gross haematuria or hypertension.

When renal imaging is considered after trauma, CT is the optimal modality. Limited IU may be performed to document the presence of two functioning kidneys if the patient's clinical status does not allow for performance of CT.

Sonographys not typically ***used*** in the acute assessment of potential renal injury, but can be used ***to*** follow previously ***documented renal injuries, such as extrarenal haematoma or urinoma, as well as to follow the course of post-traumatic hydronephrosis.*** In the acute setting portable sonography can be used to document the presence or absence of a kidney when one is not visualized by intravenous urography (IU). Further, Doppler sonography can be used to assess the patency of the renal artery and vein if a nonfunctioning or delayed-functioning kidney is seen by intravenous urography or CT scan. ***Generally, MRI does not have a role in the acute assessment of renal trauma.*** Surgical staging classifications for renal injury have been adapted to include observations from CT examination.

Grade 1. Renal trauma refers to minor renal injuries including focal or global renal contusion; superficial lacerations that do not extend to the collecting system; small or limited perinephric or subcapsular haematomas; and segmental renal ischaemic infarcts. These grade 1 injuries comprise 75–98% of renal injury seen with blunt trauma. Renal contusions generally appear as ill-defined areas of diminished attenuation with irregular margins. Oedema associated with contusions may delay renal urine excretion focally resulting in an irregular or striated-appearing nephrogram on CT scan. Contusions may also be accompanied by disruption of collecting tubules with focal interstitial staining of the renal parenchyma with contrast-enhanced urine (renal intravasation) that may be detected on follow-up noncontrast-enhanced CT scan studies. Segmental renal infarcts are relatively uncommon and primarily affect the upper pole. Often these are associated with stretching and thrombotic occlusion of segmental intrarenal, capsular, accessory renal artery, or main renal artery branch injuries. Segmental infarcts appear as focal, well demarcated, nonenhancing regions of parenchyma that are wedge-shaped and tend to involve the renal poles. In general, grade 1 injuries are managed with observation.

Grade 2. Renal trauma refers to major renal injuries including deep lacerations of the renal parenchyma that extend into the collecting system, limited extravasation of urine, and moderate to large perinephric or subcapsular haematoma. It is important to distinguish renal contrast extravasation from active haemorrhage. Renal contrast leak can typically be identified arising directly from a disruption in the renal collecting system. Contrast arising from the arterial or venous haemorrhage often appears before the renal collecting system is opacified, verifying its vascular origin. The management of major renal injury typically depends on the clinical picture and evolution of the injury with time.

Grade 3. Renal trauma refers to catastrophic renal injuries including major renal pedicle injuries involving either the renal artery or vein, renal parenchymal fragmentation with extensive haemorrhage, active haemorrhage of renal origin, and renal pelvic or disruption of the proximal ureter. Renal artery occlusion usually results from stretching of the renal artery beyond the elastic limits of the intima during rapid deceleration, followed by renal artery thrombosis. The injury typically occurs in the proximal third of the renal artery. ***CT scan findings are usually diagnostic demonstrating no or only patchy peripheral renal parenchymal enhancement from intact collateral vessels. The kidney may be intact but smaller than normal owing to lack of inflowing blood and may be displaced laterally from its usual location. Angiographic confirmation of renal artery occlusion is not necessary and only serves to diminish further any chance for successful renal revascularization.*** Revascularization is most likely to be successful within 2 hours of injury. Delayed revascularization hours to days after injury is occasionally successful. Main renal vein injury may produce extensive perirenal haemorrhage or if thrombosed may lead to an enlarged kidney with a delayed, but progressively dense nephrogram, ongoing haemorrhage seen as patchy areas of dense contrast material surrounded by less dense haematoma. When ongoing haemorrhage is detected in haemodynamically stable patients, selective angiographic embolization is preferred to maximize renal parenchymal salvage. Bleeding in unstable patients or those who require urgent surgery for other indications is best managed operatively.

Severe renal fragmentation is considered a catastrophic injury. If CT or renal scintigraphy indicates minimal residual renal function, or if ongoing haemorrhage or gross urine leakage accompany severe parenchymal disruption, nephrectomy is required.

Hydronephrosis. Hydronephrosis, dilatation of the intrarenal collecting system. It may be divided into obstructed and nonobstructed. In the former group, the obstruction may be mechanical or functional and may occur anywhere in the collecting system. If the obstruction occurs more distally in the ureter, then hydroureter (dilatation of the ureter due to a distal obstruction) is also seen. Among the diverse causes, the more common ones include: urolithiasis, tumour, stricture, vesicoureteric reflux, congenital abnomalities (ureteropelvic junction obstruction, posterior urethral valves), and extrinsic compression (retroperitoneal fibrosis or lymphandenopathy). Nonobstructed hydronephrosis, also known as "urinary ileus", may be associated with previous obstruction or urinary infection.

In the acute state, the affected kidney is enlarged and of smooth contour. Atrophy and fibrosis are seen with long-standing hydronephrosis. Infection is a serious complication of hydronephrosis. An infected and obstructed collecting system is known as pyonephrosis, and the affected patient can quickly succumb to sepsis.

Hydronephrosis is easily detected by ultrasound. A dilated intrarenal collecting system is imaged as enlarged anechoic fluid structures, which communicate with each other to form the renal pelvis. In contrast, the multiple cysts in polycystic renal disease are separate and do not communicate with each other. Internal echoes are seen in the dilated collecting system in the setting of pyonephrosis. While ultrasound usually cannot distinguish between obstructed and nonobstructed hydronephrosis, excretory urography may provide additional information in that it may demonstrate the level of obstruction. Forniceal rupture is a complication of hydronephrosis in excretory urography; it may result from a sudden increase in urine volume due to contrast-induced diuresis.

Hydronephrosis can also be imaged by CT or MRI, though the expense of MRI precludes its use given the usefulness of the other imaging modalities for this purpose. CT is particularly helpful when imaging hydronephrosis due to obstruction from an abdominal or pelvic tumour. Not only can it depict the level of obstruction, CT can often demonstrate the cause and its extent, as well as mass effect upon the adjacent structures.