MINISTRY OF HEALTH OF UKRAINE
ZAPORIZHZHYA STATE MEDICAL AND PHARMACEUTICAL UNIVERSITY
DEPARTMENT OF PEDIATRIC SURGERY

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PEDIATRIC SURGERY

DIAGNOSIS AND TREATMENT OF URINARY SYSTEM INJURY IN CHILDREN

TUTORIAL

Zaporizhzhia
2026

616.61/.62-001-053.2(075.8)
S71

Approved at the meeting of the Central Methodological Council of ZMFU and recommended for use in the educational process (Minutes No. _ of _____ 20)

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Diagnosis and treatment of urinary system injury in children / Under the general editorship of Professor Spakhi O.V. [et al.]. - Zaporizhzhia: ZMFU, 2026.-106 p.
For students of higher medical educational institutions of III-IV level of accreditation.

The manual provides data on the main criteria for diagnosis and tactics of treatment of urinary trauma that require early surgical correction. The tutorial contains information necessary for self-preparation of 5th- 6 th year students, interns, pediatric surgeons for practical classes in pediatric surgery. The tutorial was developed taking into account modern views on the clinic, diagnostics, additional examination methods, tactics of treatment of children with surgical diseases and congenital malformations

616.61/.62-001-053.2(075.8)
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Preface

For the successful treatment of any disease, especially a disease that requires surgical treatment in childhood, its accurate and timely detection is of great importance. Therefore, in surgical practice, the widespread use of various special research methods is relevant, which differ from generally accepted physical research methods (examination, palpation, percussion and auscultation) in objectivity and allow you to more accurately establish the nature of the pathological process affecting the organ and determine the zone of its spread to other organs.

The problem of timely diagnosis and treatment of kidney and urinary tract injuries remains relevant in pediatric surgery today.

With the development of medicine, new knowledge appears in the course of the pathological process and the means of their treatment. Therefore, knowledge of diseases will allow you to timely determine the leading syndrome of the disease, conduct intrasyndromic diagnostics, correctly interpret the results of additional examination methods, correctly diagnose the child and choose the right treatment tactics. Diagnostic and tactical errors can become fatal in treatment, which determines the relevance of this manual and has the general goal of being able to carry out therapeutic and diagnostic measures for children with these diseases at the modern level and apply the basic principles of rehabilitation in the interests of ensuring timely assistance to patients.

The diagrams and some of the figures are the author's, otherwise the source is indicated.

The tutorial corresponds to the working curriculum "Pediatric Surgery" and covers most topics.

I. Relevance of the topic

Traumatic injuries of the upper urinary tract in childhood are common. According to leading scientists, they make up 3% of all injuries in children. School-age boys are particularly affected, with the largest number of victims occurring in the spring and autumn months of the year. Most children are victims of street injuries, in second place is domestic and sports injuries. Damage to the ureters can occur during complex surgical interventions on the pelvic organs. Closed trauma in children is more common than open trauma.

When choosing the optimal treatment tactics, it is important to understand the mechanism of occurrence of the pathological process in the injured kidney, which is complex and is due to many factors, including the strength, direction of the blow and the nature of the traumatic factor, the patient's body structure (the development of subcutaneous adipose tissue and the muscular layer of the lumbar region, softening the blow), the condition of the kidneys (the function of each kidney in particular, the presence of hydronephrotic transformation, cysts, developmental anomalies).

Introduction

Trauma is the leading cause of death, accounting for almost 50% of deaths among children aged 1 to 17 years. Urinary tract injuries occur in 3-10% of patients that arise from blunt or penetrating trauma and are second only to injuries to the central nervous system in the frequency of childhood injuries. However, death due to injuries to the genitourinary system is rare.

Although a pediatric urologist is rarely involved in the initial resuscitation of a patient with injuries, the surgeon relies heavily on him to deal with complex injuries to the urological system. A team approach to management provides the highest level of knowledge in reducing morbidity and preventing mortality.

The anatomy and physiology of children differ in many ways. Pediatric patient management should be adapted to reflect these differences. There are several aspects in the evaluation of patients with injuries that are specific to the child population.

2. Embryonic development of the kidneys.

At the **3rd** week of intrauterine development, the formation of pronephros occurs, which is located extraperitoneally at the cranial end of the embryo (**stage I**). The prorenal gland, not functioning, undergoes reverse development;

in **the 4th** week, the stage of mesonephrosis (**stage II**) begins. Tubules and excretory ducts are formed, which open into the cloaca;

at **5-6 weeks,** metanephros or a permanent kidney begins to form in the caudal part of the embryo (**stage III**

In the embryonic development of the kidneys, it should be noted:

A. The formation of the urinary system occurs in stages from two different parts of the mesoderm, which are subsequently connected;

B. The kidneys are laid and formed in the caudal part of the embryo, and then "rise" from the pelvic cavity into the abdominal cavity and turn 90 degrees.

C. The formation of kidneys and ureters from different bookmarks of embryonic tissue can lead to the appearance of anatomical abnormalities in the number of kidneys and ureters

D. As a result of a violation of the "lift" of the kidneys from the pelvic cavity, the appearance of kidney dystonia and a change in shape are possible: S - similar, L - similar, tumor-like, disc-shaped.

The kidney is a paired organ. Topographically, the kidneys are located with the upper pole at the level of IX and IIX thoracic vertebrae, and the lower pole - respectively with the IV lumbar vertebra.

At the birth of a child, the weight of the kidney is on average 10-12 g. by 5-6 months, its mass doubles, and at the end of the first year it triples. By puberty, the increase in the size of the kidney is slow, during puberty, the mass of the kidney increases by 10 times. By the age of 7, the increase in the surface of the kidney for each year averages 1 cm2, and in children 7-15 years old - 1.5 cm2. The renal pelvis is determined, as a rule, at the level of the II lumbar vertebra. The kidneys in children are lobular in nature, the cortical layer is underdeveloped. The tissue is delicate, with little

connective tissue. The renal pelvis are well developed, but their muscle and elastic tissue is poorly developed. The pelvis is located intrarenally. There is a close connection between the lymphatic system of the kidneys and the lymphatic system of the gastrointestinal tract. Plasma flow in the kidneys of a newborn baby, both in absolute and relative values, is less than in adults.

The main structural and functional unit of the kidney is the nephron. It consists of 6 departments that differ in function and structure:

- renal body (glomerulus and Bowman's capsule),
- proximal branchial tubule,
- descending knee of the loop of Henle,
- ascending knee of the loop of Henle,
- distal branch tubule and system of collecting tubes.

By the age of 2, the nephron is not sufficiently differentiated. After 5 years, the structure of the glomerulus is similar to that of an adult.

In the kidneys of newborns, the glomeruli are located compactly: there are 50 of them per 1 cm3 of the surface (in 7-8 month-old babies, there are 18-20 of them, in adults - 7-8). The filtering surface of the glomeruli is much smaller, the tubules are short. Their lumen is 2 times narrower than that of adults. The visceral leaf of the capsule of the renal glomerulus in fetuses and newborns consists of cubic epithelium, in which the filtration process is difficult. By 2 months, the cubic epithelium is located in all renal glomeruli, at the 4th month squamous epithelium already appears near the cerebral glomeruli, at the 8th month it is found in the peripheral glomeruli. Between the 2nd and 4th years of life, only the remains of the cubic epithelium can be found.

The small size of the glomeruli is due to their small total filtering surface in newborns (about 30% of the norm of an adult). Only after 1 year of life, the filtration of urine in the glomeruli approaches that in adults (in adults, the filtering surface is 1.5 m2). The incompleteness of the structure of the capsule of the renal glomerulus in children of the first year of life is complemented by similar features of the tubular apparatus.

The tubules in newborns are much shorter, and their lumen is almost 2 times narrower than in adults. This also applies to the nephron loop (Henle loop).

3. Anatomical and morphological features of the urinary system in children

Morphological features of nephrons in young children

The glomeruli of the nephrons are not fully differentiated and are small in size. The epithelium covering the glomerulus is not flat, but cylindrical. The leaf of the Bowman capsule consists of epithelial cells that do not penetrate between the vascular loops of the glomerulus.

These features cause a much smaller filtration surface and permeability of the renal glomeruli in young children.

Features of the urinary tract

Renal pelvis in newborns and infants are relatively large, their walls are poorly developed, hypotonic (weak development of muscle and elastic fibers). Therefore, the shape of the pelvis can be different: ampullary, branched, sac-shaped. The final formation of the renal pelvis takes place by the 12th month of the child's life.

In children under 5 years of age, the intrarenal placement of the pelvis predominates, they are located inside the renal sinus. In subsequent years, as the renal sinus opens, the pelvis are placed extrarenally.

The length of the ureter in a newborn is 6-7 cm, in a 1-year-old child - 10 cm, up to 4 years old - 15 cm, in an adult - 20 - 28 cm. processes in the bowl.

The distal ureter in newborns is very short and the length of the intravesical segment does not exceed 0.5 cm. By the age of 10-12, it increases to 1.5 cm. Such a short intra-vesicular segment of the ureter causes the development of vesicoureteral reflux, that is, it leads to the reflux of the contents of the bladder into the ureter (or even into the pelvis). Although the ureters in young children are relatively wider than in adults, they are more tortuous, hypotonic due to the poor development of muscle and elastic fibers, which leads to stagnation of urine and the development of a

microbial-inflammatory process in the kidneys. The bladder in young children is located higher than in adults, so it can be easily felt above the pubis, which, in the prolonged absence of urination, makes it possible to differentiate its reflex retention from the cessation of urination. The mucous membrane is well developed in the bladder, weakly elastic and muscle tissue. The capacity of the bladder of a newborn is up to 50 ml, in a one-year-old child - up to 100-150 ml. The urethra in newborn boys is 5-6 cm in length Its growth is uneven: it slows down somewhat in early childhood and accelerates significantly during puberty (increases to 14-18 cm). In newborn girls, its length is 1-1.5 cm, and at the age of 16 - 3-3.3 cm, its diameter is wider than that of boys. In girls, due to these features of the urethra and proximity to the anus, easier infection is possible, which must be taken into account when organizing their care (it is necessary to wipe and wash the girl from front to back in order to avoid infection from the anus into the urethra). The mucous membrane of the urethra in children is thin, delicate, easily vulnerable, its folding is weak.

The bladder in infants is located higher than in school-age children, partially enters the small pelvis, gradually descends into the pelvic cavity with age, this allows it to be palpated in young children, in a filled state it is palpated at the level of the navel and even higher. In school-age girls, it acquires a round, In boys, it retains an oval-oblong shape. The muscle layer and elastic fibers are poorly developed, the longitudinal muscular layer of the bladder wall is better defined, the circular layer is less pronounced. Active development of the muscle layer is observed from the age of 6. The mouths of the ureters have the shape of a fossa, dilated due to the poor development of muscle fibers in these areas. The mucous membrane of the bladder, represented by a connective tissue base, is relatively thick and better developed than in adults. However, it is loose, delicate, well vascularized, which causes the frequent development of the inflammatory process.

The capacity of the bladder is: in a newborn approximately 50 ml;

in a one-year-old child up to 200 ml, at the age of 9-10 years - 600-900 ml.

4. Kidney function

Glomerular filtration: in newborns it is weakly expressed, which is explained by the immaturity of the glomerulus and low blood pressure (it is even more immature in the fetus). The total filtering surface is smaller than in older children, and the value of glomerular filtration is reduced. Thus, glomerular filtration on 1 m of the body surface in a newborn is 1/3 - 1/2 of an adult. The value of glomerular filtration reaches the indicators of an adult only by the end of the 1st beginning of the 2nd year of life. Low level glomerular filtration in newborns and children of the first year of life is due to low blood pressure, a smaller diameter of the abductor vessel (1/3 less than the diameter of the adductor vessel), lower glomerular permeability and a relatively small total filtering surface of the glomeruli, which is 5 times smaller than in adults.

The value of glomerular filtration in a one-year-old child is 50-60 ml / min., in older children and adults -80-120 ml / min. To date, there is no way to directly study glomerular filtrate, and therefore, to determine the magnitude of glomerular filtration, purification indicators (clearance) of those substances are used, which, diffusing into the primary urine, are subsequently not subject to reabsorption and are not secreted (inulin, creatinine).

Clearance is understood as the amount of plasma (in ml), which is completely cleaned of this substance in 1 minute. The study of glomerular filtration by clearance of inulin and endogenous creatinine revealed a significant decrease in renal filtration function in children of the first year of life compared to adults.

The imperfection of the drainage function explains the high diuresis (urine excretion per unit of time). In the first days of life, minute diuresis is 2 ml / min per 1 sq.m of body surface, in an adult - 0.6 ml / min. The daily amount of urine increases with age. By the end of the first month of life, daily diuresis is 200-300 ml, by the end of the year - 600 ml. In children over one year old and up to 10 years of age, daily diuresis can be determined using the empirical formula:

$$600 + 100(n - 1),$$ where n is the age of the child in years.

Children over 10 years old excrete the same amount of urine per day as adults (1700-2000 ml).

However, the child's kidneys are capable of removing water if it is not injected at once, but fractionally during the day. Due to such a large diuresis, metabolic rate, and rapid water metabolism, children require more water per 1 kg of body weight. So, in a newborn, the need for water is 180-200 ml / kg, at 6 months 150 ml / kg, at 1 year - 120-130 ml / kg, 2-3 years - 90 ml / kg, in adults 40-50 ml / kg.

It should be mentioned that the water content in the body of a newborn is 75-80% of its weight, in adults 60%. The relative volume of extracellular fluid in adults is 2 times less than in newborns (20% and 40%, respectively), which causes mild dehydration of the body of a young child.

On the other hand, a large volume of extracellular water and a delayed water excretory capacity of the kidneys can lead to hyperhydremia with water load, which is manifested by edema. These features should be taken into account in clinical practice when establishing the optimal water regime. In the first days of a child's life, the frequency of urination is 5-6 times a day (oliguria or anuria). On the 3-4th day of life, the number of urination increases and from the 2nd week is 20-25 times a day. This number of urination persists for up to 6 months, subsequently decreases to 15-20 times, up to a year 10-15 times a day, in preschool and school age - up to 6-8 times a day. In children under 6 months. The frequency of urination is defined as physiological pollakiuria. On average, with each urination, children distinguish:

newborns - 10-15 ml;

at 6 months - 30 ml;

at 1 year old - 60 ml;

at 3-5 years old - 90-100 ml;

at 7-8 years old - 150 ml;

at 10-12 years old -250 ml.

QUANTITATIVE AND QUALITATIVE CHANGES IN URINE.

Some urological diseases occur with changes in urine, others without them. They can be quantitative and qualitative. Quantitative changes in urine Polyuria is an

increase in the amount of urine excreted per day. At the same time, daily diuresis reaches 2-5 liters, sometimes more than 10 liters.

Polyuria can occur in healthy people after drinking large amounts of fluids, but in most cases, an increase in the amount of urine indicates a painful condition. A characteristic sign of polyuria, in addition to an increase in the amount of urine, is its low specific gravity /1000-1005/. Only with diabetes mellitus, along with a large amount of excreted urine, its specific gravity remains high /1030 and above/. In urological patients, polyuria, as a rule, indicates a decrease in the concentration function of the kidneys, which is observed in chronic pyelonephritis, prostatic hyperplasia, polycystic kidneys and others. Sometimes reflex polyuria can be observed after various diagnostic and therapeutic procedures on the urinary tract, for example, after catheterization of the bladder and ureters.

Oliguria - a significant decrease in the amount of urine. It can be physiological when the body receives little fluid. Urine in such cases has a very high specific gravity. In practice, we can talk about oliguria when a person excretes from 100 to 300 ml of urine per day. Oliguria is also observed in neurological diseases, which are accompanied by diarrhea, frequent vomiting, bleeding, fever, as well as in some heart diseases and acute nephritis. With oligouria, the filtration, reabsorption and secretory function of the kidneys is impaired. The urine is watery, with a low specific gravity. The term "anuria" defines such a painful condition when the kidneys do not excrete urine, or it does not flow from the kidneys into the bladder. In both cases, the bladder is empty.

Depending on the mechanism of anuria, there are three types of anuria: prerenal, renal, postrenal. The first two types belong to secretory anuria, the third type is excretory anuria - the kidneys excrete urine, but it is not excreted from the bladder.

Opsiuria is a slow, late excretion of a large amount of urine /a day or more/ after drinking fluids, observed with hyperglycemia, kidney failure, hyperthyroidism, etc.

Prerenal anuria occurs as a result of a sharp disruption of the blood supply to the kidneys due to collapse due to blood loss, shock, severe general trauma, acute intoxication, etc. 7 The cause of renal anuria is diseases that are accompanied by acute

renal failure and lead to cessation of urination - acute glomerulonephritis, acute pyelonephritis, embolism and renal infarction, acute necrotizing tubular nephrosis due to poisoning with sulema /the so-called sulema kidney/, carbon tetrachloride and other poisons, criminal abortion, hyperkalemia, anaerobic infection, crush syndrome, hepatorenal syndrome, kidney damage due to myoglobinemia /transfusion incompatible blood/ and so on. Secretory anuria should also include those relatively rare types of anuria that are caused by renal aplasia or removal of a single congenital kidney.

Postrenal anuria is excretory anuria. It is based on a mechanical obstacle in the upper urinary tract to the outflow of urine /bilateral stones of the pelvis or ureters, blockage of the ureters with salts or blood clots, compression of the urinary tract by a tumor, accidental imposition of ligatures on the ureters during gynecological operations, etc./. Rarely, excretory anuria is observed after ureteral catheterization or endovesical manipulations, it is based on spasm of the upper urinary tract or segmental edema of the ureters. Qualitative changes in urine During the day, a healthy person excretes about 60 g of dense substances in the urine, of which organic salts account for 35 g and inorganic salts 25 g.

The specific gravity of urine can be increased /hyperstenuria/, or decreased /hypostenuria/. In addition, it may change or not change at all during the day, regardless of fluid intake /isostenuria/. With the use of a large amount of liquid, the specific gravity decreases, with a small volume of liquid, it increases.

Hyperstenuria, as a rule, is not observed in kidney disease. It is more common in diabetes mellitus, hyperparathyroidism, poisoning with heavy metal salts, etc. In kidney diseases, there is mainly a decrease in the specific gravity of urine /hypostenuria/, which is due to a violation of their concentration capacity. Isostenuria has a major diagnostic disorder, especially in combination with hypostenuria /isohypostenuria/, which indicates chronic renal failure. 8 When drinking a large amount of liquid, the relative density of urine decreases, with a small volume, it increases.

Therefore, after a single urine test, no conclusion can be drawn about the concentration capacity of the kidneys. For this, tests for dilution and concentration were proposed.

By far, the most common test is Zimnitsky. It is based on determining the amount and relative density of urine in 8-hour portions during the day. The test is carried out under normal conditions of nutrition and water regime. Urine is collected every 3 hours, the volume of each serving is measured, the relative density, level of urea and sodium chloride are determined. The main components of urine that determine its specific gravity are urea, sodium, potassium and chlorine. Violations of their excretion in kidney failure cause a decrease in the relative density of urine. The reaction of urine is normally slightly acidic. The degree of acidity depends on the level of hydrogen ions in it. Normally, the pH of urine ranges from 5 to 7 and depends on nutrition. Urine color. With a sufficiently high specific gravity, urine has a rich yellow color. Normal urine is clear. Cloudiness of the patient's urine should always alert the doctor, in such cases it is necessary to find out the cause of the cloudiness, which may depend on the presence of salts, bacteria, mucus, pus, blood in the urine. The excretion of salts in the urine can also be observed in healthy people, depending on the intake of different types of food.

In order to establish the cause of cloudy urine, there are several tests. Thus, the disappearance of turbidity of urine when heated indicates the content of urate /uraturia/. If the turbidity of urine disappears when acetic acid is added to it and heated, but with the formation of gas, then this indicates the presence of carbonates in the urine /carbonaturia/. Turbidity, which disappears when urine is heated with acetic acid, but without gas formation, indicates the presence of phosphates /phosphaturia/. Turbidity of urine, which disappears with the addition of hydrochloric acid, is characteristic of oxalates /oxalaturia/. If, when heated with the addition of acid, the urine does not become transparent, then the cause of turbidity can be found out using microscopic examination. The content of pus (pyuria) in the urine is a consequence of various kinds of inflammatory processes in the kidneys, urinary tract, genitals of men. To determine its approximate localization, there are several samples.

The most common is the so-called two-glass sample. The patient releases urine in two glasses, while a little urine is excreted in the first /50-60 ml/, and in the second - the rest. If only the first portion of urine is cloudy, then this indicates damage to the prostate gland and seminal vesicles. The presence of cloudy urine in both the first and second portions /total pyuria/ indicates an inflammatory process either in the kidney or in the bladder. Not every inflammatory process in the organs of the genitourinary system is accompanied by pyuria.

With closed inflammatory foci in the kidney, prostate, pyuria is absent. With pyuria, it is always necessary to identify the causative agent of inflammation, because only this will allow for rational etiopathogenetic therapy. The presence of protein in the urine is called albuminuria, or proteinuria. Distinguish between false and true albuminuria. The first depends mainly on the content of blood and pus in the urine, the protein content in the urine with false proteinuria, as a rule, does not exceed 1-2 g / l. True proteinuria depends on inflammatory and degenerative processes in the kidneys and is caused by a violation of the membranes of the renal glomeruli. The amount of protein in the urine in this case can reach 10-20 g / l. Cylindruria - the presence of cylinders in the urine. In urological diseases, cylinders, with the exception of hyaline, are rare. Hematuria - the presence of blood in the urine. Microscopic hematuria is observed in many urological diseases and therefore is not as important in diagnosis as macrohematuria. Macrohematuria should be distinguished from urethrrhagia - the discharge of blood from the urethra regardless of the act of urination. It is observed with damage or certain diseases of the urethra. Macrohematuria is a very serious symptom, as it often indicates tumors of the kidneys and urinary tract. Before starting hemostatic measures, it is necessary to establish the source of hematuria. To determine the localization of macrohematuria, sometimes the two-glass test described above allows. If blood is contained only in the first portion of urine /initial, initial hematuria/, then this indicates a pathological process in the urethra. If, on the contrary, there is blood only in the second portion /terminal hematuria/, then this indicates the presence of a pathological process in the bladder, mainly in the area of its neck. Along with this, blood can be contained in both portions of urine /total hematuria/, which indicates the

existence of a source of bleeding either in the kidney and upper urinary tract, or in the bladder. In such cases, it is impossible to establish the source of bleeding without endoscopic examination. The presence of blood clots in the urine can contribute to the topical diagnosis of hematuria. Shapeless clots most often indicate bleeding from the kidney and upper urinary tract.

Total hematuria can be observed in many urological diseases, but most often it occurs as a result of tumor lesions, initial forms of tuberculosis, necrosis of the renal papillae, trauma, urolithiasis, pyelonephritis. Remembering that macrohematuria is very often a sign of a malignant neoplasm of the genitourinary system, the doctor is obliged to immediately refer patients with hematuria for endoscopic examination /to determine the source of bleeding during cystoscopy/. If this is not possible, immediately hospitalize the patient. Hematuria is not a disease, but only a symptom of various 10 serious diseases, so it is necessary not to treat hematuria, but to find out its cause, to apply etiopathogenetic treatment.

With some blood diseases, poisoning, after severe burns, transfusion of incompatible blood, hemoglobinuria is observed. Urine for hemoglobinuria is red, but retains transparency. In urine, which contains a large amount of blood pigments, erythrocytes are not found during microscopic examination. Myoglobinuria is observed with traumatic compression of the limbs or large muscles of the trunk, when crushing or compression syndrome occurs. From the crushed muscles into the bloodstream, and then into the kidneys, the pigment myoglobin, close in composition to hemoglobin, enters in large quantities. The myoglobin molecule is 3 times smaller than the hemoglobin molecule, due to which myoglobin is excreted by the kidneys and can be easily detected in the urine. Pneumaturia is the excretion of air or gas in the urine. Air or gas is released at the end of the act of urination, accompanied by a characteristic noise, forming foam or bubbles in the external opening of the urethra.

Pneumaturia can be caused by:

1/ accidental penetration of external air into the urinary tract by cystoscopy, catheterization of the ureters, deliberate injection of gas by cystography, pneumopyelography.

2/ spontaneous penetration of external air through the external fistula of the urinary tract.

3/ ingress of intestinal gas into the urinary tract through the enteric-vaginal fistula.

4 / the formation of gas by bacteria in the urinary tract, especially due to diabetes.

Lipuria - the presence of various fatty substances in the urine. Lipuria can be observed as a result of fatty embolism of the renal capillaries with massive fractures of tubular bones, diabetes. Hiluria - the presence of an admixture of lymph in the urine. Urine has the appearance of milk. This painful condition is based on the appearance of communication between large lymphatic vessels and urinary tract. Violation of the integrity of the lymphatic vessels of the urinary tract can occur as a result of an inflammatory process, trauma or tumor that compresses the thoracic duct, or as a result of pathological processes in the urinary tract that are caused by the parasite orillaria. Hydaturia /echinococuria/ is characterized by the presence of small echinococcal vesicles in the urine, which break into the bowl from the hydatous bladder in the kidney. Fermenturia is characterized by the appearance of enzymes in the urine.

II. Kidney injuries

Kidney damage is observed in at least 1-5% of cases. The kidneys are the most damaged organ among all organs of the genitourinary system and abdominal cavity. Moreover, up to 70-80% of injuries are combined with damage to other organs and systems. The ratio of men to women for this pathology is 3:1. Kidney injury can be life-threatening immediately, but most kidney injuries should be managed conservatively. Advances in imaging techniques and treatments over the past 20 years have reduced the need for surgery and increased organ-preserving results. Most patients are admitted to the urology department with isolated kidney damage. Victims with combined injuries are more often admitted to general surgical hospitals.

Etiology

Blunt kidney injury is more common than penetrating kidney injury. The causes of blunt kidney injury in order of frequency are: car accidents, falls, sports injuries and pedestrian collisions. Blunt injuries can occur as a result of a direct blow to the organ, crushing of the organ by the paravertebral muscles, or as a result of rapid braking. Rapid deceleration can cause an avulsion in the ureteral-pelvic junction, renal vessel avulsion, or arterial dissection/thrombosis, leading to devascularization of the kidney. The most common cause of penetrating kidney injury is gunshot wounds followed by stab wounds

Epidemiology

As previously stated, kidney injury accounts for approximately 1% to 5% of all trauma patients, most of which are caused by blunt abdominal trauma (80% to 90%). [2][3][4] Of those patients with blunt abdominal trauma, 8% to 10% will have kidney damage, while 6% will have kidney damage if it was penetrating. [4] Traumatic blunt or penetrating kidney injury has 86% associations with concomitant damage. [5] Morbidity and mortality are highly dependent on the extent of the injury, co-occurring injuries, and the intervention. Although kidney injury is still a significant cause of morbidity, renal loss has been reduced by the "standard treatment" approach in non-

surgical treatment of hemodynamically stable patients, regardless of the extent of damage [5]. The reduction in renal loss is associated with the popularization of superselective angioembolization of the renal artery, when there is a selective embolization of the bleeding vessel directed to the affected part of the kidney, compared to traditional embolization of the main artery or nephrectomy, resulting in complete kidney loss.

Trauma patients with blunt or penetrating chest, abdomen, and pelvic injuries are at increased risk of kidney damage, so it is important to exercise caution when taking a history of possible kidney damage. It is also important to recognize the patient with pre-existing anatomical abnormalities of the kidneys, as they may have significant kidney damage with minor trauma, emphasizing the importance of adequate medical history for these patients.

These patients need a thorough examination of the chest, abdomen, flank and genitourinary area. Kidney damage should be seriously suspected in a patient with tenderness, pain, palpable mass or ecchymosis in the side, abdomen or back. [2] Hematuria increases the suspicion of kidney damage, but it is not always present, especially in patients with polytrauma. [10] In penetrating trauma, the location of kidney damage can be predicted based on the entry or exit wounds depending on the form of penetrating trauma (injection or gunshot wound). For example, a puncture wound in the anterior axillary line raises concerns about damage to the renal orifice (blood vessels, nerves, ureter), while if the posterior axillary line was the insertion point, then the kidney parenchyma is more likely to be damaged. However, for gunshot wounds, the trajectory may vary, and even if entry or exit points increase the suspicion of kidney injury, kidney damage may not be present at all.

Among injuries to the parenchymal organs of the abdominal cavity, closed kidney injuries (OTN) occupy the 2nd place after liver injuries. According to statistics, kidney injuries are observed in 1-5% of all injuries and in about half of all traumatic injuries of the genitourinary organs.

Kidney injuries are divided into closed or open, isolated or combined with damage to other organs.

Kidney injuries are classified as blunt or penetrating. Blunt trauma is more common, accounting for more than 90% of injuries. In pediatric practice, 14% of patients with blunt abdominal trauma have kidney damage. Blunt kidney injuries are most often associated with rapid exposure to deceleration forces, car accidents, accidents involving pedestrians, vehicles, contact sports, as well as personal violence.

Kidney tissue can also be damaged directly by a rib fracture. Of the renal injuries, 10-20% are penetrating injuries, most of which require surgery. Penetrating injuries from stab wounds or gunshot wounds are less common in children than in adults. Gunshot wounds produce a radiating wave known as the "explosion effect" that damages tissues beyond the projectile's direct contact. This effect can cause delayed tissue necrosis, which leads to bleeding, urine leakage or abscess from areas that prove to be viable during surgery. Previously, it was thought that congenital kidney abnormalities such as hydronephrosis, tumors, or malposition could lead to kidney injury as relatively mild traumatic forces. Historically, congenital kidney anomalies in injured patients vary from 1% to 21%. Kidney abnormalities, especially the hydronephrotic kidney, may be first diagnosed after a minor blunt abdominal injury. Most often, these patients end up with hematuria after blunt trauma. Others may be admitted to the clinic of an acute abdomen due to intra-abdominal rupture of the hydronephrotic kidney.

Major slowdowns of the injury can lead to trauma to the artery or vein of the kidney, due to stretching of the normally fixed vascular pedicle. This type of damage is more common in children due to increased flexibility and mobility of the kidneys. Post-traumatic thrombosis of the renal artery occurs secondary to the intima. The mucous membrane of the intima differs from the vessel wall in that the middle layer and adventitia of the renal artery are more elastic than the intima. The intima of the mucosa produces turbulence, thrombosis, and eventually blockages, which then leads to renal ischemia. A high index of suspicion must be in order to identify these injuries. Urologists adhere to active surgical tactics in the treatment of TNI and constantly

expand the indications for organ-preserving operations. Proponents of active surgical tactics relied on the facts of secondary bleeding that occurred in damaged kidneys 2-3 weeks after injury and required nephrectomy due to intense paranephral inflammatory infiltration and widespread destructive changes in the kidney parenchyma. Researchers believed that active early surgical interventions can avoid the loss of the affected organ.

Closed injuries

In the occurrence of damage, the direction, place and strength of the impact, the anatomical location of the kidney and its topographic relationship with the XI and XII ribs, the spine, the physical properties of the kidney, the development of muscles, subcutaneous fat layer and paranephral tissue, etc., are important. A ruptured kidney occurs either as a result of direct trauma (lower back bruise, falling on a hard object, squeezing the body) or from an indirect effect (falling from a height, jumping, bruising the whole body). The interaction of these factors can lead to compression of the kidney between the ribs and transverse processes of the vertebrae, as well as to hydrodynamic effects due to an increase in fluid pressure (blood, urine) in the kidney.

In the presence of pathological changes in the kidney preceding the injury (hydro- and pyonephrosis, developmental anomalies), organ damage can also occur with bruises of insignificant force - the so-called "spontaneous rupture of the kidney", most often caused by trauma to the abdomen or lumbar region. A special type of closed kidney injury includes their accidental damage during instrumental studies: perforation of the renal pelvis, calyx with penetration of the ureteral catheter, loops and other instruments inserted retrograde into the kidney parenchyma, periorbital tissue; tears of the mucous membrane of the calyx in the area of the fornix due to the introduction of an excessive amount of fluid into the bowl under significant pressure during retrograde ureteropielography.

The development and implementation of new technologies in clinical urological practice (extracorporeal shock wave lithotripsy (EUHL)) have led to the appearance of a special type of closed kidney damage:

- • the mechanism of injury is due to the short-term effect of high positive (more than 1000 atm.) and low negative (-50 atm.) pressure on the kidney;
- • Depending on the initial state of the kidney (acute pyelonephritis, shrunken kidney and other features), organ damage can occur even with insignificant shock wave energies.

When using high energies, the severity of damage is directly proportional to the number of shock wave pulses per kidney. When using the optimal parameters of the EUHL, it can be equated in severity of injury to kidney contusion without damaging the capsule and cellular structures. At the same time, under certain conditions, intrarenal subcapsular and paranephral hematomas can occur.

Open injuries

The causes and conditions of open kidney damage are diverse. Especially severe injuries are observed when wounded by modern firearms. This is due to the complex structure of the wound canal, the branching of the tissue damage zone, frequent combined lesions of several adjacent areas, and often the number of injuries (up to 90%). The high modern kinetic energy of projectiles, especially in mine-explosive wounds, has led to an increase in the frequency of indirect kidney damage in case of injury to nearby organs.

Classification

Mechanical damage to the kidneys according to their type is divided into two groups: closed (blunt or subcutaneous); open (penetrating or wounded): bullet, fragmentation, piercing, cutting, etc.

- • Depending on the nature of the damage: *isolated; combined.*
- • Depending on the number of injuries: *single; multiple.*
- • Depending on the side of the injury: *left-sided; right-sided; bilateral.*
- • 3 examinations at the site of kidney damage: *upper segment; lower segment; kidney body; vascular pedicle.*

The Organ Lesions Committee of the American Association for Trauma Surgery (AAST) has developed a special scale that is widely used in the world. Injuries are divided depending on severity into degrees from I to V.

AAST Kidney Injury Scale*

Degree	I Description of the damage
AND	Contusion or hematoma, non-increasing subcapsular hematoma; trauma without tearing
II	Non-increasing perirenal hematoma; cortical tear up to 1 cm deep without extravasation of urine
III	Cortical tear >1 cm without urine extravasation
IV	Rupture due to corticomedullary combination in the collecting system or vascular damage - damage to the segmental artery, vein with a hematoma formed, partial damage to the vessel wall or vascular thrombosis
V	Multiple ruptures of the kidney, or damage to the vessels of the renal pedicle, or detachment of the kidney from the vessels

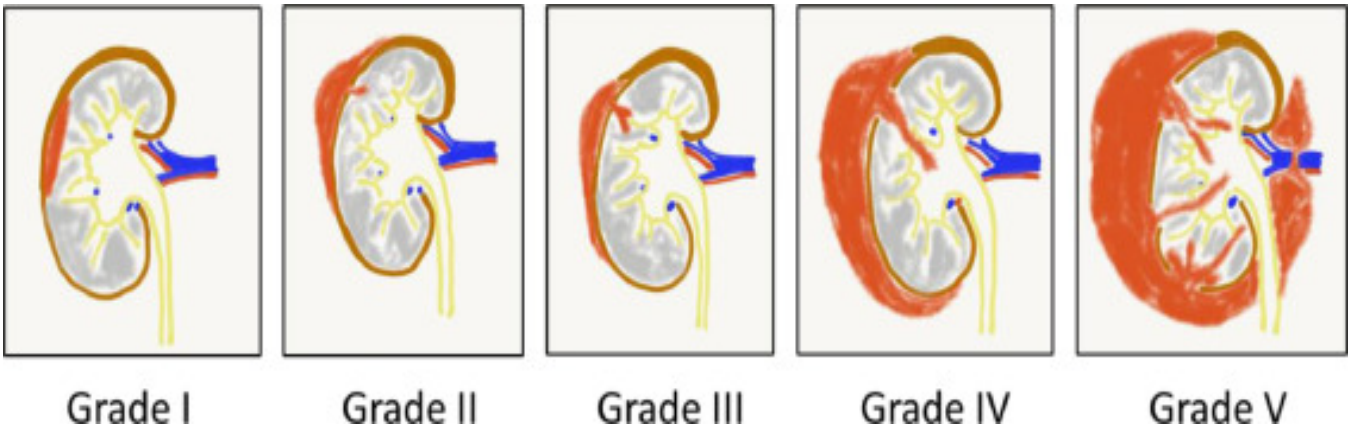


Figure. Kidney Injury Scale according to the 2018 update of the AAST (Georg Singer, Christoph Arneitz, Sebastian Tschauner, Christoph Castellani, Holger Till, Trauma in pediatric urology. Seminars in Pediatric Surgery. Volume 30, Issue 4, 2021. 151085. Doi:10.1016/j.sempedsurg.2021.151085.)

Clinical picture

Closed injuries

Kidney damage is characterized by a triad of symptoms: pain in the lumbar region, swelling and hematuria:

- **pain in the lumbar region** is observed in 95% of patients with closed injuries and in all victims with combined trauma. Pain occurs as a result of damage to the tissues and organs surrounding the kidneys, stretching of the fibrous capsule of the kidney, ischemia of its parenchyma, pressure on the parietal peritoneum by a growing hematoma, obstruction of the ureter by blood clots. vomiting, bloating, symptoms of peritoneal irritation, fever often cause a diagnostic error;
- **Swelling in the lumbar or hypochondrium is** caused by a hematoma or urohematoma in the paranephral or retroperitoneal tissue. Some clinicians note the presence of swelling in 40-45% of patients. Large urohematomas can spread from the diaphragm to the pelvis through the retroperitoneal tissue, and after 2-3 weeks they can be detected even in the wicket and on the thigh;
- **Hematuria** is the most significant, characteristic and frequent sign of kidney damage. Microhematuria is detected in almost all patients. The duration of hematuria and its intensity can be different. Usually it lasts 4-5 days, and in some cases - up to 2-3 weeks or more.

The intensity of clinical manifestations of closed kidney injury depends on the severity of morpho-functional disorders in the renal parenchyma throughout the post-traumatic period. In case of mild damage, the damaged structures of the kidney are restored with the loss of 1-15% of the functioning parenchyma. Moderate kidney damage causes loss of up to ZO % of functionally active parenchyma, and severe damage is accompanied by irreversible degenerative-dystrophic changes of up to 65% of the parenchyma.

Open damage

The main symptoms of kidney injuries are pain in the wound area, hematuria, urohematoma, localization of the wound and the direction of the wound canal, urine leakage from the wound. The latter symptom, although it is the most likely, is rarely observed in the early stages after injury (in 2.2% of cases). If a kidney injury is suspected, a technique with Nessler's reagent can be used to determine urine in bloody discharge from the wound. Urohematoma in kidney injuries is rarely observed, since blood and urine flow out of the wound or (with combined wounds) enter the abdominal or pleural cavity.

Diagnostics.

Blunt trauma

Kidney injury must be suspected in a patient in the presence of:

- characteristic anamnesis;
- hematuria;
- significant hematoma, bruises in the lumbar region;
- fractures of the vertebral bodies $Th_{VIII-XII}$;
- rib fractures;
- combined injuries due to falls or car injuries;
- penetrating wounds of the abdomen or lumbar region

The main objectives of renal trauma imaging are to adequately stage the injury of the kidney, to reveal preexisting pathologies and to identify concomitant injuries to other organs.

Guidelines by the European Association of Urology on upper urinary tract injuries published in 2014 have stated that even though sonography may help to identify patients requiring more detailed investigations and is useful for follow-up examinations of parenchymal lesions, hematomas and urinomas, it has a low sensitivity

for detecting renal lacerations. Likewise, the WSES-AAST (World Society of Emergency Surgeons and American Association for the Surgery of Trauma) guidelines recommend ultrasound in pediatric patients as an alternative to CT in the presence of hemodynamic stability during the immediate assessment and in follow-up examinations. Following initial CT for accurate staging of pediatric blunt renal trauma, sonographic monitoring is safe in most pediatric patients excluding those with hemodynamic instability.

The effectiveness of treatment of patients with injuries in general and kidney injuries in particular depends on the time of the patient's request for medical help, clear diagnosis and the correctly chosen method of treatment. When choosing the optimal treatment tactics, it is important to understand the mechanism of occurrence of the pathological process in the injured kidney, which is complex and is due to many factors, including the strength, direction of impact and the nature of the traumatic factor, the patient's physique (development of subcutaneous adipose tissue and the muscular layer of the lumbar region, softening the blow), the condition of the kidneys (the function of each kidney in particular, the presence of hydronephrotic transformation, cysts, developmental anomalies).

Laboratory Evaluation

Standard trauma laboratories should be obtained, for example, a complete blood count (CBC), a complete metabolic panel (CMP), a coagulation panel, lactate, among others, together with urine for analysis. Hematuria is more common in patients with blunt kidney injury than with penetrating kidney injury, and if present, microscopic hematuria is more common compared to macrohematuria. Although hematuria may be a sign of kidney damage, the degree of hematuria (present or not) has not shown a correlation in predicting the severity of kidney damage.

Instrumental methods

The method of choice in a patient with suspected kidney injury is contrast-enhanced computed tomography with immediate and delayed imaging. The different imaging phases allow a more precise assessment of the renal cortex, renal vessels and the collecting system, since they intensify at different time intervals, distinguishing urine extravasation from active bleeding. Computed tomography (CT) scans determine the findings and severity of the injury that would have been seen if surgery had been performed, and the contrast allows the renal vessels to be evaluated, where the blush in the image confirms active extravasation. Often, the first image that an injured patient receives takes place in the trauma department with a targeted assessment using ultrasound examination for trauma (FAST). This imaging examination is performed to evaluate intra-abdominal or pericardial fluid, which, if present, will indicate bleeding in the patient with the injury and will help in the timely diagnosis and help decide whether surgery is necessary. This is an examination that depends on the operator, and it is limited to retroperitoneal bleeding and minor kidney damage. Patients with stable hemodynamics or those who have responded well to resuscitation measures can be further evaluated using contrast-enhanced computed tomography. It is important to note that a negative scan does not rule out kidney damage, and further examination depends on the clinical status of the patient. Finally, if there is hemodynamic instability that requires immediate surgical intervention, intraoperative intravenous urography (IVU) should be performed. This makes it possible to assess the function of the second kidney, which can further guide the surgical approach to the affected kidney.

Renal imaging should be included, but not limited to, the following clinical scenarios:

Blunt abdominal trauma with macroscopic and microhematuria

Blunt abdominal trauma with hemodynamic instability

Penetrating trauma to the chest, abdomen, side, or back and any entry/outlet wounds that escape a trajectory that involves the kidneys

Strong clinical suspicion based on the mechanism of injury (e.g., rib fractures with displacement near the kidney, high-speed accident, fall from a considerable height)

Ultrasound examination

The use of focused ultrasonography has now become an extension of the physical examination of a patient with trauma and is conveniently used in the initial examination and triage of patients [1-5]. Most of the time, the kidneys are removed as part of a routine abdominal scan, which is performed to detect damage to other abdominal organs that are often damaged. It can detect kidney ruptures, but cannot accurately assess their depth and extent and does not help distinguish extravased blood from urinoma. There is a possibility that a small lesion may be missed, with retroperitoneal hemorrhage, or if there is a concomitant other solid visceral injury. In the presence of hematuria, even a negative scan does not rule out an underlying injury, and the decision on further treatment is based on the clinical status of the patient. The management protocol for patients with suspected kidney damage generally divides patients into three groups: (1) patients with hemodynamic instability usually require surgery, while patients who have stabilized after initial poor evaluations may undergo CT scan or repeat RAPID and further decisions may be made accordingly; (2) hemodynamically stable patients with hematuria should undergo CT scans; and (3) patients who are hemodynamically stable, do not have hematuria and negative FAST results should be under clinical observation for at least 6 hours.

Intravenous pyelography (IVP) is the choice among radiographic examinations to determine the presence and degree of kidney damage. The sensitivity of the study reaches 90% in the diagnosis of renal injury. Unfortunately, GDP does not detect other intra-abdominal injuries and does not determine kidney damage in children by 50% compared to computed tomography (CT), several studies currently show that conventional GDP has extremely low rates and is rarely used in pediatric practice in children with blunt kidney injury, especially in patients with isolated microhematuria.

However, GDP still plays an important role in all penetrating and hemodynamically unstable blunt kidney injuries that require immediate surgical examination without preoperative imaging. A single GDP can be performed promptly and consists in the intravenous administration of 2-3 ml / kg of non-radioactive substances, followed by a single radiography of the abdominal cavity after 7 minutes. The purpose of the GDP is to determine the presence of two functioning kidneys, hemorrhages and damage to the kidney parenchyma. During operations, the need for GDP was eliminated in 32% of patients.

Computed tomography

Multidetector computed tomography is considered the gold standard for radiographic evaluation of patients with kidney injury and has completely replaced intravenous pyelography.

Due to the short time of the examination, CT provides all the necessary information regarding the degree of parenchymal damage with or without ACL involvement and kidney vascular damage, as well as provides information on the functional state of the kidneys. Performing a phase scan also helps differentiate active bleeding from urine extravasation. With the widespread availability of the latest computer computers and spiral multi-slice scanners, much faster scanning, increased volume coverage, and improved multi-plane reconstruction capability can now provide high-quality images with shorter patient time on the table. Because most CT patients don't cooperate much in holding their breath, motion artifacts can often compromise the study and lead to additional confusion in the interpretation of the scan. Faster imaging with a multi-slice scanner and multi-plane reconstruction can help overcome these challenges and provide an accurate assessment of the injury.

Contrast enhanced computed tomography (CECT) with a delayed urographic phase is considered the gold standard for grading renal injuries. It allows accurate evaluation of the renal parenchyma, vasculature and the collecting system with a negative predictive value of as high as 99.8%. Therefore, CT is recommended in pediatric patients with high energy/penetrating/deceleration trauma and/or in cases of

drop in hematocrit associated with any degree of hematuria. Furthermore, Dalton and coworkers recommend performing CT as initial imaging modality in pediatric patients with concerns for intra-abdominal injury and visible or microscopic hematuria.

The exposure to ionizing radiation coupled with a higher radiosensitivity of children compared to adults, associated costs and the absent therapeutic consequences (most renal injuries do not require any intervention), however, have challenged the routine use of CT imaging for diagnosing pediatric renal trauma. It is unquestionable that an initial CT scan allows accurate grading of the renal injury and detection of hematomas, urinomas, extravasation and renal fragmentation. Nevertheless, an increasing number of trauma centers no longer guide their management solely by the grade of injury. As a consequence, studies have assessed the necessity of CT examinations of pediatric patients with blunt renal trauma. In a prospective observational study Streck et al. have developed a prediction rule using history and physical examination, chest x-ray, and laboratory evaluation at the time of presentation after blunt abdominal trauma and could successfully identify children at very low risk for intra-abdominal injuries for whom CT could be avoided. Additional future studies should aim to develop well-defined guidelines based on injury mechanism, clinical findings and non-invasive, non-radioactive imaging modalities to limit the number of "unnecessary" negative CT scans without missing significant renal injuries.

The International Association of Surgeons has divided kidney injuries into five classes that have prognostic value in further treatment tactics:

I degree - kidney contusion or uncommon subcapsular hematoma without damage to the renal parenchyma;

Grade II - uncommon paranephral hematoma or cortical tear (<1 cm) without hemorrhage;

III degree - tear of the cortical layer (> 1 cm) and absence of hemorrhage;

IV degree - tear of the fibrous capsule and kidney parenchyma with spread to the pelvis or pelvis. Such injuries are accompanied by hemorrhage and leakage of urine into the paranephral tissue with the formation of a urohematoma;

V degree - kidney dilution, detachment of the kidney from the renal pedicle or thrombosis of the renal artery.

Contusion is described as an ill-defined and poorly defined hypodense zone with reduced gain in the nephrographic phase, which may show delayed or persistent amplification.

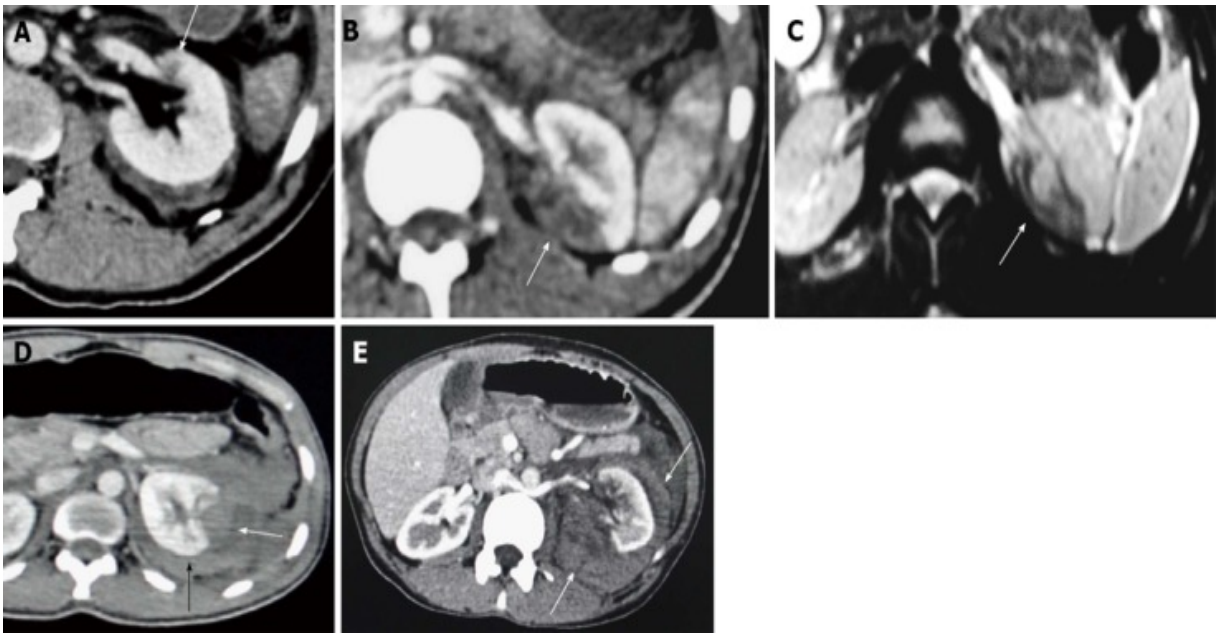


Figure 1. Answer: Contusion. A section of axial contrast enhanced computed tomography (CECT) shows a fuzzy and poorly defined hypodense area with reduced gain (arrow), indicating intraparenchymal contusion; B, C: heart attack; B: axial CECT; C: axial T2 weighted magnetic resonance imaging (MRI) showing infarcts as a wedge-shaped, sharply confined hypodense region on computed tomography (arrow) and hypointense region on T2W MRI image (arrow); D: Subcapsular hematoma. An axial CECT section showing a hypodense area of blood collection along the contour of the kidney, causing flattening or deepening of the lower surface of the kidney (arrow). There is also an associated periorbital hematoma (black arrow); E: Perirenal hematoma. The axial CECT image shows a hypodense area of fluid accumulation (arrows) around the left kidney, bounded by the fascia of Gerot and not causing flattening of the renal circuit. [Dayal M, Gamanagatti S, Kumar A. Imaging in renal trauma. *World J Radiol* 2013; 5(8): 275-284 [PMID: 24003353 DOI: 10.4329/wjr.v5.i8.275]]

First degree injury

Grade I trauma is characterized by a contusion or subcapsular hematoma that does not expand, without rupture of the parenchyma. Other findings include a limited perinephral hematoma and a minor subsegmental infarction. Grade I injuries account for the majority of kidney injuries (approximately 80%), which are clinically manifested by mild or extensive hematuria and are treated conservatively.

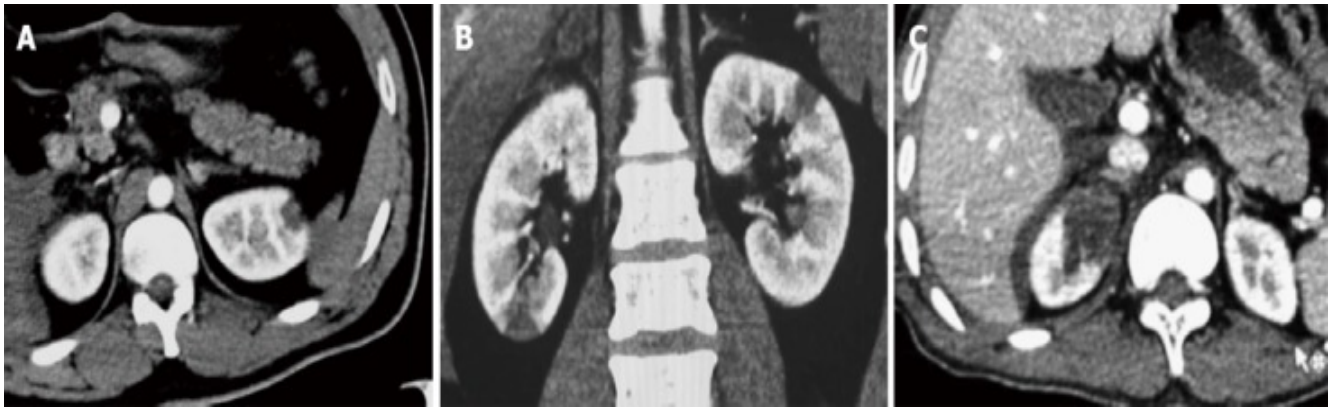


Figure 2. Injury of the first degree. A: Axial; B: Coronal computed tomography (CECT) imaging shows a small contusion in the upper pole of the left kidney (grade I trauma). A small wedge-shaped hypodense area of infarction in the lower pole of the right kidney is also visible; C: Axial CECT image of another patient showing a larger area of contusion at the upper pole of the right kidney. [Dayal M, Gamanagatti S, Kumar A. Imaging in renal trauma. *World J Radiol* 2013; 5(8): 275-284 [PMID: 24003353 DOI: 10.4329/wjr.v5.i8.275]

Injury of the II degree

Kidney damage of the second degree is characterized by a non-expanding perinephral hematoma limited by the retroperitoneal space, or a rupture of the cortex < 1 cm deep without the involvement of the collecting system. Other concomitant signs are thickening of the lateroconal fascia, compression of the colon and displacement of the kidney by a perilateral hematoma. (Figure3).

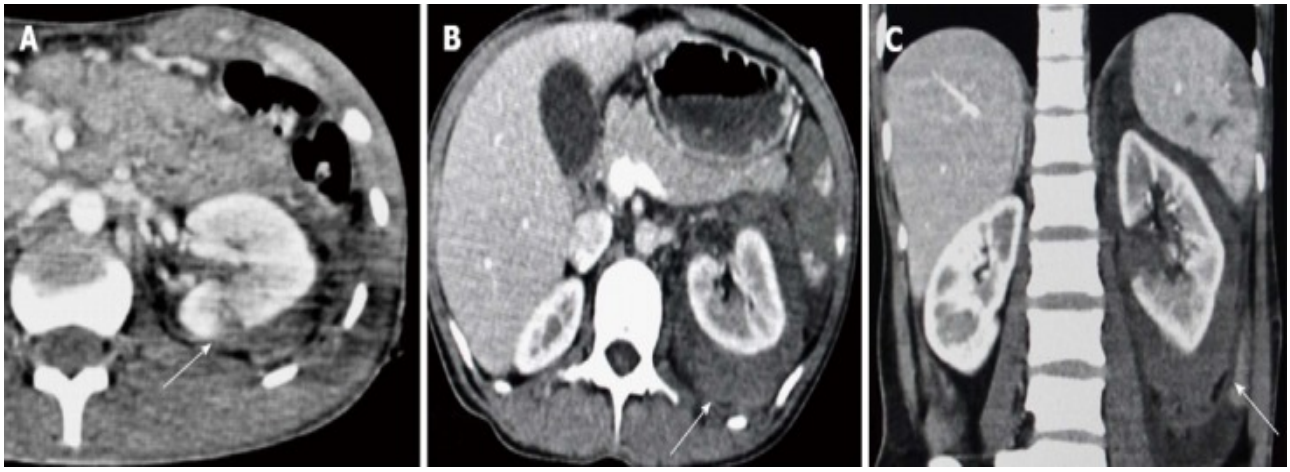


Figure 3. Injury of the second degree. A: Axial contrast computed tomography (CECT) section of a small superficial irregular and linear hypodense area of rupture (arrow) involving the posterior cortex of the left kidney with a mild lesion of perinephral hematoma. No damage to the calyx-pelvic system; B: axial; C: The coronal CECT image shows periorbital hypodensia (arrows) surrounding the left kidney and bounded by the fascia of Gerot. [Dayal M, Gamanagatti S, Kumar A. Imaging in renal trauma. *World J Radiol* 2013; 5(8): 275-284 [PMID: 24003353 DOI: 10.4329/wjr.v5.i8.275]

Injury of the III degree

Only the depth of the kidney rupture distinguishes a grade II injury from a grade III injury. Grade III kidney damage is characterized by a non-expandable perinephral hematoma limited by the retroperitoneal space, and a rupture extending more than 1 cm in depth. The rupture may involve the medulla oblongata, but there is no damage to the PCS that is detected in the excretion phase image, demonstrating the absence of urine extravasates (Figure).

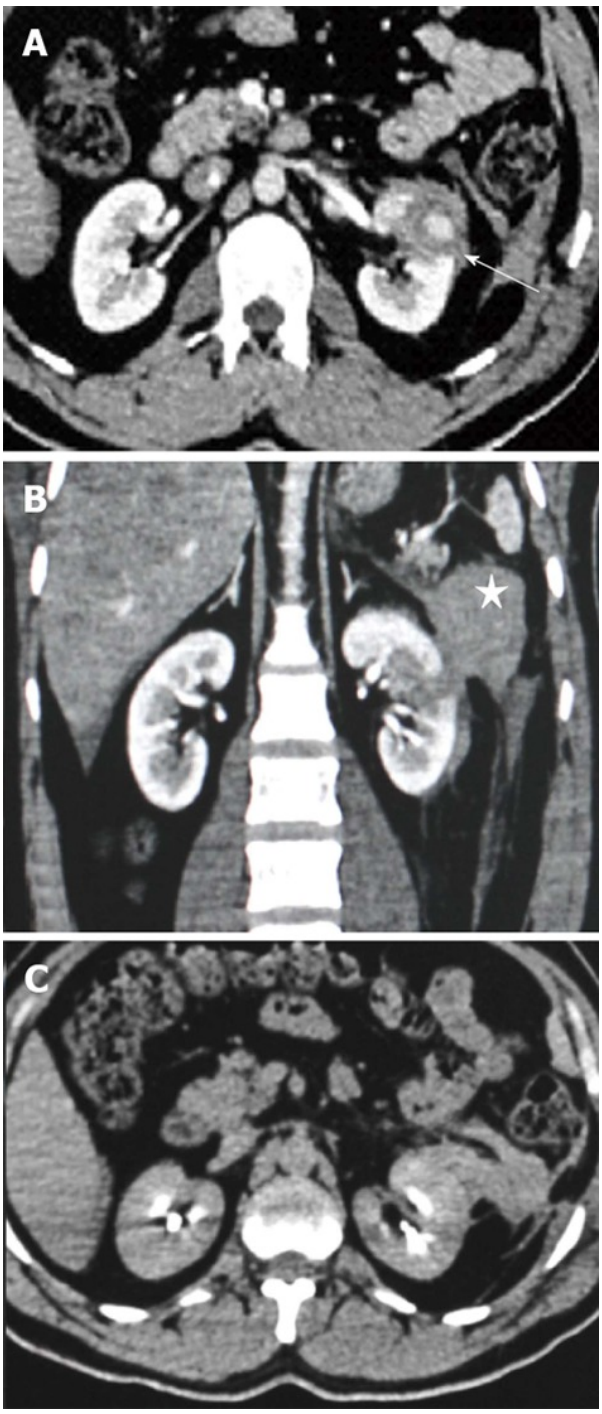


Figure 4. Grade III trauma. Contrast-enhanced computed tomography (CECT). A: Axial incision showing a deep laceration (arrow) reaching the gate; B: Coronal incision showing a deep rupture at the midpole with a rupture of the pararenal fascia and a large hematoma (asterisk) lateral to it; C: The axial slow-motion image in the selection phase did not show extravasation of the selected contrast. [Dayal M, Gamanagatti S, Kumar A. Imaging in renal trauma. *World J Radiol* 2013; 5(8): 275-284 [PMID: 24003353 DOI: 10.4329/wjr.v5.i8.275]]

Injury of the IV degree

Grade IV injury involves damage to the main renal artery or vein with localized hemorrhage and damage resulting in segmental devascularization and ACL ruptures. In addition, multiple kidney ruptures, expanding subcapsular hematomas, and a kidney fracture are included in this degree. The presence of a hematoma in the perigillar site and medial side of the kidney, or deeper tears extending to the pyloric bone, should increase the likelihood of ACL damage, so an excretory phase scan is necessary to confirm urine leakage (Figure)

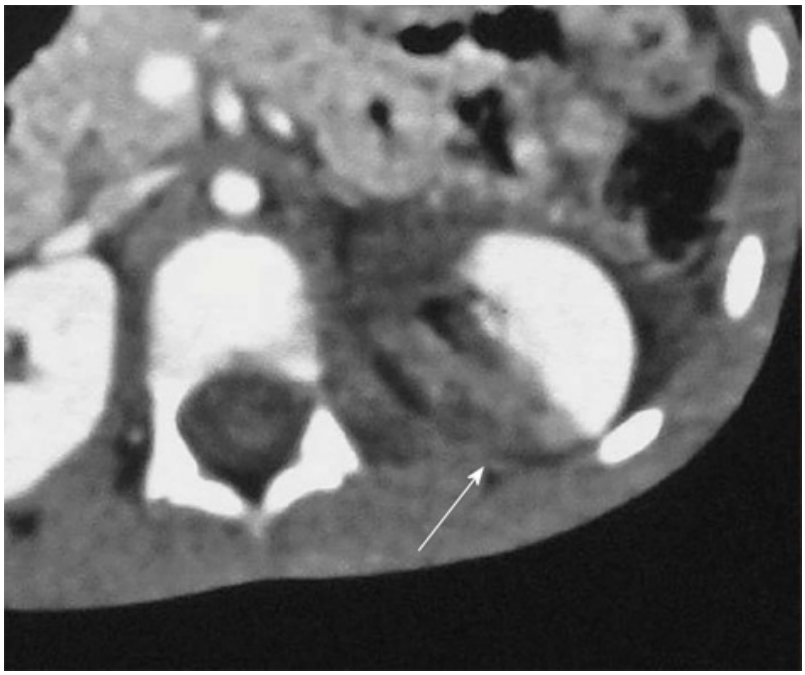


Figure 5. Injury of the IV degree. Segmental infarction. Contrast computed tomography of an axial incision of a 6-year-old child who has received a blunt injury. A sharply defined undilated hypodense area covering the posterior medial cortex of the left kidney. [Dayal M, Gamanagatti S, Kumar A. Imaging in renal trauma. *World J Radiol* 2013; 5(8): 275-284 [PMID: 24003353 DOI: 10.4329/wjr.v5.i8.275]

Injury of the V degree

Grade V is the highest degree of kidney damage, characterized by the separation of the pelvic-ureteral junction. It occurs as a result of a shear injury at this fixation

point, as it stretches over the transverse process and leads to a violation of the PUJ. They can be partial or complete, with the presence of a hematoma or urine in the medial and perigillar region of the kidney. Extravasation of cloudy urine on scans of the excretory phase with cloudiness of the ureter distal to the injury helps to confirm the diagnosis and differentiate complete damage from partial damage. With a complete detachment of the ureter, the damage will not be visible outside and the patient will need surgery, while with a partial rupture, there will be a distal opacity of the ureter and such patients can be treated with minimally invasive methods, such as the placement of a ureteral stent. through the site of damage or urine drainage through the percutaneous nephrostomy tube. Surgical intervention may be chosen if the above conservative methods do not allow the damage to be cured.

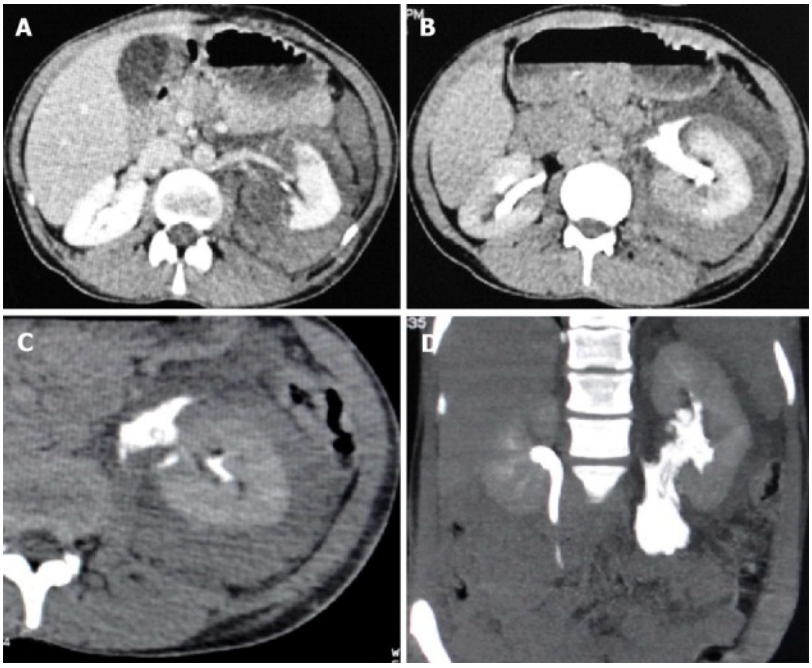


Figure 6. Injury of the V degree. Damage to the ureto-pelvic junction (stage IV grade revised). Contrast computed tomography. A: Axial incision showing a deep rupture of the posteromedial cortex of the left kidney involving the pylorus with periperirenal hematoma; B: axial incision of the excretory phase showing the leakage of cloudy urine from the pelvic-ureteral junction that runs along the medial side of the kidney; C: Axial Projection of Maximum Intensity (MIP); D: A coronal MIP image showing extravasated cloudy urine from the renal pelvis and tracking in the

retroperitoneal space along the ureter. [Dayal M, Gamanagatti S, Kumar A. Imaging in renal trauma. *World J Radiol* 2013; 5(8): 275-284 [PMID: 24003353 DOI: 10.4329/wjr.v5.i8.275]

Treatment

The therapeutical regime of pediatric renal injuries has shifted from an aggressive surgical approach in the past to a non-operative observational approach in the present for most patients.

It is generally accepted that prolonged observation is not necessary in patients with grade I and II injuries and that conservative treatment should also be performed in grade III injuries. The optimal treatment of higher grade renal injuries, however, is still a matter of debate. Even though grade IV and V injuries are associated with higher rates of surgical interventions and complications, initial observation is feasible provided that the patients are hemodynamically stable.

Indications for conservative therapy:

a) stable hemodynamic parameters, satisfactory general condition of the patient;

b) the insignificant force of the blow received and the mild nature of the injury;

c) absence of signs of violation of the integrity of the kidneys and urinary tract according to EU and ultrasound data;

d) the presence of minor post-traumatic changes in the renal parenchyma without signs of impaired urodynamics and significant active extravasation of urine;

e) positive clinical dynamics under the influence of drug therapy;

f) in the presence of subcapsular or periorbital hematomas - their small size (diameter up to 3 cm subcapsular and up to 5–7 cm periorbital) and the absence of an increase in the size of hematomas during dynamic observation.

Indications for surgery:

Absolute:

a) unstable hemodynamic parameters (a sharp decrease in blood pressure, tachycardia ≥120 beats/min), severe general condition of the patient and the presence of significant combined lesions that are life-threatening to the patient;

b) growing or pulsating hematoma;

c) technical impossibility to determine the condition of the affected kidney and the function of the contralateral kidney by available diagnostic methods with obvious signs of hemodynamic disorders;

d) damage of the IV degree according to the classification of AAHT with damage to the main artery or vein and concomitant bleeding;

e) severe injuries of the V degree according to the classification of the AAFT.

Relative:

a) the degree of injury is not clearly defined;

b) extravasation of a large amount of urine;

c) the presence of a large area of non-viable kidney tissue;

d) significant size of subcapsular or periperinatal hematomas without a tendency to increase;

e) damage of the IV degree without vascular damage according to the AAFT classification;

f) combined injuries that require surgical treatment;

g) premorbid or incidental diseases of the injured kidney;

g) suppurative urohematoma;

h) the absence of the effect of previously performed conservative treatment or invasive intervention.

Indications for organ-preserving surgery:

a) rupture or detachment of one of the poles of the kidney;

b) single ruptures of the kidney parenchyma;

c) injury to one of the kidneys with a pathologically altered other;

d) simultaneous injury to both kidneys;

e) injury to a single kidney.

Indications for early nephrectomy:

a) multiple deep kidney ruptures that cannot be reconstructed;

b) necrosis of most of the parenchyma;

c) crushing of the kidney;

d) damage to the vascular pedicle that does not lend itself to suturing.

Conservative treatment consists of bed rest, frequent vital sign evaluation, hemoglobin/hematocrit measurements, pain therapy and intravenous fluid replacement. The length of bed rest has not been clearly defined, but generally it is performed until resolution of visible hematuria. Routine placement of urinary catheters as well as antibiotic prophylaxis do not seem to be necessary. Periodical monitoring of the injury can safely be performed with sonography to rule out complications such as increasing urinary extravasation or ongoing hemorrhage. Recommended time points range from 4-24 hours to 48 to 72 hours following the initial scan.

The necessity and duration of observation on intensive care units (ICUs) vary considerably in the literature ranging between 24 hours and one week. While several authors recommend observation on the ICU, others do not admit stable patients to the ICU at all. However, close clinical observation with hemodynamic monitoring in an intensive care environment has been recommended especially for higher grade injuries.

Guidelines are also lacking regarding the length of total hospital stay. In a considerable amount of studies the total length of hospital stay is not recorded. Graziano and coworkers prospectively applied an abbreviated protocol in the management of blunt renal injury in children. Mobilization was immediately allowed regardless of injury grade and patients were discharged when tolerating diet and pain regardless of hematuria. Their mean length of stay was 2.9 days; however only four patients had grade V injuries and 7% of the patients had to be readmitted for either pain, hematuria or bladder clot. Most of the other studies report lengths of stays of approximately 10 days increasing with the grade of injury.

Penetrating injuries

Penetrating renal injuries should be suspected if there are wounds in the lower chest, lateral surfaces or upper abdomen. These injuries tend to be more serious and more unpredictable than blunt injuries. Hematuria usually accompanies large parenchymal cuts. However, kidney injury in children can be isolated and not lead to hematuria.

Renal imaging is performed in any patient with any degree of hematuria if this injury is penetrating. As in the case of blunt trauma, a CT scan of the abdominal cavity is an imaging study in patients with suspected penetrating renal injury.

Treatment

In general, you should try to treat all kidney injuries conservatively, with the exception of vasorenal class V trauma, where surgery is more appropriate. Most blunt kidney injuries are minor and usually resolve without complications. Only 10-15% are lacerated parenchymal injuries.

Conservative therapy

- strict bed rest for all injured for 10-17 days;
- "cold compress" on the injured area for all patients during the first 1-2 days;
- painkillers for the first 3-4 days;
- hemostatics until hematuria stops;
- uroantiseptics and antibiotics for 7-21 days to all injured persons to prevent suppuration of hematomas and prevent the development of pyelonephritis.

Surgery is not always necessary and most blunt kidney injuries are treated conservatively. If necessary, kidney tests are performed to assess kidney damage or treat significant renal injuries while preserving the renal parenchyma. Surgical

treatment consisted of revision of the injured kidney and retroperitoneal space, followed by organ-preserving surgery or nephrectomy. The need for surgical examination is much higher in patients with penetrating injuries, in contrast to blunt trauma.

Blunt trauma

Indications for renal examination vary greatly between individual degrees of injury. For most injuries of I-III degree, bed rest and observation are necessary. Discrepancies arise in the decision of treatment for IV-V degrees of injuries. Most blunt kidney injuries occur due to blows and lacerations that are minor in nature. Even in the presence of macrohematuria, blunt kidney injuries do not require examination.

Absolute indications for renal examination include constant life-threatening, dilating, pulsating or unrestrained bleeding, retroperitoneal hematomas, or suspicion of detachment of the vascular pedicle of the kidney. Relative indications for the study include - significant non-viability of the renal parenchyma or hemorrhage. After the macrohematuria disappears, it is necessary to limit physical activity for two to four weeks until the microhematuria disappears.

Early complications can occur within the first four weeks after injury, including bleeding, abscess, sepsis, urinary fistula, hemorrhages, cysts, hypertension. The greatest risk of untimely retroperitoneal bleeding occurs during the first two weeks after injury and can be life-threatening. In these cases, immediate surgical examination is indicated - angiography of embolized vessels. Angiographic examination is an alternative to surgery in patients with stable hemodynamic parameters in whom there is persistent macrohematuria, which indicates constant bleeding from the damaged kidney. Persistent hemorrhages are successfully managed with percutaneous drainage. Hypertension in the early period after injury is rare. Hypertension can develop in the following months and in most cases does not require further treatment, except for medical correction.

Penetrating injuries

Almost all penetrating kidney injuries should be treated promptly. The exception is the stable condition of the patient without penetration into the peritoneum and if the injury was examined using CT. Superficial and peripheral puncture wounds respond well to conservative treatment. In sharp contrast, each of the four degrees (III-IV) of injuries from a penetrating wound is observed. Gunshot wounds of the abdomen or lateral surfaces of the abdomen, which are accompanied by hematuria, suggest the possibility of destruction of most of the kidney due to the possible effect of an explosion. Most penetrating abdominal injuries require laparotomy (61%). The presence of an unexpected retroperitoneal hematoma during laparotomy, where kidney damage has not been fully detected radiologically, usually guarantees renal examination.

Kidney research and follow-up

Operations for kidney damage.

Methods for stopping bleeding from the kidney

A vertical median incision from the xiphoid process to the pubis is made quickly with open and closed wounds for maximum assistance. A complete examination of the contents of the intra-abdominal cavity is performed. Restoration of the function of the main vessels, spleen, liver and intestines, as a rule, should be performed before renal examination. Obviously, if a kidney hemorrhage is life-threatening, the kidneys should be examined first.

Renal vascular damage must be resolved as soon as possible. Major renal vein ruptures are directly resolved with venous sutures. Various methods may be required to repair the renal arteries, including end-to-end anastomosis resection, autogenous vein shunt or synthetic graft, and of course an arterial suture. Traumatic occlusion of the renal artery requires many treatments. However, this must be done within the first 12 hours of injury, otherwise, the kidneys tend to become unviable after a long ischemia.

If a rupture of the kidney is detected during the revision of the retroperitoneal hematoma, it is necessary to determine the adequate amount of intervention on the damaged kidney. Removal of the kidney is indicated in cases of detachment of its leg and rupture of the kidney in several places. Before nephrectomy, you should make sure that there is a second functioning kidney. For this purpose, the leg of the injured kidney is clamped with a clamp or tourniquet, and then 5 ml of indigo carmine solution is injected intravenously. The appearance of colored urine in the catheter standing in the bladder indicates the preservation of the function of the second kidney. It must be remembered that in a victim with severe combined trauma and shock, with blood pressure below 80 mm Hg. The function of the second kidney can be drastically reduced. In such cases, you have to be guided by the results of examination and palpation of the second kidney.

In case of severe damage to a single kidney, it is necessary to try to preserve it by performing a resection of the parenchyma with ligation of segmental vessels, applying a nephrostomy and reliably draining the paranephral space. Resection is performed as follows. After opening the fibrous capsule, hemostasis is performed and the parenchyma is wedge-shaped excision within the unchanged tissues. If this reveals a violation of the integrity of the cups, they are sutured with separate nodal sutures. In order to avoid the rapid formation of calculi, the defect of the pelvis is sutured without capturing the mucous membrane. The edges of the wedge-shaped defect of the parenchyma are brought closer together by applying a series of sutures with the capture of the fibrous capsule. When erupting such sutures, free pieces of muscle tissue taken in the access zone are placed under them.

A nephrostomy tube with one or two holes at the end is inserted into the zone of kidney rupture, fixed to the fibrous capsule with catgut (or synthetic absorbable) sutures, removed through a counterperture in the lumbar region and securely fixed to the skin with a non-absorbable thread.

Kidney resection

The kidney is removed separately by ligating the artery, vein and ureter with non-absorbable suture material. The renal vessels should be isolated in such a way that when a hemostatic clamp is applied, its branches are easily pinched, and the working surfaces fit snugly together, otherwise (with insufficient mobilization) the ligature may slip off the vessel. When removing the right kidney, one should remember about the immediate proximity of the inferior vena cava. In about 30% of observations, additional vessels go to the kidney, which also need to be carefully ligated. After removal of the kidney by laparotomy, the posterior leaf of the peritoneum is sutured with nodal sutures, while the paranephral tissue is pre-drained through the counterperture in the lumbar region.

Often, the cause of a growing retroperitoneal hematoma is a severe fracture of the pelvic bones with bleeding. In such cases, the retroperitoneal space opened during the revision is reliably drained and, after the laparotomy is completed, the pelvic ring is fixed with a plate or external fixation is used. After fixing fractures of the pelvic bones, bleeding, as a rule, stops.

It should be remembered that external fixation must be performed at the end **of the intra-abdominal stage of** the intervention, since otherwise bulky external structures will not allow free manipulation in the abdominal cavity.

III. **Ureteral injuries**

Overall, a ureteral **injury** is rare. The most common cause is iatrogenic trauma during open surgery, laparoscopic, or endoscopic procedures. Penetrating trauma accounts for most non-iatrogenic ureteral **injuries**. Ureteral **injuries** are often subtle, and clinicians must have a high index of suspicion for them. An unrecognized or mismanaged ureteral **injury** can lead to significant complications, including urinoma, abscess, ureteral stricture, and potential loss of ipsilateral kidney or even death.

The ureter is the least injured part of the genitourinary tract due to its small caliber and mobility, and it is well protected from injury by the back muscles and extraperitoneal fat. Even so, blunt trauma to the ureter or urinary passage is more common in children than in adults (3: 1).

Ureteral injuries in children are very rare. Locheretz et al. (1971) collected from the literature 23 observations of this trauma over 20 years and added a description of one case. Due to its elasticity and mobility, a healthy ureter is easily displaced in case of injury to the lumbar region and abdomen. There are closed and open ureteral injuries. The last damage is usually the result of gunshot wounds. The most important and relevant for pediatric surgeons are accidental damage to the ureters during operations in the abdominal cavity in the pelvis.

This is more likely during surgical interventions for malformations of the rectum and anus. The left ureter, lying in the thickness of the posterior leaf of the parietal peritoneum in the immediate vicinity of the pathologically altered sigmoid colon, can be bandaged or dissected if it is carelessly mobilized. Such damage is possible with laparotomy and an attempt to remove large tumors or cysts in the pelvis. D. V. Kahn (1967) distinguishes between the following types of ureteral damage: ligation, dissection, detachment from the bladder, segment resection and crushing.

Ureteral injury is very rare and is believed to account for less than 1% of blunt and penetrating trauma to the genitourinary system. It is most common in gunshot wounds, and the proximal ureter is most often affected.

Ureteral injuries are three times more common in the right kidney than in the left. The injury is believed to be the result of compression of the renal pelvis and the upper part of the ureter by the 12th rib or transverse processes of the lumbar region, or by stretching the ureter with sudden flexion of the trunk. It is believed that this is more common in children, since the child's spine and torso are much more mobile and elastic than in adults.

Isolated damage to the ureters is very rare. Due to its elasticity and mobility, the ureter is easily displaced during injury. Only with a strong blow does it press against the transverse processes of the spinal column and rupture. Most often, the ureter is injured with severe combined injuries to other organs. Sometimes the integrity of the ureter is violated during surgery on the organs of the abdominal cavity, pelvis, extraperitoneal space or with careless performance (endoureteral) intraureteral manipulations.

Epidemiology

Ureter damage after external trauma is rare, occurring in less than 4% of penetrating trauma and less than 1% of all cases of blunt trauma. A patient with ureteral **injury** from a gunshot wound often has significant concomitant **injuries** and a large risk for mortality.

The overall incidence of iatrogenic ureteral **injuries** caused during operative procedures varies from 0.5 to 10%. Analysis of 13 published studies concluded the following procedures contribute to iatrogenic ureteral **injuries**: hysterectomy (54%), colorectal surgery (14%), pelvic procedures such as ovarian tumor removal (8%), transabdominal urethropexy (8%), and abdominal vascular surgery (6%). Another retrospective review identified 55 patients with iatrogenic ureteral **injuries** during a 16 year period and noted the majority of ureteral **injuries** occurred during gynecologic procedures (55%). The remainder of procedures were urologic (25%), colorectal (15%), and vascular (5%).

The incidence of **injury** to the ureter may be lower for laparoscopic versus open surgical approaches. A review looking at over 90,000 colectomies showed the incidence of ureteral **injury** in laparoscopic approach to be 0.54% compared with 0.66% with open surgery.

Classification

Ureteral injuries can be classified by location:

1. Urethromycular junction (UPJ)
2. Abdominal ureter (UPJ to iliac vessels)
3. Pelvic ureter (lower from the iliac vessels)

Ureteral injuries can be classified depending on when the diagnosis is made:

1. Immediate diagnosis (diagnosed shortly after injury)
2. Late diagnosis (diagnosed long after surgery)

The American Association for Trauma Surgery (AAST) classifies ureteral injuries as follows:

I degree - hematoma; contusion or hematoma without devascularization

II degree - laceration; less than 50% of the transsection

III degree - laceration; 50% or more transsection

IV degree - laceration; complete transsection with devascularization less than 2 cm

V degree - laceration; avulsion with devascularization of more than 2 cm

There are the following types of ureteral damage:

- **dressing**,
- **dissection**,
- **separation from the bladder or kidney**,
- **segment removal** and **crushing**.

Ureteral injuries are divided into open and closed.

Closed ureteral injuries

Closed ureteral injuries include:

A. contusion (partial destruction of the wall, which causes the formation of narrowing and ureterohydronephrosis);

B. incomplete rupture or crushing of the ureteral wall, when its lumen does not communicate with the surrounding tissues (this, in turn, causes narrowing of the ureter or necrosis of its wall);

C. complete rupture of the ureteral wall when its lumen communicates with the surrounding tissues;

D. **interruption of the ureter**.

According to statistics, the pelvic part of the ureter is most often damaged. Contusion, incomplete rupture, crushing are diagnosed very rarely. Usually, such patients are treated for kidney contusion.

Damage to the ureter is often combined with trauma to the abdominal organs, therefore, complete or partial rupture of the ureteral wall and its interruption are not always diagnosed in a timely manner.

Pathophysiology

A basic understanding of the anatomy of the ureters is important for further discussion of the pathophysiology of ureteral damage. The ureters are peristaltic tubular structures that are located in the retroperitoneal space and transport urine from the kidneys to the bladder. They are divided into three segments. The proximal ureter is a segment that extends from the ureteral-pelvic junction (UPJ) to the area where the ureter crosses the sacroiliac joint. The middle ureter runs along the bony pelvis and iliac vessels. The pelvic or distal ureter extends from the iliac vessels to the bladder.

The ureter is located close to numerous structures in the abdomen and pelvis, which poses a risk to it during surgical procedures. The left UPJ is located slightly behind the pancreas and duodenal-hollow junction. The right VPZ is located posterior to the duodenum and lateral to the inferior vena cava. Passing down, the ureters lie on the psoas muscle and pass medially from the sacroiliac joints. They turn laterally near the ischial spines before passing medially to penetrate the base of the bladder. The left ureter is crossed in front by the inferior mesenteric artery and sigmatic vessels. The right ureter is crossed by the right enteric-colonic and ilio-colonic vessels. When the ureters descend into the pelvis, they pass in front of the iliac vessels and posterior from the gonadal vessels. In women, the ureter runs behind the ovary, lateral to the pelvic ligament and medial to the anterior vessels. It runs posteriorly from the latissimus ligament and laterally from the uterus. The uterine arteries run slightly ahead of the ureter in the ureter. In men, the ureter is crossed in front by the medial umbilical ligament and passes under the vas deferens before entering the bladder.

It is believed that the mechanism by which bullets or other penetrating injuries damage the ureter is not a direct cross-section, but most likely due to a violation of the delicate intramural blood supply to the ureter. Patients with blunt trauma with ureteral damage are subjected to extreme force that is applied to the whole body or a larger surface.

Clinical picture with closed ureteral injuries

In the clinical picture of closed ureteral injuries, the main ones, of course, are signs of combined damage to the abdominal organs. Only later do symptoms of urinary infiltration of the retroperitoneal space appear: fever, manifestations of intoxication, pain in the lumbar region, muscle tension, irritation of the parietal peritoneum, pastosity during rectal or vaginal examination.

Urinary infiltration of the retroperitoneal tissue is accompanied by soreness, swelling in the lumbar region, as well as the appearance of edema in the labia in women and the calf in men.

The main symptom of ureteral damage is a single hematuria, which disappears immediately and usually goes unnoticed. Persistent clinical manifestations occur 2 to 3 days after injury or surgery. The main signs are urinary drip or urine leakage into a wound or abdomen. When ligating the ureter in violation of the outflow from the corresponding kidney, the child complains of increasing pain in the kidney area. Daily diuresis is noticeably reduced, an enlarged and painful kidney begins to be palpable. If the bandaged ureter belongs to the solitary kidney, urination stops. At the same time, the body temperature may rise, the general condition gradually worsens. Ultimately, the ligature on the ureter erupts and symptoms of urinary stasis or peritonitis occur.

Diagnostics

A high index of suspicion occurs when assessing all traumatic ureteral injuries. Very often, disorders in the urinary system are not initially detected. Delayed diagnosis often leads to complications such as abscess or obstruction with massive hemorrhages. Hematuria is a universally inconsistent indicator of ureteral injury and is detected in 45-63% of cases. If there is any suspicion of potential damage to the ureter due to a case of penetrating wound to the abdominal cavity, retroperitoneal space, or pelvis; fracture of the 11th or 12th rib; transverse processes of the lumbar spine; pelvic bones; or significant abdominal or pelvic injuries, excretory urography or CT must be performed.

To detect closed ureteral lesions, excretory (infusion) urography and computed tomography with intravenous injection of contrast agent are used. Signs of ureteral damage are:

- delayed excretion of contrast agent or lack of kidney function on the affected side;

- expansion of the calyx-pelvic system and, often, the ureter to the level of the lesion;
- extravasation of the contrast agent outside the ureter.

Information about the patency of the ureter can be obtained by chromocystoscopy. In addition, intravenous indigo carmine can also be detected in urine secreted from the wound canal.

If urography does not provide the necessary information, **retrograde ureteropielography is performed**. It allows you to clarify the condition and degree of patency of the ureter, as well as the level of its damage. During radionuclide scanning or scintigraphy, attention is paid to the accumulation (timely or delayed) and distribution (uniform or uneven) of the radionuclide drug in the kidney.



Figure 7. Retrograde pyelogram illustrating a ureteral arterial fistula. [Burks FN, Santucci RA. Management of iatrogenic ureteral injury. Ther Adv Urol. 2014 Jun;6(3):115-24. doi: 10.1177/1756287214526767. PMID: 24883109; PMCID: PMC4003841.]

Such injuries go undiagnosed in 66% to 75% of research cases. The results of an GDP or CT scan are usually necessary to make a diagnosis. Retrograde urography and direct surgery remain the most sensitive instruments with an accuracy ranging from 85% to 100%. However, this is rarely performed in an acute injury situation.

Treatment

Several important principles are necessary for successful ureteral repair. It is important to debride all devitalized tissue. There must be sufficient ureteral mobilization to permit a tension-free anastomosis. It is important to preserve the ureteral adventitia and vasculature to ensure adequate ureteral blood supply. The ureteral ends should be spatulated. A water-tight, tension-free, mucosa-to-mucosa anastomosis should be created over a ureteral stent using absorbable suture.

The choice of repair depends on the site of ureteral **injury** and timing of identification. If the **injury** is grade I-III, consider placing a ureteral stent and allowing the ureter to heal over the stent. If the **injury** is to the upper or middle ureter, consider direct ureteroureterostomy (UU) or transureteroureterostomy (TUU). If the **injury** is to the lower ureter, consider ureteral reimplantation (ureteroneocystostomy), psoas hitch, or boari flap.

Depending on the nature of the damage to the ureter and the degree of violation of its integrity, the treatment of ureteral injury can be conservative or surgical.

Conservative treatment is recommended in case of bruising and tearing of the ureteral wall, in case of damage to it during intraureteral (endoureteral) manipulations. Patients are prescribed painkillers, antibiotics, anti-inflammatory drugs that prevent the development of periurethritis and narrowing of the ureter.

Surgical treatment consists in emptying the urinary flow and restoring the continuity of the organ. Nephrectomy is advisable only with complete destruction of the kidney parenchyma and loss of its function.

In case of incomplete rupture of the ureter and the absence of urinary infiltration, nodular sutures are applied to the ureteral wound. With a complete rupture of the ureter, its peripheral and central ends are compared and a primary suture is performed. To prevent a narrowing from forming, in the area of the suture, it is recommended to dissect the ureter not across, but obliquely, and connect its ends without capturing the mucous membrane with U-shaped sutures, which alternate with knotty ones. This allows you to slightly increase the lumen of the ureter. The ureter should not be separated from the surrounding tissues, as this leads to impaired blood supply to its walls and necrosis. With the correct application of the ureteral-ureteral anastomosis, the normal lumen of the ureter is preserved, which ensures kidney function at the proper level.

If the ureteral injury is combined with massive urinary infiltration, then the operation is carried out in two stages. First, urine is diverted (with the help of nephrostomy, ureterostomy, drainage of retroperitoneal tissue), and 6-10 weeks after the elimination of urinary infiltration, plastic or restorative surgery is performed. In such cases, it is necessary to remove the ureteral segment and suture its ends.

Damage to the distal ureter

Ureteroneocystostomy. Most surgical injuries occur in the distal ureter. The distal ureter is most often damaged when trying to ligate the branches of the internal iliac vessels, and after these manipulations, the damaged ureter may have an even weaker blood supply than usual. Since the blood supply to the distal ureter can be disrupted, ureteronecystostomy is an ideal option for repairing the distal ureter. When preparing the ureter for implantation, it should be carefully restored to viable tissue and spatulaled. Reimplantation can be performed in a reflux or non-reflux manner, and the consensus is that reflux-free reimplantation is preferable [Png and Chapple, 2000]. Despite the consensus on non-reflux reimplantation, no technique has a deleterious effect on kidney function or increases the risk of stenosis [Stefanovic et al. 1991]. If non-reflux reimplantation is planned, the ureter should be tunneled in the bladder wall,

as in the Politano-Lidbetter technique, with the tunnel length three times the diameter of the ureter, as shown in Figure 2 [Shokeir and El-Hammady, 1996]. The site of reimplantation should be on the posterior or anterior dome of the bladder, and not on the sides. Reimplantation of the ureter on the sides of the bladder is prone to kinks with bladder filling [Hensle et al. 1982]. The reimplanted ureter should be stented and the Foley catheter maintained in the bladder after surgery along with Jackson-Pratt (JP) drainage near the anastomosis. The Foley catheter can be removed after about 1 week and the JP drainage removed as soon as it is determined that repairs are not underway. The stent is removed after 6 weeks.

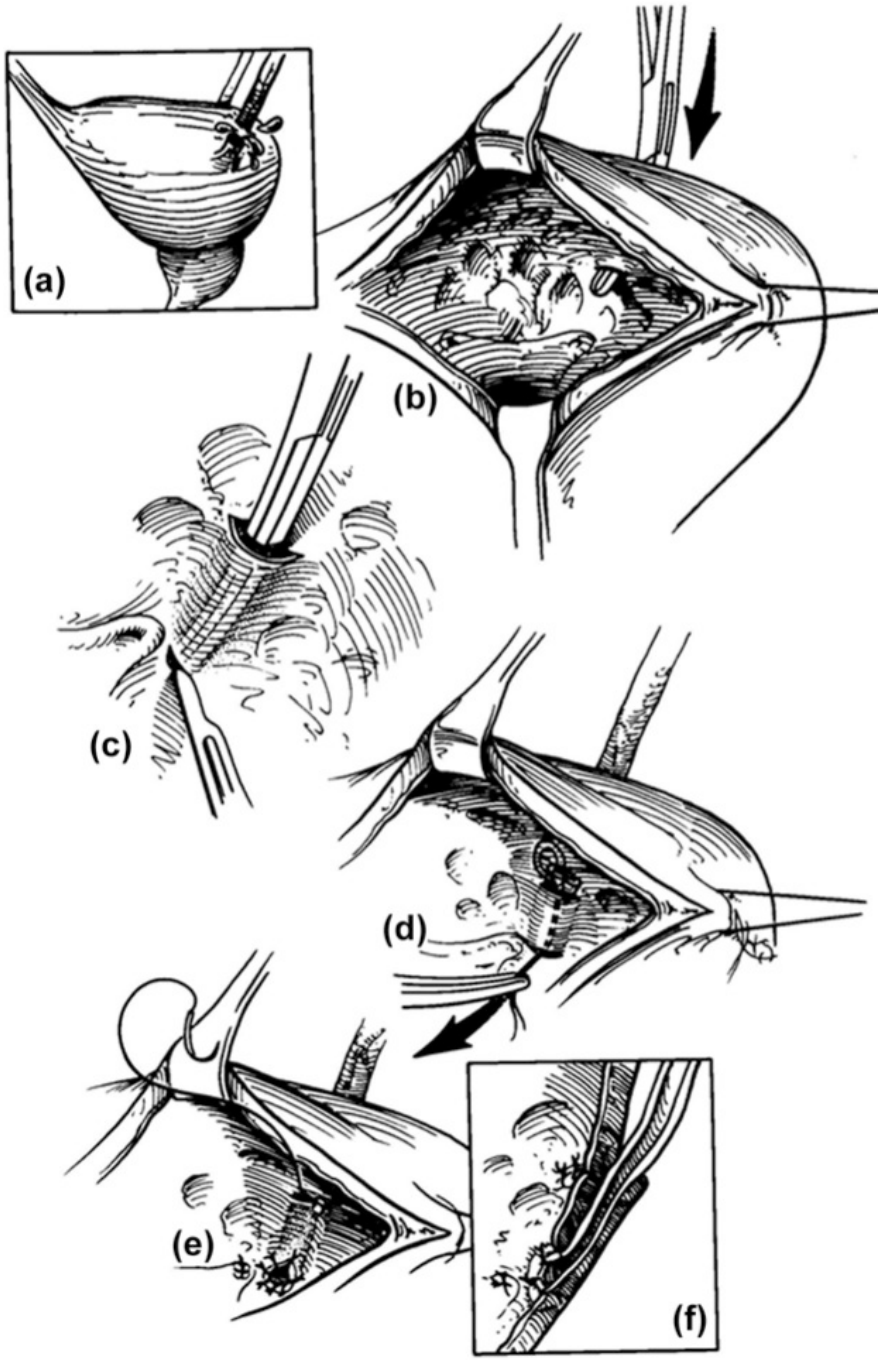


Figure 8. Tunnel ureteronecystostomy with damage to the distal ureter.[Burks FN, Santucci RA. Management of iatrogenic ureteral injury. Ther Adv Urol. 2014 Jun;6(3):115-24. doi: 10.1177/1756287214526767. PMID: 24883109; PMCID: PMC4003841.].

Vesicolumbar rupture. When a long-term defect is found in the distal ureter, such that performing a simple ureteroneoctomy can lead to anastomosis tension, often this distance can be overcome by the vesicolumbar coupling first described by Zimmerman and colleagues [Zimmerman et al. 1960]. Mobilization of the bladder in the Retzius space and ligation of the contralateral bladder pedicle helps to position the

bladder near the psoas muscle. Then the bladder detrusor It is "attached" to the psoas muscle by longitudinal, non-absorbable monofilament filaments to compensate for the length between the bladder and the proximal ureteral stump, as shown in Figure 3. Make sure to avoid the genito-femoral nerve, which lies on the anterior surface of the psoas muscle. The ureter is then reimplanted in the altered bladder in a similar way to the previously mentioned ureteronecystostomy. Some authors advocate the routine use of the vesicolumbar clasp for ureteral reimplantation because it provides a long, fixed, straight submucosal tunnel that is hardly affected by the degree of bladder filling [Middleton, 1980]. A large series of 181 patients for whom vesicovascular adhesion was used for ureteronecystostomy reported a 97% success rate with a median follow-up period of 4.5 years. In this series, the authors argue that the key to success is tension-free anastomosis, anti-reflux long submucosal tunnel, and direct ureteral reimplantation to prevent kink at the point of entry into the bladder. A more modern series of 24 patients reported no difference in outcomes when iatrogenic injury recovery was treated with immediate recovery (less than 6 weeks) with psoas engagement or delayed recovery (more than 6 weeks).

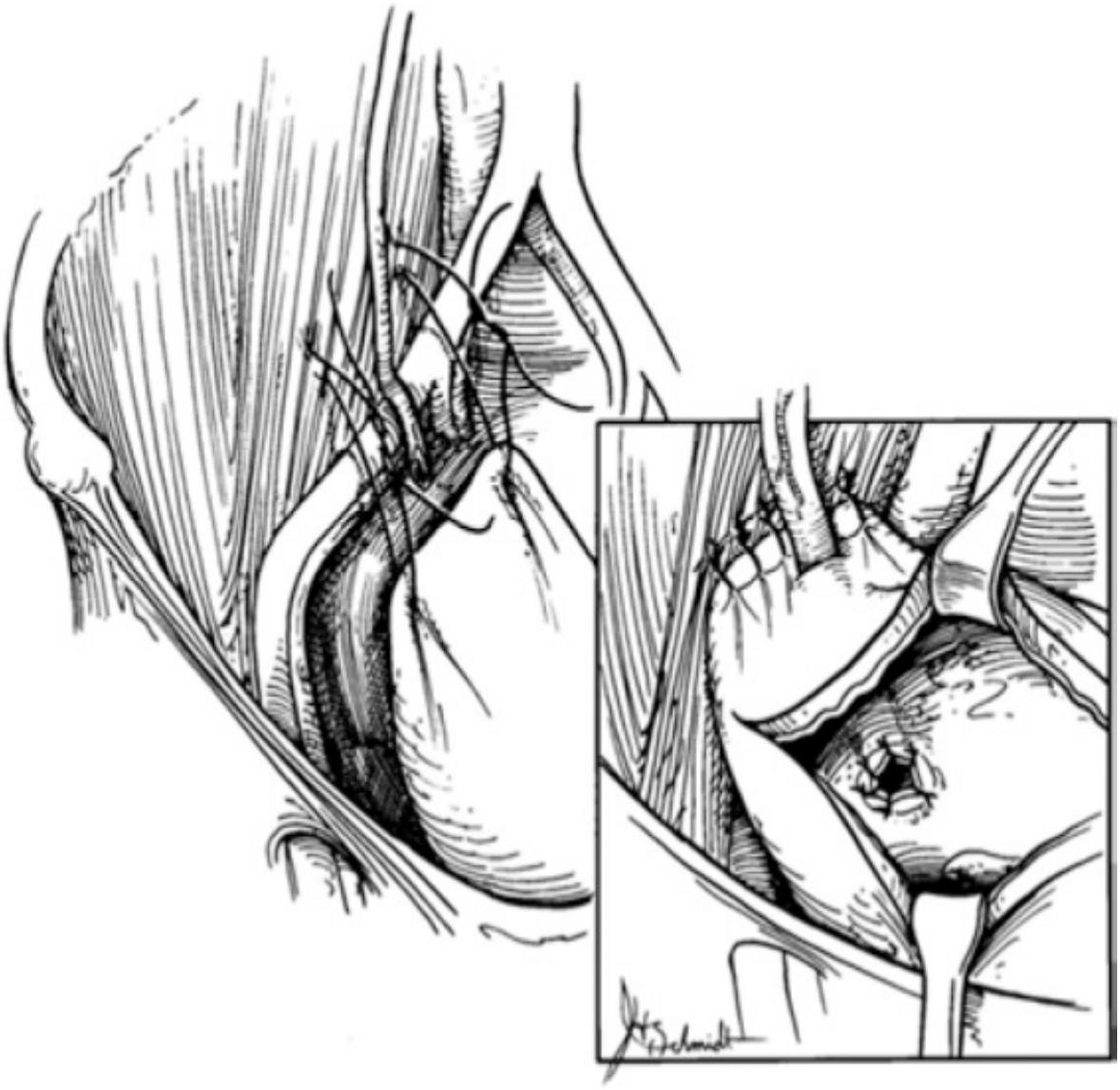


Figure 9. Vesicolumbar clasp for distal ureteral reimplantation. [Burks FN, Santucci RA. Management of iatrogenic ureteral injury. Ther Adv Urol. 2014 Jun;6(3):115-24. doi: 10.1177/1756287214526767. PMID: 24883109; PMCID: PMC4003841].

With significant defects of the ureter and its changes expressed over a long distance, partial or complete replacement with a graft from the intestine is performed. However, after this operation, severe complications often develop, so it is performed only when the ureter of a single kidney is damaged at a considerable distance.

Surgical examination and direct intravenous administration of methylene blue or indigo carmine are the best investigations when acute ureteral injury is suspected. Surgical intervention depends on the location and degree of damage. The goal of the primary intervention should be without tension and non-penetrating anastomosis. For

distal injuries below the iliac vessels, reimplantation of the ureters into the bladder is the best option. Additional length during reimplantation can be obtained by maneuvering the bladder to the psoas muscle or bringing a bladder flap to the injured ureter. The kidneys can also be mobilized to create an anastomosis.

Ureteral injuries in the middle and proximal regions are best resolved with uretero-ureterostomy with an interrupted anastomosis over a radiopaque urinary stent.

Ureteroureterostomia Often, with small (2–3 cm) defects in the middle part of the ureter and the upper ureter, primary ureteroureterostomia may be performed. who were treated for ureteral injuries during gynecological and general surgical procedures, the results of treatment with ureteroureterostomia were considered. They reported an average length of ureter loss of 3 cm and reported no adverse events with an average follow-up period of 36 months.

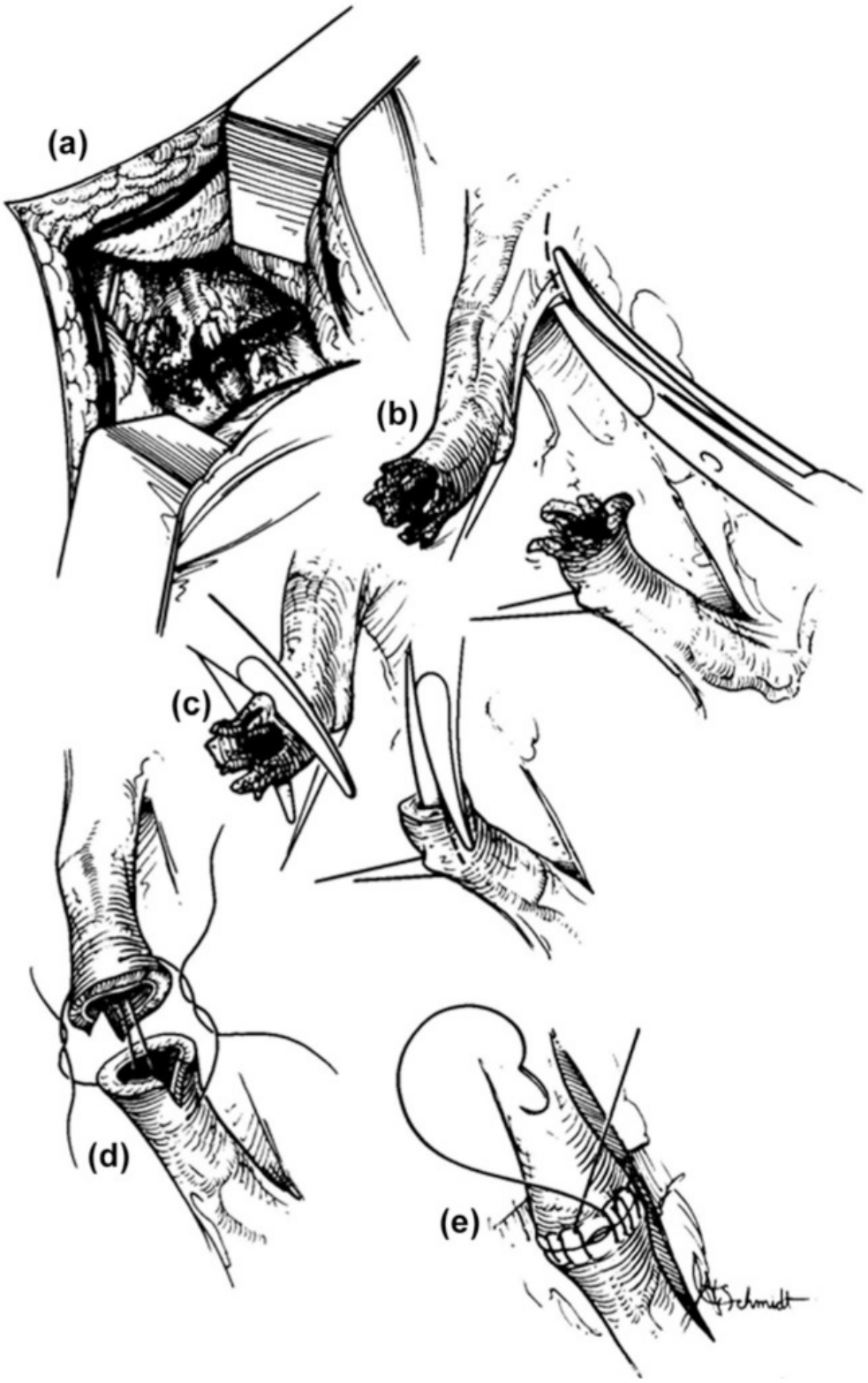


Figure 10. Ureteroureterostomia: the ends of the ureters are cut off and an anastomosis is applied. [Burks FN, Santucci RA. Management of iatrogenic ureteral injury. Ther Adv Urol. 2014 Jun;6(3):115-24. doi: 10.1177/1756287214526767. PMID: 24883109; PMCID: PMC4003841]

This will be done after all dead non-viable tissue has been surgically removed. When the damage to the ureter is too great, expectant measures such as cutting off the end of the ureter to the skin (ureterostomy) can be performed, or by placing a nephrostomy with definitive intervention at a later time when the patient's condition is stable. Recovery may include iliac or appendicular alignment, transuretero-ureterostomy, or autotransplantation of the kidney to the hypogastric vessels. Retroperitoneal injuries always require reconstructive surgery. Penetrating ureteral injuries are extremely rare in children. However, the principles of treatment are the same as stated above. Adequate sanitation and placement of a direct ureteral stent is the preferred approach for most cases with a short defect. In severe life-threatening cases, a nephrectomy can be performed if the patient's contralateral kidney is functioning well. However, nephrectomy should be avoided if possible.

Treatment of ureteral injuries is always surgical. Its task is to empty the urinary accumulation in the soft tissues and restore the continuity of the organ. The best method of therapy in childhood is plastic surgery, which makes it possible to preserve the corresponding kidney. The latter are possible only with early diagnosis and timely surgical intervention. The prolonged existence of a urinary fistula or obstruction of the ureter leads to a severe inflammatory process in the surrounding tissues. Such children are further shown nephrectomy.

The nature of the surgical intervention depends on the level of damage to the ureter. An injury in the middle section requires stitching the last end to end. Detachment of the prevesicular area is best treated by reimplantation of the ureter into the bladder (T. Burgelo, P. Shimich, 1972- Carlton, Scott, Guthrie, 1971). In the presence of urinary congestion and urinary infiltration, it is necessary to drain the retroperitoneal space and pelvic cavity by lumbotomy or through the obturator opening, and the surgical intervention should be divided into two stages. In the first, it is necessary to divert urine by nephrostomy or ureterostomy, and then perform plastic surgery to restore the passage of urine. During this period, the functionality of the kidney is revealed and the indications for organ-preserving surgery or removal become clear.

If it is impossible to restore the ureter and the function of the opposite kidney is good, in extreme cases, it is necessary to perform a nephrectomy according to the technique described above. The crossed ureter must be removed completely (always below the site of damage), since the stump left in the child continues to grow. In the absence of a second kidney or its functional inferiority, the restoration of the ureter is often associated with great technical difficulties.

7. Surgical tactics for trauma.

Technique for Poggi Boar operation

With a lumbar incision, the ends of the damaged ureter are exposed, isolated and refreshed. Then both segments are mobilized by 2-3 cm so that there is no tension after stitching them. The principle of intervention is to invaginate the upper segment into the lower one, for which the latter is split longitudinally by no more than 1 cm in length. The upper segment is sewn through with catgut thread, the ends of which are brought out through the lower one, from the inside out. Tightening this suture, the surgeon, with the help of an assistant, performs intussusception.

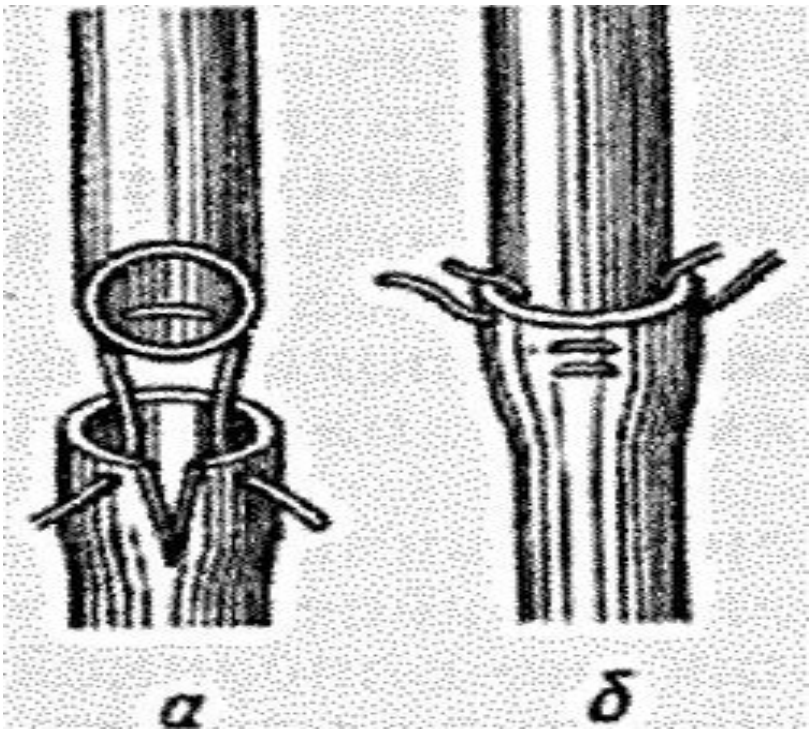


Figure 11. Scheme of the Poggi-Boar operation (according to S. P. Fedorov and R. M. Fronstein) [Burks FN, Santucci RA. Management of iatrogenic ureteral injury. Ther Adv Urol. 2014 Jun;6(3):115-24. doi: 10.1177/1756287214526767. PMID: 24883109; PMCID: PMC4003841].

Then it is necessary to apply sutures at the site of splitting of the lower segment and side sutures at the site of intussusception. The suture line is covered with fatty tissue and isolated from the lumbar muscles. Drainage is brought to the site of the anastomosis for several days (until urine leakage stops from it). All sutures on the child's ureter are applied with a thin catgut, trying not to pierce the mucous membrane.

When end-to-end stitching, it is safer to intubate the ureter with a thin vinyl chloride tube removed through the urethra. To do this, you must first cateterize its lower segment.

A very thin ureter should not be sutured using the method described. Its invaginated area can serve as a valve, the lumen is obstructed. It is better to carefully match the updated ends of the organ and sew them together with a thin catgut paramucosal.

If the ureter is damaged in the lower third, it is technically difficult to suture it. It is easier and more profitable to do a ureterocystoneostomy after ligation of the lower segment of the damaged organ. The resulting large diastasis creates tension on the ureter, which is why Boara's operation should be considered the best surgical method, in which the lower segment of the ureter is replaced with a tubular flap of the bladder (Mellin, 1969).

BOARA OPERATION TECHNIQUE

With a transverse incision, the distal end of the ureter is isolated externally and ligated as low as possible. The upper segment is mobilized and the size of the defect is determined. Then the bladder is exposed, it is taken on a holder, the anterior and lateral walls are sharply and bluntly isolated, up to the neck (they are guided by a metal catheter inserted into the bladder, or its filling). The anterolateral surface of the bladder wall is incised closer to the neck in the transverse direction for 2.5-3 cm. From the ends

of this incision, in accordance with the direction of the vessels, two parallel longitudinal incisions are made, forming a flap with a base at the bottom of the bladder. The shred is unscrewed up and its compliance in length is checked. It turns out to be trapezoidal, and the width of the base is 1.5 times wider than the free end of the flap (D. V. Kan, 1965). Then the mucous membrane of the upper edge of the flap is removed for 1-1.5 cm.

A ureter is laid on the demucosated bed and its edge is sutured from the mucous membrane of the flap with 2-3 catgut sutures. The vesicular flap is sutured around the ureter, which is fixed with additional sutures applied to the upper edge of the flap around its entire circumference. Then the entire flap is sutured into a tube on a catheter inserted into the ureter with single-row Catgut sutures. The bladder wound is closed with single-row Catgut sutures passed through the entire elephant bladder wall. The catheter is preliminarily perforated at the level of the bladder and removed through the urethra. With extensive urinary infiltration and leakage, the pelvic cavity is drained through the locking hole according to Buyalsky, since other types of drainage poorly drain the perivesical space and contribute to the formation of urinary phlegmon.

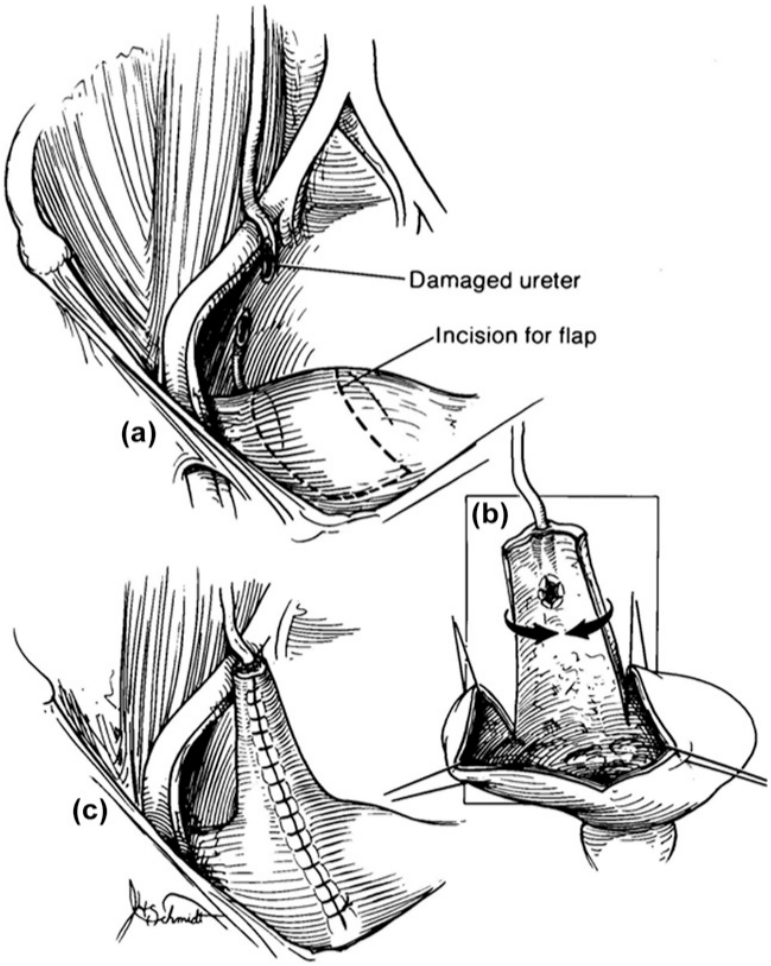


Figure 12. Scheme of the operation according to Boar (according to J. Kucher)

[Burks FN, Santucci RA. Management of iatrogenic ureteral injury. Ther Adv Urol. 2014 Jun;6(3):115-24. doi: 10.1177/1756287214526767. PMID: 24883109; PMCID: PMC4003841]

Transureteroureterostomia In most cases, the duration of ureteral loss as a result of iatrogenic ureteral injury is quite short, making transureteroureterostrostomy (TTU) unnecessary. In cases where primary reanastomosis into the distal segment is not possible, or if ureteroneocystostomy is excluded (i.e., rectal injury, extensive vascular damage, or bladder damage), a TU is an acceptable option. Contraindications to TUU include insufficient length of the donor ureter, which can create tension on the anastomosis, or diseases of the recipient ureter, such as urothelial carcinoma, urolithiasis, retroperitoneal fibrosis, or pelvic tumors with ureteral involvement [Iwaszko et al. 2010]. The donor ureter should be mobilized extensively, but care should be taken not to disrupt the longitudinal blood supply in the adventitious layer. A very small part of the recipient ureter must be mobilized so that the anastomosis area

has sufficient blood supply. The donor ureter should be passed under the sigmoid colon through the mesentery to the location of the recipient ureter. The donor ureter is then burned about 2 cm and the recipient ureter is opened to match the opening of the donor ureter [Barry, 2005]. An end-to-side anastomosis is performed, as shown in Figure 6. The donor ureter should be stented so that the stent passes through the distal portion of the recipient ureter to the bladder. You should try to re-try the peritoneal anastomosis of the ureter, if possible.

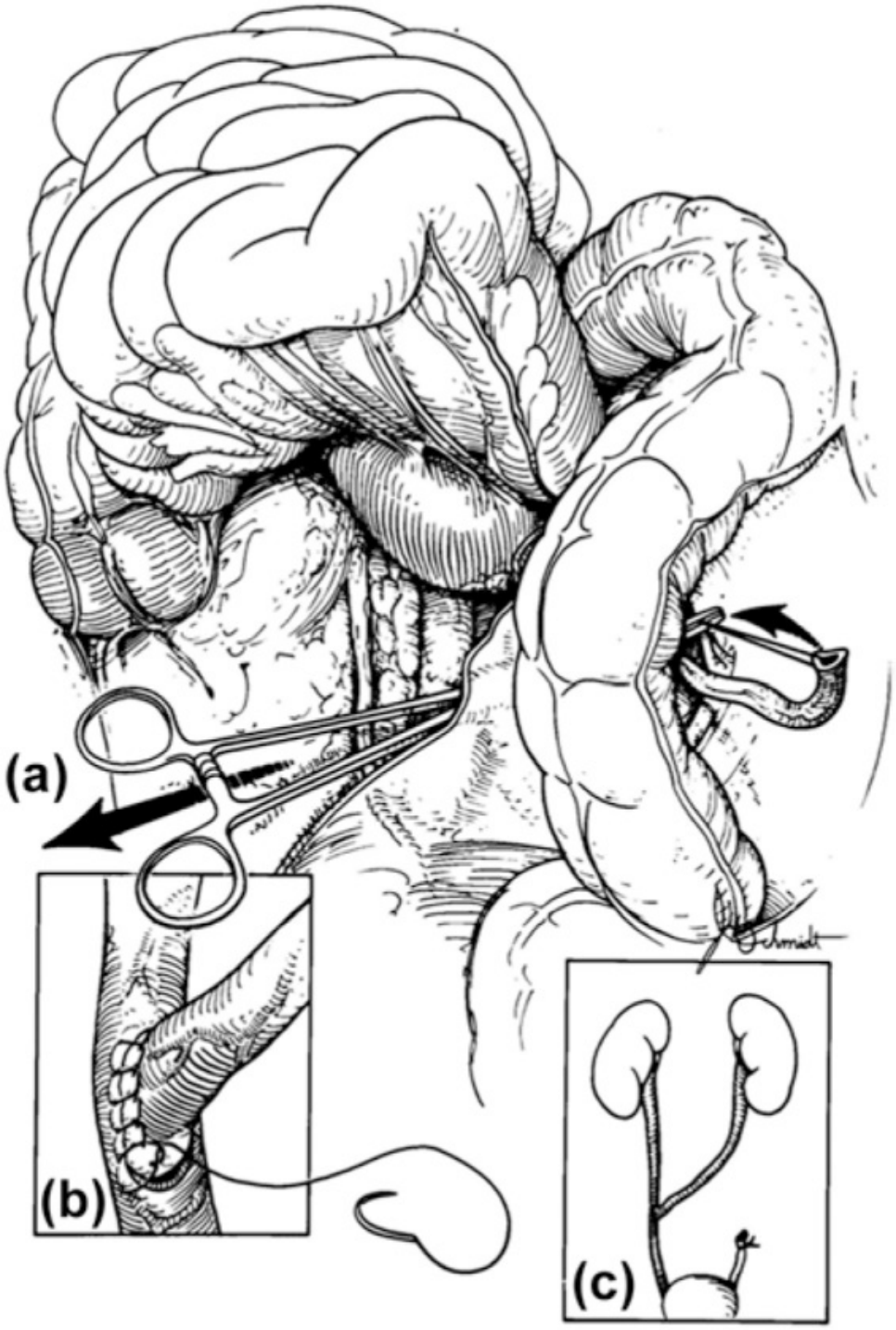


Figure 13. Transureteroureterostomia. (a) The donor ureter passes through the mesentery. (b) Anastomosis end towards the donor's ureter and recipient's ureter. (c) Final configuration of transureterourerostomy. [Burks FN, Santucci RA. Management of iatrogenic ureteral injury. Ther Adv Urol. 2014 Jun;6(3):115-24. doi: 10.1177/1756287214526767. PMID: 24883109; PMCID: PMC4003841]

Kidney autotransplantation. Kidney autotransplantation is rarely, if at all, indicated during intraoperative consultation for ureteral damage. If iatrogenic damage to the ureter prevents ureteral reconstruction and kidney autotransplantation is considered, then the ureter should be ligated and a percutaneous nephrostomy tube should be inserted to drain the kidney. Kidney autotransplantation requires a detailed discussion with the patient of possible complications and options for planned recovery. Meng and colleagues reported a series of seven patients who underwent laparoscopic nephrectomy and autotransplantation for severe ureteral damage. Of the kidney units collected, six were sufficient for transplantation. At follow-up for 17 months, imaging showed that all kidney autographs had normal function. The authors emphasized the need for coordination with transplantology staff to preserve and prepare the graft [Meng et al. 2003].

Ureter replacement The use of gastrointestinal segments, such as the ileum, to replace the ureter was first popularized in the 1950s by Goodwin et al. 1959 [Goodwin et al. 1959]. Other known sources of tissue for ureter replacement include the appendix, tubular stomach, and colon [Moreira et al. 2004]. By far, the most common source of tissue for ureter replacement is the ileum. Armatys and colleagues retrospectively analyzed the results of ileal ureter replacement in a large series of 91 patients. Most patients in this series received iliac ureter for the treatment of ureteral stricture as a result of genitourinary surgery (32%) and radiation therapy (19%).

Laparoscopic and minimally invasive treatment of ureteral injuries. Probably the most minimally invasive treatment for iatrogenic ureteral injury is cystoscopy and retrograde placement of a stent in the ureter or antegrade placement of a stent in the ureter. nephrostomy tube, wire recanalization of the ureteral lumen, antegrade expansion of the ureter and placement of a stent in the ureter. A total of 25 ureters were treated in this way due to iatrogenic injuries such as ureteral rupture and ureteral obstruction. Successful recanalization or dilation of the affected ureter was achieved in 18 out of 25 patients (72%). While two patients died of unrelated causes,

the rest of the patients did not experience serious complications. At a median follow-up of 13 months, six patients had their ureter open, while the remaining patients required repeated ureteral dilation [Koukouras et al. 2010].

Many reconstructive methods have been performed laparoscopically, and ureteral reconstruction after iatrogenic injury is no exception. Laparoscopic treatments for ureteral injuries include ureteroureterostomy, ureteroneocystomy, and Boari flap procedures. In a comparative retrospective review of patients undergoing laparoscopic and open ureteral reimplantation techniques, patients who underwent laparoscopic distal ureteral reimplantation required fewer painkillers, had a shorter length of stay, and had less blood loss [Rassweiler et al. 2007]. Since ureteral reconstruction often requires intracorporeal suturing, the use of robotics in ureteral reconstruction is an area of great interest.

DRAINAGE TECHNIQUE ACCORDING TO BUYALSKY

In the supine position with the hips apart from the side of the surgical wound, a locking hole is determined with a finger and, in accordance with this place, an incision 1 cm long is made on the skin of the groin region. Through the wound formed, a hemostatic clamp is bluntly carried out from the outside to the inside so that it penetrates through the obturator hole into the small pelvis . With the same clamp, a thick rubber drainage with holes is removed from the surgical wound in the opposite direction, which is laid on the side of the bladder. The removed part of the tube is fixed to the skin with separate silk sutures.

POSTOPERATIVE TREATMENT

The intubation tube should not be kept in the ureter for more than 7-9 days, washing it daily with 3-4 ml of disinfectant solution. It is necessary to monitor the child's daily diuresis. The patient should receive broad-spectrum antibiotics, blood and plasma transfusions. Drainage according to Buyalsky is removed after the cessation of discharge from it, after 10-12 days. To prevent infiltrates in the wound area from the

first days after surgery, active physiotherapy is indicated (UHF currents, electrophoresis with antibiotics and calcium).

So, with closed kidney injuries, conservative therapy is the method of choice. With an increasing hematoma of the retroperitoneal space and a deterioration in hemodynamic parameters (despite anti-shock and hemostatic therapy), urgent surgery is indicated, the volume of which will depend on the nature of the kidney rupture.

Iatrogenic damage to the ureters

The ureter can be injured during radical interventions on the pelvic organs. The occurrence of such injuries is explained by two reasons: a) violation of anatomical topographic relationships; b) significant bleeding. Most often, those parts of the ureter in which it intersects with large vessels (uterine, ovarian) are injured. This is especially observed when the clamps simultaneously capture the vessels and the ureter. Two types of damage are possible - crossing and dressing (gripping in a ligature). The damage can be one- and two-sided.

In case of unilateral damage to the ureter, there is a picture of a violation of its patency (obstruction) and pain of the type of crucifixion (and not as in renal colic), an increase in body temperature, the phenomenon of pyelonephritis in combination with acute expansion of the upper urinary tract.

Palpation reveals an enlarged and painful kidney. During cystoscopy, no urine is released from the corresponding ureteral opening. When trying to carry out ureteral catheterization, the catheter stops at a certain level: when ligating together with the uterine vessels - immediately behind the eye, and together with the ovarian vessels - at a distance of 10-12 cm.

Excretory urograms show signs of urinary tract obstruction. If the ureteral ligation is recognized during the operation, then a simple removal of the ligature is sufficient. If the ligation is recognized more than 24 hours after surgery, it is necessary to remove the ligature with simultaneous stent placement. If a complete ligation is recognized 72 hours or more after surgery, a ureteral resection is performed and a primary suture is applied with simultaneous drainage with a stent. If the ligature is not

tightly tightened, it can be removed after 10 days, with simultaneous drainage with a stent. To do this, sutures are removed from the incision made during laparotomy, or the operation is performed with conventional access to the ureter. Bleeding, as a rule, does not happen, because the vessels are already thrombosed by that time.

In the case of crossing the ureter, urine is released into the retroperitoneal, pelvic tissue. Urinary leakage occurs. Since urine from the second ureter continues to flow into the bladder, the doctor interprets pain, fever, irritation of the peritoneum as a complication of surgery on the abdominal cavity and pelvic organs. Often, the diagnosis is made only after urine begins to flow from the vaginal stump. Urinary leaks may occur in other cellular spaces. Sometimes pyelonephritis joins.

If the ureter is injured, its integrity should be restored immediately by releasing the ends and suturing them on the catheter. If the perivesical end of the ureter is injured, the ureter is transplanted into the bladder, since it is impossible to isolate the peripheral section.

In case of late diagnosis of ureteral damage, urine is first diverted with a pyelostome or nephrostomy and urinary leaks are drained, and then they try to restore the passage of urine.

Bilateral damage (ligation) of both ureters leads to anuria. It must be differentiated from anuria, which occurs with large blood loss, surgical shock, transfusion of incompatible blood. In this case, catheterization of the ureters is performed. If the anuria is caused by surgical shock, the catheters will pass freely, and there will be an obstacle when ligatures are applied on both sides. Immediate repeated laparotomy, ureteral isolation and removal of ligatures are advisable. Immediately afterwards, polyuria occurs, which is accompanied by a significant loss of electrolytes.

Similar complications (ligation, crossing of the ureters) occur during operations on the abdominal organs: during herniotomy, appendectomy, etc. Treatment of patients is the same as for gynecological operations.

Sometimes damage to the ureters is detected immediately on the operating table. In such cases, their integrity is restored: the ends are sutured, the ureters are transplanted into the bladder, etc.

In the case of perforation of the ureteral wall with a catheter performed for the purpose of retrograde pyelography, the radiograph shows the passage of a radiopaque substance past the lumen of the urinary tract and its accumulation in the surrounding tissue in the form of an irregular or oval spot.

Open ureteral injuries

Open ureteral injuries are almost always combined. They can be firearms, stabbed, and also iatrogenic. There are the following open ureteral injuries:

A. **non-penetrating**, in which only the muscular membrane is damaged, and the mucous membrane is intact;

B. **parietal**, or **incomplete**, when the muscular and mucous membrane of the ureter is injured;

C. **complete ruptures with divergence of the ends of the ureter**.

Non-penetrating lesions of the ureter are detected by chance during operations for injury to the kidneys or abdominal organs.

Clinical picture of open ureteral injuries

The clinical picture of open ureteral injuries is diverse. It is dominated by symptoms of damage to the abdominal organs. During laparotomy, an infiltrate of urine and blood can be detected in the retroperitoneal space (primarily the spermatic vein is injured). In such cases, they try to restore the ureter or limit themselves to drainage to prevent the occurrence of urinary leaks.

If damage to the ureter is not eliminated in time, a urinary fistula forms over time. Urine discharge from the wound canal is usually observed on the 6-12th day. This is explained by the fact that the wound canal has convolutions. With a complete rupture of the ureter, the fistula does not close, with a partial rupture, it periodically closes. Even in the most favorable conditions, the kidney dies due to the formation of a narrowing of the lumen (stricture) of the ureter, as well as ascending pyelonephritis.

Diagnosis of open ureteral injuries

The diagnosis of open ureteral lesions is established using excretory urography, chromocystoscopy, retrograde ureteropyelography, fistulography, computed tomography with intravenous administration of a contrast agent. In case of blind wounds, plain radiography allows you to detect a foreign body.

If the ureter is injured in a small area, you can limit yourself to installing a stent with drainage of urinary accumulations, with extensive urinary leakage and a serious condition of the patient, urinary accumulations are drained and uretero or nephrostomy is applied, or the ureter is transplanted into the skin. In the future, reconstructive surgery is performed.

Treatment of open ureteral injuries

In case of ureteral injuries in the proximal region, primary surgical treatment of wounds and ureteroureteroanastomosis, ureteropieloanastomosis or kidney autotransplantation is performed, in case of ureteroureteral injury in the middle third - ureteroureteroanastomosis. In case of injury to the distal ureter, a damaged ureter is transplanted into the skin, bladder or intestine, it is better to use a ureteral transplant into the bladder - ureteroneocystoanastomosis. In case of extensive damage to the distal ureter, an indirect ureteroneocystomy is performed using a piece of the bladder or transplantation of the ureter into the intestinal wall, partial or incomplete replacement of the ureter with the intestine.

The choice of plastic surgery method should be strictly individual. With urinary infiltration, ureteral plastic is ineffective.

A contraindication to reconstructive reconstruction operations for ureteral injury is the general serious condition of the patient and significant urinary infiltration.

IV. Bladder injuries

Compared to adults, the bladder in children occupies a more abdominal position, especially when completely full. This position makes the baby's bladder more vulnerable to external injuries. When the pelvic bones are strengthened, the bladder becomes more protected from injury. The dome of the baby's bladder is mobile and dimensionless and therefore more susceptible to rupture from external forces. Even so, the incidence of bladder injuries combined with pelvic bone injuries appears to be lower in children than in adults. In the adult population, the incidence of 10-25% is recorded between pelvic injuries and injuries of the lower urinary tract.

Etiology

Bladder injury occurs in motor vehicle collisions, work-related accidents, and violent crimes, but can also be iatrogenic. The two main mechanisms of blunt bladder injury are a high-energy blow to the lower abdomen when the bladder is stretched, which usually results in an PI, which usually results in an PI, and an injury that causes pelvic fractures, which usually leads to injury to the bladder VP. Thus, bladder injury usually occurs with concomitant orthopedic and abdominal-pelvic visceral injuries. Researchers found that traumatic bladder rupture is responsible for 1.6% of cases of blunt pelvic abdominal injuries. [3] There are problems associated with consistent results regarding bladder injury. For example, there is evidence that approximately 85% of bladder injuries are the result of blunt trauma, while the number of incidents can be up to 51% of injuries resulting from penetrating trauma. Although the national incidence of penetrating wounds in 2015 was less than 10%, the incidence of bladder injuries resulting from penetrating wounds may be much higher. In addition, another less common etiology of bladder injury includes iatrogenic injuries, most commonly during obstetric, gynecological or urological procedures.

Epidemiology

While extraperitoneal and intraperitoneal bladder injuries occur with blunt and penetrating injuries, iatrogenic bladder injuries are also well documented. 60% of bladder injuries are DP, intraperitoneal – 30%, combined – 10% [1]. Iatrogenic intraperitoneal bladder injuries are not uncommon.

Pathophysiology

In an adult, the bladder is located in the front of the pelvis. The dome is covered with peritoneum, and the bladder neck is fixed to the small pelvis by fascia and ligaments. Bladder rupture intraperitoneal occurs at the bladder dome and above the peritoneal reflection, while bladder rupture occurs below the peritoneal reflection and on the anterior or lateral side of the bladder.

Bladder contusion is a partial rupture of the thickness of the bladder with the formation of a hematoma due to blunt trauma. Patients with bladder contusion may have macrohematuria. With cystography, there is no extravasation of contrast. It is usually self-limiting, since it is a relatively benign process. Bladder rupture is most often caused by rapid deceleration. It is believed that the main mechanism of rupture of the extraperitoneal bladder is a combination of shear force and direct penetration of bone spicules into the broken pelvis. A complex rupture of the extraperitoneal bladder can cause urine leakage into the thighs, perineum, or anterior abdominal wall. Researchers have found that 85% to 100% of bladder injuries are associated with concomitant pelvic fractures. [5]

Bladder rupture intraperitoneal most often occurs on the dome of the bladder, since it is the only part covered by the peritoneum; Thus, it is the least protected area of the bladder. Unlike a ruptured bladder, a ruptured bladder intraperitoneal is usually caused by a direct blow to the swollen bladder, although it can also be due to delayed injuries. Urine drains into the abdominal cavity and is absorbed by the abdominal cavity, which manifests itself in the form of an increase in blood urea nitrogen and

creatinine, electrolyte and metabolic disorders, as well as a decrease in urine output. Combined extraperitoneal and intraperitoneal bladder rupture is less common, accounting for 5% to 8% of bladder injuries associated with pelvic fractures.

Classification of bladder injuries

Bladder injuries are divided into closed and open, isolated and combined, intraperitoneal, extraperitoneal and mixed.

The classification of bladder injuries is of great practical importance for choosing a method of treatment.

All bladder injuries can be divided into open and closed.

In children, subcutaneous injuries of the bladder predominate (E. A. Ostropolskaya, A. I. Gorenshtein, 1972).

The most modern classification is given by V. P. Dyakonov (1969).

It divides all damage into 4 groups:

A) simple: a) retroperitoneal, b) intraperitoneal;

B) *mixed (a combination of extra- and intraperitoneal rupture);*

C) *combined:*

a) with fractures of the pelvic bones

b) with damage to other organs, skull, bones of the skeleton, etc.;

D) *Complicated:*

a) shock

b) peritonitis

c) urinary infiltration of the pelvic tissues.

Using this classification, it is easier to assess the condition of the victim and outline a plan for examination and treatment.

AAST Classification of Bladder Injury:

Grade I: bruise, hematoma or partial rupture of the bladder wall

Grade II: extraperitoneal rupture of the bladder wall <2 cm

Grade III: extraperitoneal rupture of the bladder wall >2 cm or intraperitoneal rupture <2 cm

Grade IV: intraperitoneal rupture of the bladder wall >2 cm

Grade V: rupture of the bladder wall extending to the neck or triangle of the bladder

Intra-abdominal bladder rupture occurs when there is a sudden increase in pressure in the bladder secondary to a blow to the pelvic bones or a blow to the lower abdomen. This increase in pressure causes the dome, the weakest and most mobile part of the bladder, to rupture. As mentioned earlier, this type of bladder injury is more common in children than in adults due to the intraperitoneal position of the bladder. Intraperitoneal bladder ruptures account for one-third of all bladder injuries in children. Extraperitoneal ruptures are exclusively found with pelvic injuries. In these cases, the bladder may be on the anterior side wall at the base of the bladder injured as a result of a ruptured pelvic ring. Sometimes the bladder can be injured by sharp bone spicules. Bladder injuries should be suspected when a physical examination reveals a suprapubic, vague, diffuse mass in the lower abdomen or bruises above the suprapubic and pelvic region. The patient may report that he cannot empty the bladder. Hematuria is a hallmark and is present in 95% of patients.

Closed bladder injuries

In the mechanism of occurrence of closed bladder injuries, not only the nature of the injury plays a certain role, but also the conditions that contribute to it. The cause of intraperitoneal rupture of the bladder is an increase in hydrostatic pressure, which is observed with a full bladder. In this case, it is not so much the force of the impact that is of great importance during the injury as the speed and suddenness of the injury, the degree of filling of the bladder. From the inside, the bladder can be damaged during rough or forced insertion of various instruments - a metal catheter, a bougie, a

cystoscope, etc. In the case of a fracture of the pelvic bones, rupture of the bladder can be caused by their fragments.

There are bruises and incomplete ruptures of the bladder wall, in which urine does not penetrate beyond it, and complete ruptures - with urine leakage into the surrounding tissues and abdominal cavity. At the site of injury to the bladder wall, submucosal or intrawalled hemorrhages are formed, sometimes deforming the shape of the organ. Hematomas in most cases resolve. With an incomplete rupture, only part of the layers of the bladder wall is damaged. Depending on which layers of the bladder wall are damaged, there are external and internal ruptures. Incomplete ruptures can turn into complete ones. Most often, there is one gap, but there are two or more of them. The size of the defect varies - from minor to massive damage.

With internal ruptures of the bladder, blood penetrates into the bladder cavity, the intensity of hematuria depends on the nature of the damaged vessels: venous soon stops, arterial often leads to tamponade of the bladder with blood clots. With external ruptures, blood pours into the perivesical space, causing deformation and displacement of the bladder wall.

Complete extraperitoneal ruptures of the bladder are accompanied by significant bleeding into the perivesical tissue from the venous plexus and into the bladder cavity from the vascular network of the neck and bladder triangle. Simultaneously with bleeding, urine enters the paravesical tissues, which leads to their infiltration. The formed urohematoma deforms and displaces the bladder. Bleeding of intraperitoneal ruptures is small. The urine that has spilled out is partially absorbed, causing chemical irritation of the peritoneum, which eventually causes purulent peritonitis.

Clinical picture with closed bladder injury

The clinical picture of bladder injury largely depends on the degree and nature of the violation of the integrity of the bladder wall.

With **an extraperitoneal rupture of the bladder**, pain in the suprapubic region is observed, which intensifies with the urge to urinate, especially during straining. The pain spreads to the perineum, rectum, penis.

An important symptom of a ruptured bladder is urination disorders. With an extraperitoneal rupture, false urges to urinate are observed, which are accompanied by tenesmus and the release of a small amount of urine colored with blood or blood. Urinary retention is possible. During percussion above the pubis, dullness is detected, which does not have a clear boundary.

In the case **of an intraperitoneal rupture of the bladder** , the earliest symptom is pain, which is first localized in the pubic region, and then spreads throughout the abdomen.

With **combined damage to the bladder** and pelvic bones, the patient is pale, covered with cold sweat. Tachycardia, a decrease in blood pressure are noted. After the infection, urinary phlegmon, urosepsis develop.

Symptoms of intraperitoneal rupture of the bladder include lack of urination with frequent false cravings for it. In such patients, urine enters the abdominal cavity through a defect in the bladder wall. Sometimes the act of urination is preserved due to tamponade of the defect in the bladder wall with a loop of the intestine or omentum. Due to the accumulation of fluid in the abdominal cavity, bloating (flatulence), dullness of the percussion sound in the gentle areas of the abdominal cavity, above the pubis, are noted.

Diagnosis of a ruptured bladder

The diagnosis of bladder rupture is established on the basis of anamnesis, clinical manifestations and the results of instrumental and radiological examinations, ultrasound examination and laparoscopy.

One of the diagnostic methods is bladder catheterization. In the case of an extraperitoneal rupture, urine does not pass through the catheter or is released in a weak stream, has blood impurities. With an intraperitoneal rupture, when a catheter is inadvertently passed through a defect in the bladder wall into the abdominal cavity, a large amount of fluid containing up to 10% protein or more can be released.

Retrograde cystography allows you to differentiate between non-penetrating and penetrating, intraperitoneal and extraperitoneal ruptures of the bladder, to identify the

location of urinary currents and the approximate location of the rupture. Mandatory: the introduction of at least 350 ml of contrast agent solution and the performance of radiographs in lateral projection and, especially, after emptying the bladder from contrast. A sign of an extraperitoneal rupture is the accumulation of radiopaque substance in the perivesical tissue, intraperitoneal - in the abdominal cavity, mainly in one of the lateral canals in the form of a strip with a convex external and scalloped internal contours, in the form of a continuous mass above the bladder or in the vesicorectal fossa. When the bladder neck is detached on a retrograde urethrogram, there is a swim of radiopaque substance outside the contours of the urethra near its internal opening.

If it is not possible to pass the catheter through the urethra, it is necessary to perform excretory (infusion) urography and descending cystography.

Whether or not an intraperitoneal rupture of the bladder can be detected by cystography.

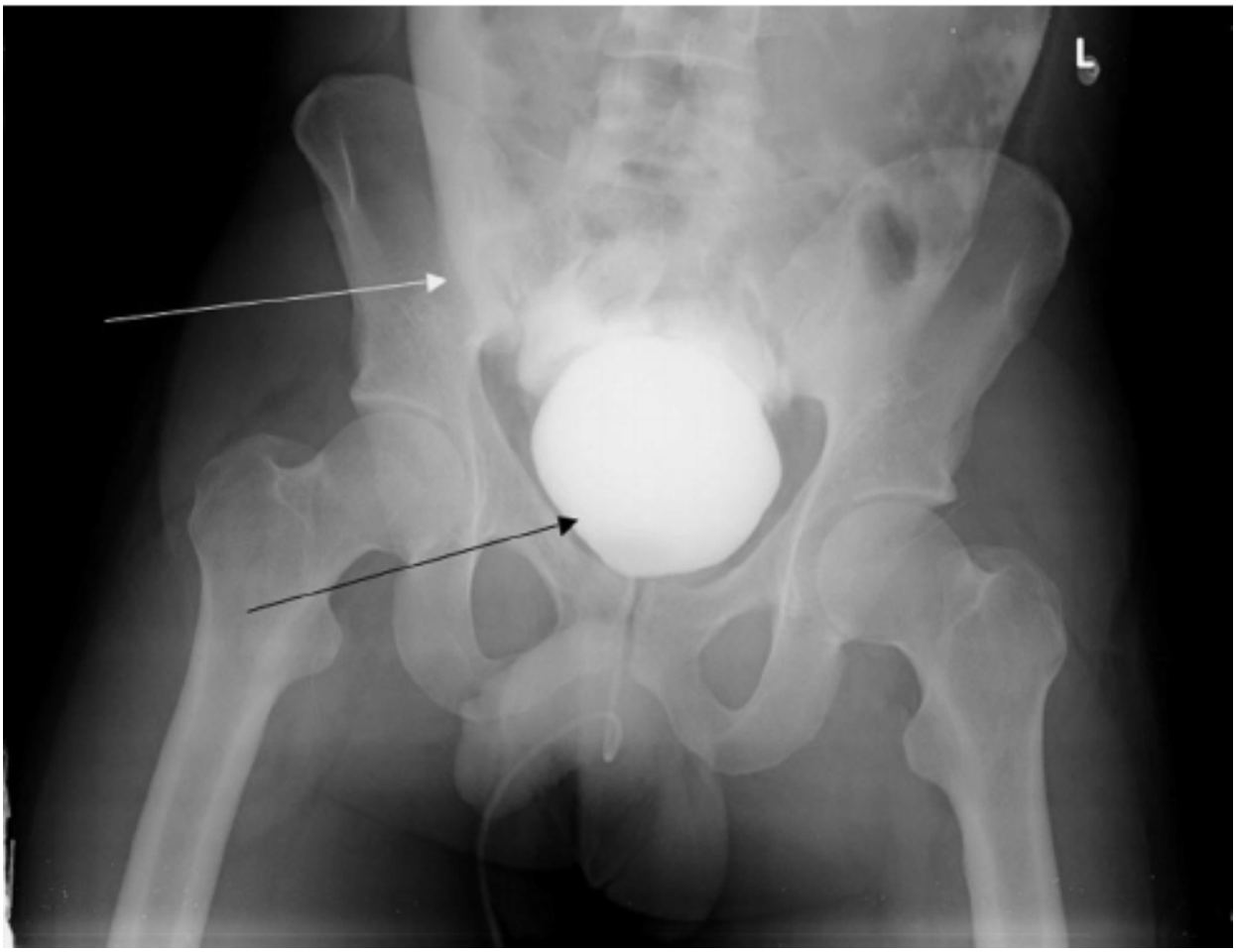


Figure 13. Cystogram showing intraperitoneal rupture of the bladder.

CT- scanning



Figure. CT - Intraperitoneal bladder injure. (https://radiopaedia.org/articles/urinary-bladder-trauma)

Differential diagnosis for closed bladder injuries

Extraperitoneal bladder rupture should be differentiated from damage to the posterior urethra. Retrograde urethrocystography allows you to determine the location of the damage.

Intraperitoneal rupture of the bladder often resembles closed damage to the abdominal organs (liver, spleen, intestines, mesenteric vessels). There is intense abdominal pain, signs of internal bleeding, a positive symptom of peritoneal irritation.

The diagnosis is made after urethrocystography. In addition, if the abdominal organs are damaged, there are no disorders of urination and hematuria.

Bladder catheterization, cystography, ultrasound and laparoscopy are the most acceptable methods for timely diagnosis.

Treatment of closed bladder injury

In case of complete closed bladder damage, immediate surgical intervention is required. With an intraperitoneal rupture, a wide laparotomy, revision of the abdominal organs is performed, and the area of damage is determined. After surgery on the abdominal organs (suturing a liver wound, resection of the intestine, suturing the wall or mesenteric wound, etc.), if there is no urinary infiltration, the bladder wound is sutured with two-row catgut sutures, without capturing the mucous membrane. A catheter with two passages is inserted into the bladder, through which it is irrigated with an antiseptic solution for 6-8 days. In case of urinary infiltration, as well as combined or multiple injuries, the operation is completed with the application of suprapubic bladder drainage - epicystostomy.

In the case of extraperitoneal complete rupture of the bladder, it is exposed with a suprapubic extraperitoneal approach, carefully examined (revised) and the defect is sutured with a two-row catgut suture. Be sure to perform drainage by epicystostomy. In case of multiple ruptures of the anterior or anterolateral wall of the bladder and the absence of urinary infiltration, two or more drainage tubes are additionally inserted into the perivesical space. In other cases, the perivesicular tissue must be drained through the occipital opening. When the bladder neck is torn off, it is pulled to the urethra using a catheter with an inflatable balloon and connected with a two-row catgut suture. The operation is completed by draining the prostate and pelvic tissue. To prevent the formation of urinary currents, in all cases of extraperitoneal rupture of the bladder, the perivesical space is drained through the occipital opening or the ischicorectal space.

TECHNIQUE OF SURGERY FOR EXTRAPERITONEAL RUPTURE OF THE BLADDER.

The middle lower incision, extraperitoneally, exposes the bladder. In this case, the localization of the damage is detected and the urinary drain is emptied. In the upper corner of the wound, the peritoneum is opened wide. Through this incision, it is easy to examine the inside-peritoneal organs. In the absence of violations of their integrity, antibiotics are injected into the abdominal cavity and sutured tightly. Then the bladder is opened, after which it is much easier to suture its damage using a finger inserted into the lumen (the hole is then used to apply an epicystostomy). Suturing the bladder from the inside is a mistake, since calculi develop on ligatures, even catgut ligatures, in the future.

When the bladder neck is torn off from the urethra, urine is retained in the bladder due to the contraction of its internal sphincter, but periodically there is an urge to urinate and the next portion of urine enters the tissues. Surgery should ensure not only the drainage of urine, but also the connection between the bladder and urethra. Otherwise, the axes of the bladder and urethra deviate from each other and it is technically difficult to restore them. It is most advisable to insert a two-way catheter with an inflatable can into the bladder through the urethra. With its help, the neck of the bladder is pressed against the urethra and held in the correct position.

Iatrogenic damage to the bladder

Iatrogenic damage to the bladder occurs during gynecological operations, removal of inguinal hernia and replacement of epicystostomy drainage. During gynecological interventions, the bottom or back wall of the bladder is damaged (with adhesions). Usually, damage is detected immediately and eliminated during surgery.

When removing a direct inguinal hernia or a large one, when part of the bladder is contained in the gate, it can also be damaged. Therefore, with any inguinal hernia, before surgery, you need to make sure that the bladder has not moved. With this pathology, urine is released after urination when pressing on the hernia. The cystogram clearly reveals the displacement of the bladder.

In some cases, it is not the bladder itself that is damaged, but the protrusion of its wall (diverticulum), which is located directly near the hernial sac. Sometimes during the operation, the surgeon finds a cyst-like formation near the neck of the hernial sac, dissects it and tries to exfoliate it; In this case, urine appears.

If the bladder is injured, it is necessary to suture the defect and divert urine.

Open bladder injuries

By the nature of occurrence, open origins of the bladder can be gunshot, stabbed-cut and torn-bruised. Especially severe are laceration-bruised injuries, which are observed with an open fracture of the pelvic bones, are accompanied by rupture of the bladder and are often complicated by osteomyelitis.

Depending on the damage to the abdominal wall, intraperitoneal, extraperitoneal and mixed bladder injuries are distinguished. According to the type of damage, they are divided into tangential, through and blind. Open injuries to the bladder are often combined with injuries to other organs.

The wound canal in modern wounds is almost never straight, and necrotic and destructive changes prevail in the wound canal zone. Pathological changes in open lesions, in contrast to closed ones, are manifested by greater severity due to extensive damage.

Clinical manifestations in open bladder injuries

The clinical manifestations of stab wounds and lacerations are the same as those of closed injuries. The only difference is that with a wide wound, urine can leak out. But such a symptom is rarely observed in the first hours after an injury. The main signs of open bladder damage are impaired urination and hematuria.

Gunshot wounds to the bladder are very rare in peacetime. Most often they belong to combined injuries. Extraperitoneal injuries of the bladder in more than 50% of cases are combined with damage to the pelvic bones. At the same time, the rectum and other organs of the abdominal cavity can be injured. Osteomyelitis, which

complicates gunshot damage to the pelvic bones, becomes especially severe in conditions of urinary infiltration.

The clinic of gunshot wounds of the bladder is severe. Shock is often observed. The course depends on the nature of the lesion (intra- or extraperitoneal), the size of the defect in the bladder wall, the presence of combined lesions.

X-ray examination plays an important role in the diagnosis of open lesions. A foreign body is sometimes noticeable on the examination urogram. Cystography (ascending or descending), ultrasound and laparoscopy are quite informative.

Treatment of patients with open bladder injuries

Treatment of patients with open bladder injuries consists of surgical treatment of wounds, laparotomy, suturing of a defect in the bladder wall and ensuring the outflow of urine. In case of an extraperitoneal rupture, drainage of urinary tides, pelvic tissue through the occipital opening according to Buyalsky-McWhorter or Holtzov is required.

Early **complications of open bladder injuries** include widespread (blurred) peritonitis, which is observed mainly with combined damage to the intestinal loops and the formation of urinary phlegmon of the pelvic tissue.

Late complications of open bladder injuries are urinary phlegmons, osteomyelitis of the pelvic bones, urinary fistulas. They are usually localized at the level of the wound canal in the area of surgical intervention or where the urinary phlegmon has broken or been dissected. Often, the formation of urinary fistulas is facilitated by a purulent-inflammatory process in the tissue, unremoved foreign bodies, bone fragments, osteomyelitis. factors.

Rare late complications of blind wounds of the bladder include the formation of stones as a result of the deposition of salts on the surface of foreign bodies (fragments, bones, bullets, etc.). Usually, bone fragments, bullets are removed during the initial treatment of the wound and examination (revision) of the bladder. However, its injury may go unnoticed (a small wound opening, lack of urine flow into the abdominal cavity or into the perivesical tissue) and is detected only after the appearance of signs of

cystitis, as well as according to X-ray and cystography. Sometimes the process in the bladder develops when fragments get stuck in the pelvic tissue. In this case, a limited purulent focus occurs, which causes the same clinical picture as purulent paracystitis. The bladder wall is involved in the process, its swelling is observed, pain and dysuria appear.

In the treatment of purulent-septic complications, antibiotics are widely used in accordance with the sensitivity of microbacteria, immunostimulants, transfusion of protein solutions, blood components, physiotherapy methods.

Diagnosis of open bladder injury

The diagnosis of open bladder injury is established on the basis of the results of plain radiography and cystography and the presence of a deformed shadow of the bladder with an indentation in accordance with the place of projection of the shadows of the fragments, ultrasound examination.

The prognosis of bladder injuries is determined by the timeliness of the intervention. Early urine drainage, drainage of swims, correct and timely treatment of damaged organs can significantly reduce the number of severe complications and mortality in this category of wounded.

Imaging is indicated in all patients with macrohematuria. Significant injuries to the pubic bones and instability of hemodynamics indicate the likelihood of bladder injuries. Cystography is the definitive test to diagnose a ruptured bladder. The bladder must be completely filled for optimal detection of extravasation. In a child, the capacity of the bladder is variable and should be evaluated in order to ensure adequate bladder stretching. An iodine-containing contra solution is injected by gravity through a Foley catheter placed in the bladder. Radiography should include anteroposterior, lateral, or oblique projections. Cystography may not detect hemorrhage if the blood clot clogs the perforation. If urethral injury is suspected due to a pelvic fracture, then it is necessary to examine the prostate gland during rectal examination, if bruising and swelling of the perineum, calf and / or penis are noted, a retrograde urethrogram should be done before urethral catheterization is attempted (see the section on urethral injuries).

It has been proven that urinary extravasation can also be useful in differentiating intra-abdominal from extraperitoneal rupture in the absence of clinical data and in case of suspected bladder perforation in children. Children with an intraperitoneal rupture develop hyperkalemia, hyponatremia, an increase in serum urea and creatinine due to the peritoneal absorption of urine solutes into the blood. In contrast, no biochemical differences were found in extraperitoneal rupture.

All patients with penetrating wounds of the lower abdomen and or who have radiographic and/or clinical signs of bladder injury should have an examination of the abdominal cavity and gastrointestinal tract from the entrance to the exit of the wound. The abdominal cavity should be open, even if the injury is considered completely extraperitoneal and the abdominal cavity and main vessels have been examined for damage. If there are holes in the ureter or there are concerns about the integrity of the ureters, 5 ml of indigo carmine should be administered intravenously. Next, extravasation is searched for and a Foley catheter No. 5 is placed in the ureter. Pelvic hematomas should be detected in order to detect any other injuries to the pelvic organs. The bladder must be open and fully examined from the inside in order to fully assess the injuries. The tears must be closed in two layers with a absorbable suture. The suprapubic cystostomy tube should be placed together with the leak in the pelvic area.

V. Injuries to the urethra (urethra)

Urethral injury is a relatively rare medical condition accounting for less than 1% of all emergency department visits in the United States. Injury patterns vary and encompass urethral crush, bruising, laceration, and transection. Urethral injuries are never life-threatening, but if left untreated can cause significant morbidity. While most injuries are iatrogenic, traumatic etiologies often caused by high energy mechanisms certainly do carry mortality threats. The injury extent and anatomical location are formative in the development of a management plan.

Clinicians classically use several anatomical landmarks in the evaluation, classification, and management of urethral injuries, which is particularly important among male patients. The male urethra subdivides into anterior and posterior divisions delineated by the urogenital diaphragm. The anterior segment consists of the penile and bulbar urethra while the posterior urethra consists of the membranous and prostatic portions.

Etiology

The etiology of urethral injuries can commonly be classified as anterior or posterior injuries. With some exceptions, anterior injuries involve a crushing mechanism, whereas posterior injuries involve sheering forces. Injury to the anterior urethra is more common motor vehicle traumas, straddle injuries, and blunt/penetrating trauma, whereas pelvic fractures and iatrogenic etiologies are more consistent with injury to the posterior urethra.

Iatrogenic injury secondary to improper urethral catheterization and transurethral instrumentation is the most common cause of urethral traumas worldwide.

Another frequent cause of urethral trauma, especially in men, occurs when confused, disoriented or agitated patients pull out their Foley catheters resulting in urethral trauma. Traditionally, such patients have required restraints, sedation or a bedside sitter to prevent such traumas but more appropriate and highly successful methods have been described. Essentially, nurses are asked to make an assessment of all male patients with Foley catheters on their likelihood of inappropriate self

extraction. If this is judged to be a potential problem, various steps are taken to minimize this which include:

- Taping the catheter directly to the skin which makes it more difficult for patients to tightly grip the catheter.
- Running the catheter and tubing underneath the thigh which makes it much harder for confused patients to find.
- Liberal use of pads, pajamas, mesh pants and diapers to help protect the catheter.
- Use of decoy catheters taped over their pads or diapers. Such decoy catheters are not attached to anything so confused or disoriented patients can pull them all they want without any harm.

Because these steps are all initiated by nursing, no physician's order is required and therefore there is no delay to immediate utilization. Implementation of these procedures can dramatically reduce the incidence of patient self-induced urethral trauma from inappropriate Foley catheter extraction.

Penile fractures will sometimes include a partial or compete urethral injury. These injuries are best managed by immediate surgical exploration and repair which is described elsewhere.

In females, urethral trauma most commonly occurs as an obstetrical complication with 10.3 per 1000 vaginal deliveries resulting in some degree of urethral injury. Damage to the anterior urethra is more common in straddle injuries associated with motor vehicle trauma, whereas pelvic fractures are more consistent with injury to the posterior urethra.[3] Other notable causes of urethral injuries include cases of penile fracture during vigorous sexual intercourse causing simultaneous urethral injury, followed by foreign body associated injuries and self-mutiliation among psychiatric patients.

Pathophysiology

Urethral injuries range from tissue contusions to complete open urethral transections. In the acute phase, local tissue swelling or urethral disruption can cause

acute urinary retention. If not addressed, for instance, in an intubated patient, this retention can lead to hydronephrosis, acute kidney injury, or acute renal failure in extreme cases. For this reason, there is an overwhelming consensus to prioritize bladder decompression. To some extent, all urethral injuries cause scar tissue formation and, if significant enough, can lead to fibrosis, stenosis, and/or stricture formation. These can be relatively benign or can potentially cause clinically significant urinary retention.

Damage to the urethra is a violation of the anatomical integrity of the urethra in the event of exposure to a traumatic agent.

Urethral injuries rank first among urinary organ injuries in terms of frequency. Distinguish between isolated and conjugated; closed and open damage; penetrating (complete, incomplete) and non-penetrating (internal, external); and by localization - damage to the posterior, perineal and anterior parts of the urethra.

The urethra in boys is divided into four parts:

(1) prostate,

(2) membranous,

(3) bulbar,

(4) penis.

Anatomical relationships are important because injuries in different areas require different treatments and have different outcomes.

For therapeutic purposes, male urethral injuries are divided into two groups:

(A) posterior (prostatic or membranous) injuries or higher, including the urogenital diaphragm and

(B) anterior injuries of the bulbous and penis.

In children, it has been proven that the prepubertal pubic-prostatic ligaments and the bladder are not a structurally stable unit, as it exists in adults. Clinically, this is supported by the fact that most traumatic urethral injuries in children occur below the

prostate in the membranous part of the urethra. They can also occur through the prostate or at the junction of the prostate and bladder neck

The mechanism of damage is different. The back of the urethra is injured as a result of fractures of the pelvic bones. Therefore, the mechanism of such damage is the same as in extraperitoneal rupture of the bladder. The perineal part of the urethra is injured in the event of a direct blow to the perineum. This usually happens when falling on a solid object. Very rarely, injuries to the anterior (hanging) part of the urethra are observed.

Penetrating injuries of the urethra are divided into **complete** and **incomplete** (partial). Incomplete injuries can be limited both in depth and in length. Regardless of the degree of tissue damage, urethral injury is always manifested by bleeding (urethrrhagia) and impaired urination, which often has a course characteristic of complete acute urinary retention. there is a hematoma in the perineum and calf, penetration of urine into nearby tissues. With fractures of the pelvic bones, urine flow occurs in the same way as with extraperitoneal rupture of the bladder (perineum, thighs, pelvis, retroperitoneal and preperitoneal space, gate), with perineal injuries - limited to the perineum and wicket.

The severity of pathological changes in urethral trauma depends on the nature of the damage and the intensity of urinary infiltration. Extraurethral hematomas or urohematomas form around bruises and tears. Ruptures and fragmentation of the wall are accompanied by urinary infiltration, the formation of urohematoma, which subsequently lead to the formation of abscesses and phlegmon.

Clinical manifestations of urethral injuries are typical: trauma, pain, urethrrhagia, acute urinary retention, urinary inflows, hematoma of the perineum and calf. First of all, it is necessary to find out the nature of the injury: penetrating or non-penetrating damage to the urethra.

With non-penetrating damage to the urethra, clinical manifestations depend on damage to the layer of the urethral wall: with trauma to the inner layer, urethrrhagia, pain during urination are noted; If the outer and interstitial layers are damaged, swelling

in the area of injury, pain during urination may be observed, but there is no urethrrhagia.

In case of fractures of the pelvic bones, after operations on the perineum and in adjacent areas, after childbirth, there may also be acute urinary retention. Urethrrhagia is not observed. The diagnosis is clarified by catheterization - a soft catheter easily penetrates through the urethra, urine of the usual color.

If urethrrhagia and urination disorders are observed, but there are no signs of urine infiltration of nearby tissues, the differential diagnosis between complete, incomplete, and non-penetrating trauma is carried out on the basis of urethrography data. With a penetrating wound to the urethra, the flow of radiopaque substance into nearby tissues is noticeable. With non-penetrating damage, there is no contrast leakage.

To **diagnose** damage to the urethra, instrumental research methods (catheterization, urethroscopy) should not be used, since this can re-injure the tissues. The diagnosis of urethral damage is established on the basis of the patient's complaints, examination results, data of ascending urethrography in combination with descending urethrography.

Treatment. In patients with fresh non-penetrating damage to the urethra, conservative therapy is effective: rest, cold compresses, antibiotics.

In patients with fresh non-penetrating damage to the urethra, conservative therapy is effective: rest, cold compresses, antibiotics. 7-8 days after the injury, thermal procedures and absorbables are prescribed. If urine is retained, a trocar epicystostomy can be performed instead of a high opening of the bladder.

7-8 days after the injury, thermal procedures and absorbables, immunomodulators, antioxidants are prescribed. If urine is retained, a trocar epicystostomy can be performed instead of a high opening of the bladder. If the patient's condition is stable, an attempt to pass a catheter through the urethra is justified. The placement of the catheter does not prevent the formation of urethral stricture, but it helps to align the apex of the prostate gland and the distal part of the urethra. This facilitates the subsequent restoration of the urethra.

With fractures of the pelvic bones with a rupture of the urethra, patients are often in a state of shock. After removal from it, an operation is immediately performed: urine is drained to prevent it from flowing and reduce the patient's suffering, and the urethra is restored. If the patient's condition is very serious, it is necessary to limit yourself to urine drainage by applying a suprapubic bladder fistula.

With early hospitalization (within 6 hours from the moment of injury), fractures of the pelvic bones without displacement, the absence of massive urohematomas, it is advisable to apply a primary suture (urethrourethroanastomosis), that is, suturing the urethra after removing the damaged edges of the rupture with a perineal access. After that, additional measures are required to treat pelvic fractures and prevent related complications.

Primary plastic surgery of the urethra has an advantage over its restoration at a later date. Thanks to primary plastic surgery, the duration of the patient's stay in the hospital is reduced, there is no need for bougienage of the urethra, as in some types of urethroplasty.

In case of urine leakage and signs of infection, which are observed during late hospitalization, primary plastic surgery is impossible. Urine is diverted by applying a suprapubic bladder fistula. Drain urinary flows. The patency of the urethra is restored after the improvement of the general condition of the patient (after 3-6 months).

If not only the urethra, but also the rectum is injured, a bistem fistula of the sigmoid colon is created. When the urethra is detached from the neck of the bladder, without displacing the latter, it is possible to try to restore the patency of the urethra on catheter No. 18-20 Ch. Catheter is left for 3 weeks, and the bladder is drained with a cystostomy. Recovery surgery is performed after 3-6 months.

Iatrogenic injuries of the urethra occur as a result of inept or rough insertion of instruments: elastic or metal catheters with acute urinary retention, bougies with narrowing (strictures) of the urethra, cystoscope. an attack of urethral (urinary) fever. Iatrogenic is also urethral-venous reflux when a solution of a radiopaque substance is injected into the urethra under high pressure, in particular during retrograde

urethrography. An X-ray reveals veins filled with a radiopaque substance. Urethrovinous reflux also causes acute infectious complications.

Open damage

Open injuries of the urethra include injuries with a violation of the integrity of the skin. They are isolated and combined. There are gunshot, stabbed, cut, bruised, lacerated and bitten wounds. The most characteristic symptoms of open urethral injuries include: acute urinary retention or difficulty urinating (sometimes urine flows out in drops), frequent urge to urinate, urethrrhagia, pain in the lower abdomen or perineum, enlarged bladder, urine discharge from the wound during urination. With isolated damage to the urethra, the general condition of the patient is satisfactory.

Diagnostics. The presence of these symptoms gives reason to suspect open damage to the urethra. To determine the type, nature and location of the wound, as well as to identify combined injuries, X-ray research methods are used, in particular ascending urethrography, fistulography.

Treatment. In case of open damage to the urethra, treatment is reduced to the fight against anemia and shock. In case of significant damage to the urethra, the hematoma is emptied and its cavity is drained.

In case of a bruise, a tangential wound without damage to the mucous membrane, the suprapubic fistula is not applied, and the urine is diverted with a catheter.

In case of a puncture wound, it is revised, an aseptic bandage is applied and urine is diverted in the first days using a capillary puncture or epicystostomy (catheterization does not provide adequate urine drainage, and is the cause of an inflammatory process in the urethra, which can lead to ulcerative urethritis and complete obliteration of the lumen of the urethra.

If the wound is cut, after hemostasis, the edges of the urethra are connected with catgut sutures. The bladder is drained with a permanent catheter (smaller than the lumen of the urethra) and an epicystostomy is performed. If there is no penis at all, the mucous membrane of the urethral stump is sutured to the skin. In other cases, when a

"bridge" remains between the cut tissues, they try to sew them together and insert a permanent catheter into the urethra.

With a bitten wound, treatment methods depend on the nature and severity of the complication. In the event of a dog or cat bite, rabies vaccination is performed.

In the case of a laceration-bruised wound, combined with injuries to the bones of the pelvis, perineum, rectum and other organs, measures are taken to combat shock and anemia. Urine is diverted by applying a suprapubic bladder fistula. The periurethral tissue is drained and an unnatural anus is applied. The urethra is restored after the elimination of the acute inflammatory process.

Posterior urethral injuries

Destruction of the posterior urethra is the most severe injury to the lower urinary tract in children and usually occurs as a result of a violent external force. Strong rapid blunt and crushing injuries or at a high shear rate, in which the attachment of the prostate and pubic-prostatic ligaments to the pelvic floor is injured, while the membranous part of the urethra, attached to the urogenital diaphragm, is stretched in a different direction. As a result, the prostatic part of the urethra ruptures.

Diagnostics

In patients with posterior urethral trauma, an attempt to empty the bladder may be unsuccessful before arriving at the hospital. If patients manage to empty the bladder, then in almost all cases hematuria is present. When examining blood, most patients with urethral injury have urea. After injury to the back of the urethra, the bladder and prostate will rise above the normal anatomical position and the defect will be filled with blood and urine. Digital rectal examination should be performed in all patients with pelvic trauma. During rectal examination, swampy fluid is released, which is normally present. However, in children, this is not always useful due to the immature development of the prostate. Retrograde urethrography is performed in all patients with suspected urethral injury. The initial X-ray film is performed in the anteroposterior projection to identify the condition of the pelvic bones, bone displacements of the symphysis, or the presence of foreign objects.

Then the patient needs to perform an X-ray examination in an oblique position of 25-30 °, while a water-soluble contrast agent is injected into the urethra.

The preferred technique is to inject 1 or 2 ml of water from a small catheter. If the urethral catheter has already been inserted into the bladder, then it must be removed. In such cases, a retrograde urethrogram can be obtained by inserting an angiocatheter into the urethra and injecting contrast next to the urethral catheter.

A mild form of trauma to the posterior urethra (type I) is caused by stretching and lengthening of the urethra due to a pelvic hematoma without rupture. The causes of type II injuries of the urethra are partial or complete rupture of the prostatomembranous part of the urethra. Extravasation on the retrograde urethrogram is limited below the urogenital diaphragm. Type III is a partial or complete rupture of the prostatomembranous part of the urethra, as well as rupture of the urogenital diaphragm and urethral bulb. Extravasation of the contrast agent is observed in the pelvis and perineum. Type III urethral injuries are the most severe and are observed twice as often as other injuries.

Treatment

In patients with type I injuries, urethral catheterization is recommended for three to five days, as the hematoma compresses the urethra and can lead to incomplete urination or urinary retention. These minor injuries usually resolve without complications. In patients with minor type II trauma, you can try to insert a catheter into the bladder. If successful, the catheter is stored for 7-14 days, and a cystourethrogram is performed when the catheter is removed. Most of these injuries pass without any strictures or with a slight stricture that undergoes periodic dilatation or endoscopic incision.

Treatment of patients with a complete rupture of the posterior urethra is one of the most complex and controversial cases among injuries of the genitourinary system. The goal of therapy is adequate urinary drainage with the least negative impact on the long-term formation of stricture, urinary incontinence and impotence.

Historically, patients with posterior urethral rupture need primary examination and direct urethral examination. However, the rates of development of stricture, urinary incontinence and impotence were extremely high. Thus, the rejection of instrumental research methods at the time of injury and only suprapubic cystostomy were the preferred initial treatment in almost all cases of posterior urethral rupture within 25 years.

Advances in endoscopic technique with flexible cystoscopy and the use of wire conductors and the Seldinger technique are being reevaluated in the choice of initial treatment for posterior urethral ruptures and delayed treatment of urethral stricture. Immediate endoscopic intervention can play a role in adults. However, children have certain age-related technical difficulties that limit the use of certain endoscopic methods. Thus, until further experience with immediate intervention is properly evaluated in children, treatment delay continues to be the gold standard in the treatment of male children with posterior urethral disorders without bladder neck disorders or rectal injuries.

Anterior urethral injuries

Damage to the anterior urethra is more common than injuries of the posterior urethra in children, the cause of which is most often blunt trauma, injuries to the urethra, crushing of the bulbous part of the urethra during trauma to the pelvic arches. Anterior urethral injuries can also occur as a result of penetrating wounds from gunshots, blows, or iatrogenic devices.

Blunt or penetrating injuries of the anterior urethra can lead to a violation of the integrity of the urethra - complete or partial and a violation of the fascial integument. Buck's fascia tightly surrounds the erectile bodies and spongy body of the urethra from the proximal ligaments and the distal coronary sulcus.

Urethral rupture

A violation of Buck's fascia leads to its dissection with blood and urine, which go through the male penis, creating a hematoma that appears on the penis. A urethral rupture with extravasation of urine, blood or pus into the scrotum containing the fascia Colles' produces a characteristic butterfly-shaped hematoma configuration in the perineal area.

Diagnostics

Retrograde urethrography should be performed in all patients in whom it is possible to predict damage to the anterior urethra from a history or physical examination. These data include the presence of blood or fluid from the urethral opening, hematoma or bruise of the male penis, scrotum, perineum.

Treatment

Minor blunt contusions of the anterior urethra without dysfunction can be treated by drainage for several days. When the wound is more significant or penetrating, surgical intervention and sanitation are indicated. The incision is made in the perineum in case of injuries to the distal bulbar or proximal hanging urethra. A circular incision near the male penis can be used for injuries to the distal urethra. Partial urethral lacerations are treated, closed and a urethral catheter is placed, which persists for 7-10 days. Complete detachments of the distal bulbar portion or hanging urethra are treated by direct end-to-end anastomosis whenever possible.

It is necessary to carefully remove all non-viable tissues to healthy edges. Devastating injuries occur when wounded by a shotgun, powerful machines, or high-speed blunt contusions. Initial treatment consists of hemostasis, thorough sanitation and the imposition of a proximal suprapubic cystostomy. The purpose of the initial sanitation is to resolve massive wounds of the perineum, adequate outflow of urine and feces, removal of non-viable tissues in such a way as to ultimately preserve the opening of the posterior urethra, which can be restored within a few months by stepwise urethroplasty.

Prognosis

With timely surgical treatment for isolated damage to the urethra, which was not complicated by the formation of a hematoma and urinary floodplains, the prognosis for life is favorable, but not satisfactory in terms of complete recovery.

VI. Injury to the testicles and their appendages

Damage to the testicle and its appendage is usually accompanied by an injury to the calf. A distinction is made between closed and open testicular injuries.

Closed testicular injuries

Closed testicular injuries include: contusion (contusion) of the testicle, rupture of the testicle and dislocation of the testicle.

Testicular contusion is accompanied by hemorrhages in the connective tissue septa, testicular parenchyma and its appendage with the formation of a hematoma and hematocele. Hemorrhages in the fleshy membrane of the calf are common. In severe trauma, ruptures and crushing of the testicular parenchyma are sometimes observed. In small intratesticular hematomas, patients are prescribed bed rest, wearing tight-fitting swimming trunks, analgesics and hemostatic agents, cold on the gate area. A week after the injury, thermal procedures are prescribed. Treatment of large intratesticular hematomas is surgical.

Testicular rupture. A closed injury often leads to a ruptured testicle. A defect in the protein membrane of the testicle is an indication for emergency surgery. If the testicle cannot be palpated (hematocele, hematoma of the gate) and there are doubts about the integrity of its protein membrane, an ultrasound examination of the gate is performed. In case of severe testicular injury, therapeutic measures should be aimed primarily at combating shock. Regardless of the results of the study, if there is a clinical suspicion of a testicular rupture, an urgent operation is necessary, during which the hematoma is removed, the crushed parenchyma and protruding parenchyma are excised, and the protein membrane is sutured. In cases of rupture of the spermatic cord, it is reconstructed without vasovasostomy. With massive destruction of the protein membrane of the testicle, a mobilized flap of the vaginal membrane of the testicle is used to close its defects.

In cases where there is only a bruise and there is no hematocele and intratesticular hematoma, antibiotics are not prescribed. If surgery was performed for a closed testicular injury, broad-spectrum antibiotics are prescribed.

In boys, with damage to the organs of the calves, torsion of the testicle, epididymis or epididymis is often observed, characterized by increasing swelling of the calf, its hyperemia. Gradually, the process captures the other half of the wicket. In such patients, epididymoorchitis develops early, which, against the background of conservative therapy, in most cases leads to testicular atrophy. In recent years, active therapeutic tactics have been used against such patients.

Dislocation of the testicle. With a closed injury, often from a sudden application of force, the testicle rapidly rises up towards the inguinal canal or even through it. In such cases, it is located in the area of the outer ring of the inguinal canal, inside it or in the abdominal cavity. Patients complain of sharp pain in the groin area and abdomen, the absence of a testicle, sometimes collapse occurs.

During the examination, an empty gate is determined on the side of the injury. Often the testicle can be palpated in the groin area. Ultrasound and computed tomography of the abdominal cavity help determine the localization of the testicle and the degree of its damage. For conservative treatment, manual reduction of the testicle into the gate is used, but secondary (delayed) orchidopexy remains indicated. If manual testicular reduction fails, urgent orchidopexy is indicated.

Open injuries of the testicle and its appendage

Open injuries to the testicle and its appendage are rare. These include stabbed, cut, lacerations, gunshot wounds. Gunshot wounds of the testicle can be tangential, blind, through. There are the following types of open testicular injuries:

A. injury of the protein membrane without prolapse of the parenchyma;

B. isolated injuries of the epididymis, injury to the protein membrane with prolapse of the testicular parenchyma;

C. blind wounds;

D. crushing of the testicular pole;

E. separation of one or both testicles from the spermatic cord (traumatic castration).

Despite the fact that injuries to the gate and its organs, from the point of view of danger to life, are classified as light, shock is observed in a number of patients. When examining patients with open testicular injury, ascending urethrography is mandatory.

Treatment of patients with open lesions of the testicles and their appendages

Treatment of patients with open injuries of the testicles and their appendages is aimed, first of all, at combating shock and bleeding. With any damage to the testicle, the main task is to preserve the functioning parenchyma.

Surgery technique for damage to the testicle and its appendage. In case of an open injury during the initial surgical treatment by sparing excision of the edges of the wound of the wicket, non-viable tissues and foreign bodies are removed, and the hematoma is emptied. An intact testicle that has fallen into the wound is cleaned of contamination, washed with a warm aseptic solution and immersed in a wicket. Drainage is placed in the lower corner of the wound. Small wounds of the protein membrane, without prolapse of the parenchyma, are sutured with absorbable sutures. In this case, it is impractical to suture the vaginal membrane. It is necessary to perform Bergmann surgery.

With large wounds of the testicle, non-viable tissue is excised, and viable tissue is inserted into a protein membrane, on which liquid absorbable sutures are applied. When one of the poles of the testicle is crushed, it is resectioned. Only non-viable tissue is subject to resection. When crushing the epididymis, epididymectomy is indicated.

The loss of one testicle does not lead to endocrine disorders. With bilateral traumatic castration, sexual function is extinguished.

In most cases, immediately after severe damage to the testicle, pronounced disorders of spermatogenesis are observed, up to the state of azoospermia. Over time (within 6-9 months), active spermatogenesis is restored or improved. Moreover, with a unilateral injury, the fertilization capacity of the contralateral testicle is also impaired. In 1/4 of cases, these changes are irreversible.

In the distant period, as a result of vascular injury with the formation of ischemic areas, testicular atrophy may occur, which leads to a violation of fertilization.

The basic principles of treating patients with traumatic testicular injuries are:

- establishing the cause, nature and extent of the damage; ultrasound examination helps to determine the degree of damage, testicular ruptures, the presence of hematomas;
- early surgical intervention, in comparison with observation tactics, contributes to the speedy recovery of the patient, helps to restore active spermatogenesis; the scope of surgery depends on the nature of the injury and should be as sparing as possible;
- removal and drainage of superficial and deep hematomas, final stop of bleeding;
- removal of non-viable tissues of the testicle, its membranes and epididymis;
- adequate drainage of the wicket due to the danger of suppuration of hematomas (due to the wound and contrapperture in the lower pole of the wicket).

Direct surgery is indicated if the testicle is saved. The simplest scrotum hematomas can be observed in the absence of a rupture if the injury is stable. However, in patients with large hematomas, an incision and drainage are usually used for a speedy recovery. The best radiographic method for evaluating boys with suspected testicular rupture is ultrasound. Scrotum ultrasound is a fast, non-invasive, and relatively accurate method for detecting testicular abnormalities. Thus, ultrasound can be useful in determining if there is a testicular rupture and surgery is justified.

However, given the relatively low positive prognostic value, surgery should still be considered in ambiguous cases where ultrasound does not provide a definitive diagnosis. In all boys with pain in the scrotum after any type of injury, testicular torsion should be considered in the diagnosis.

The necrotic tissues of the seminal membranes are processed, and the protein membrane is closed with a resorbable suture. Inability to close the protein coat in the

continuation of extrusion of seminiferous tubules and increased risk of infertility in the future. Drainage placed under the vaginal membrane and removed through the puncture wound to the lower part of the scrotum is also necessary. It is imperative to prescribe a broad-spectrum antibiotic within 7-10 days.

Conclusions

Thus, in the last decade, urologists have widely used new radiation diagnostic methods (MRI, CT), which have greatly facilitated both diagnosis and the choice of optimal treatment tactics. However, many issues of treatment of children with trauma to the genitourinary organs remain controversial and require further research. At the same time, surgeons do not have much time to plan the management of patients with trauma, which is why the best way out of this situation is to think over and implement the principles of treatment of these patients, first of all, in the mind of the doctor, to such an extent that the surprise is sudden and there is more time to save the patient's life.

VII. **Recommended Reading**

Basic.

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