

The evolution of surgical treatment of urolithiasis: from lithotomy to combined intrarenal technologies

Summary

Urolithiasis (hereinafter ICD) has a long thousand-year history, worldwide spread, frequent recurrence and occupies a leading place in the structure of surgical diseases of the urinary system. The development of urology as a clinical discipline is thorny and is associated with the stages of origin and formation as a science, oblivion and revival - as a modern field of surgery. The progress of technical thought, achievements of fundamental science, naturally led to the formation of urology and, in particular, surgery of urolithiasis on the basis of new concepts of operative capabilities, preoperative diagnostics, new methods of physical impact on the structure of the calculus. The creation and improvement of new low-traumatic techniques, their active and widespread introduction into practice, contributed to the displacement of open traumatic interventions used for centuries, and made it possible to successfully remove stones from the urinary tract with minimal complications. The work is devoted to the historical review of the formation of urolithiasis surgery, comparative characteristics of alternative minimally invasive methods of treatment of KSD. The scientific work reveals the modern achievements of percutaneous surgery, the history of the development of technical improvements and the possibilities of retrograde fiberoptic intrarenal technologies. The promising directions of development of antegrade and retrograde surgery of nephrolithiasis in the present and near future have been determined.

Keywords: history of urolithiasis surgery, urolithiasis, extracorporeal shock wave lithotripsy, percutaneous nephrolitholapaxy, nephrolithotripsy, flexible ureteropyeloscopy, retrograde intrarenal surgery, combined intrarenal technologies

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Introduction

The evolution of the surgical treatment of urolithiasis

Part 1: from transperineal lithotomy to sectional nephrotomy

Medicine, as well as its constituent surgery, is a practical activity and at the same time a system of scientific knowledge about the preservation and strengthening of human health, about the treatment of patients and the prevention of diseases. Urology, as a scientific and practical discipline, as well as its branches, in particular the surgery of urolithiasis, corresponds completely to the general tasks of medicine. Urolithiasis (urolithiasis) can be rightfully considered the same age as human civilization, since the most ancient stone discovered by archaeologists in the urinary tract of an Egyptian mummy is dated to the 7th century BC. The development of urology (as a part of medicine) for many centuries proceeded according to the principle from simple to complex, from particular to general. Moreover, the transition from one stage to another took place as a dialectical process of the transition from quantity to quality. The first attempts at scientific understanding of the symptoms of urolithiasis are associated with the ancient Greek healer, philosopher and physician Hippocrates (460-370 BC). Hippocrates left a vast legacy of works on a wide range of medical problems. He owns a saying that has not lost its meaning today. "I will not undertake, - wrote Hippocrates, - to operate on a patient with a stone, I will leave this work to the specialists of this craft".¹ It is difficult to say what is more in these words: caution, a deep understanding of the essence of the matter, or both (Figure 1). Other great scientists of the past had the same powerful mind. In the 11th century AD, Claudius Galen, whose name has been a symbol of medical art for many centuries, tried to solve daring problems, rather the problems of the etiology and pathogenesis of diseases (Figure 2).

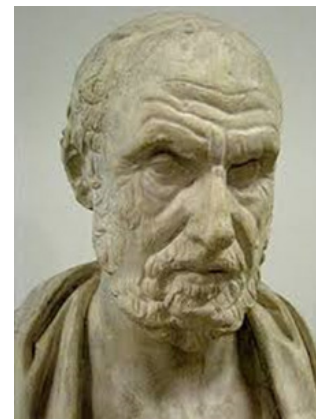


Figure 1 Hippocrates, 460-370 BC, ancient Greek healer, physician and philosopher.¹



Figure 2 Claudius Galen (130-210), ancient Roman physician, surgeon and philosopher.

Avicenna Abu Ali Allah Ibn Sina - the largest doctor of the Middle Ages and one of the most prominent doctors in history, left works on various numerous branches of knowledge. Here and philosophy, physics, astronomy, chemistry, etc. But the most significant were his works in the field of medicine, and above all - the world-famous encyclopedic «Canon of Medicine» (Tib Kanunlari) (Figure 3). Among the most interesting information and reflections in the «Canon of Medicine» we find serious reflections on the diagnosis and treatment of kidney and bladder diseases, a description of some techniques, including catheterization of the urinary tract, surgical removal of bladder stones.² The first information on the surgical treatment of urolithiasis dates back to the 12th century and consisted in the dissection of the bladder or ureter with a median open access (Arabic manuscripts) (Figure 4).

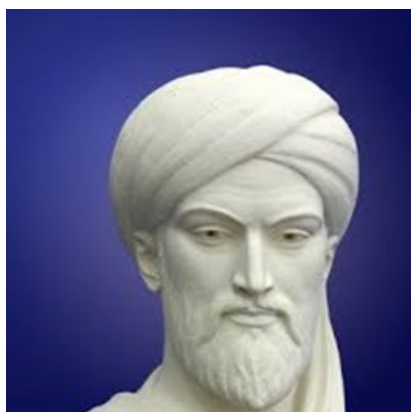


Figure 3 Avicenna (Ibn Sina), 980-1037, Persian scientist, philosopher and physician.²



Figure 4 Ancient medical instruments.

In the Middle Ages, doctors did not have modern means of asepsis and antiseptics, pain relief, methods of ensuring the tightness of the urinary tract. The extremely low percentage of recovery forced doctors to resort to therapeutic methods - the use of natural (herbal) remedies, diets, and lifestyle changes. In these difficult conditions, however, surgical interventions were widely used. Interventions on the bladder, as the most frequent, were explained by the peculiarities of the anatomical structure of this area and the relative ease of access. It is not surprising that the «Kamneseks» (as the specialists of this craft were called) performed these operations in literally minutes. As the great Russian surgeon N.I. Pirogov (1810-1881) took about one minute to complete the manipulation. It should be added that the surgical technique, his knowledge of anatomical and physiological constants, his constant striving for excellence in all spheres of activity to which his genius mind turned. The glorious name of Nikolai

Ivanovich Pirogov - a scientist and surgeon, teacher and public figure - has long been for all educated Russia a symbol of the advanced medical class.³ Numerous archaeological finds confirm that surgery in the system of scientific knowledge and practical actions was perhaps the first one that people mastered. Looking back in time, we will mention the numerous Egyptian papyri: Eberst, Hirst and others, dating back to the III-II century BC (Figure 5).



Figure 5 Papyrus by G. Ebers (medical manuscript from Ancient Egypt, discovered in 1873).

The Smith papyrus (XVIII century BC) is considered to be especially valuable. In the Middle Ages, Sectio alta (perineal section operation for bladder stones) was widely used (Figure 6). Despite the rather large anatomical difficulties, according to S.P. Botkin «was a huge success ... the stones were removed by specialists - stone-cutters, who performed this operation alone.» Now it is difficult to imagine how such an operation was done at fairs and bazaars. Subsequently, this operation was performed by qualified surgeons. In Russia, for example, Professor V.A. made about 2000 similar lithotomies. In the past, according to Guy de Chauliac (1300-1368) - «Anyone who had kidney stones could not live in safety. In case of obstruction of the passage of urine, dropsy and death occurred ...». If the blocking stone did not leave on its own, then the case was recognized as incurable, the operation was not recommended. Time passed. And, as on photographic paper, the contours of the clinical specialty - urology - began to take shape more and more clearly. So, back in 1588. F Diaz (1527-1590) - Doctor of Medicine, Master of Philosophy at the University of Alcalá de Henares (Spain), and even the king's surgeon, published a major work - a monograph on surgery. Diaz turned to urological problems. Unlike many of his predecessors, F Diaz did not confine himself to the bladder area. Kidney anatomy, pathogenesis, diagnosis and treatment of kidney stone disease were the subject of his special attention. And, of course, the clinic for renal colic, the technique of surgical interventions, a description of the instrumentation (probes, catheters, stone probes and spoons for removing stones, mirrors and dilators for perineal lithography). The work of F. Diaz gave full reason to consider the author the ancestor of urology, as a separate clinical specialty. Diaz in his work made it possible to overthrow the existing dogmas of Aristotle and Avicenna regarding the anatomy of the kidneys, the pathogenesis and treatment of urolithiasis. These and other sections of his work are striking in the abundance and detail of medical (especially surgical) knowledge.⁴

Moreover, assessing the state of medicine in the Middle Ages, one can easily draw a conclusion (in modern terms) about the priority of surgical methods, especially in the treatment of urolithiasis

over others. It is also obvious that historically, determining the development of urolithiasis surgery was the connection with the need to provide assistance to the rulers of the countries of Europe, Asia, and the American continent, who suffered from this pathology. Caesar Augustus, Frederick III of Saxony, James I of England, Louis XIV of France, Peter I, Benjamin Franklin, Leopold I of Belgium, Napoleon I, Pedro I of Brazil, Napoleon III, Lyndon Johnson, the Maori Queen, etc. After all, in terms of disease, sun-faced (at least!) did not differ in this respect from their loyal subjects. So, the history of the treatment of urolithiasis is associated with the practical activities of many scientists and specialists in the surgical craft: Ammonius - (200Sun, Alexandria);

- I. Susrata (IX century BC) - a representative of Indian surgery for the extraction of stones;
- II. Rufus of Ephesus (80-90 BC) - the author of the first monograph on kidney and urinary bladder diseases);⁵
- III. Paulus Aegineta (VII century, Byzantium) - the creator of the medical encyclopedia "Medical Compendium in Seven Books" with a section on surgery;
- IV. Albucasis (Az-Zahrawi) (936-1010) - Arab doctor, surgeon, author of the 30-volume work «Book of Az Zahrawi», dedicated to medicine and surgery (volumes 23 and 30). First used tools for stone extraction;
- V. Pierro Franco (1505-1578) - pioneer of suprapubic lithotomy;
- VI. Frere Jacques Beaulieu (16th century) - traveling lithotomist;
- VII. J. Cardano (1501-1576) - performed the first nephrolithotomy with the extraction of 18 stones - after opening the abscess of the lumbar region from the disintegrated parenchyma of the kidney;⁴
- VIII. William Cheselden (1688-1752) - first performed perineal lithotomy in 1 minute;⁶
- IX. William Thornhill - performed the first suprapubic lithotomy in 1722, was considered the best surgeon of his time;
- X. Philipp Bozzini (1773-1809) - inventor of a light guide (projector) for examining the urethra and bladder, the founder of surgical endoscopy of ICD (Figure 7);⁴
- XI. Jean Civiale (1792-1867) - the first head of the urology department at Necker Hospital (Paris, 1830), the founder of minimally invasive surgery, the inventor of the lithotripsy method, the developer of cystolithotripsy instrumentation;⁶
- XII. Auguste Nelaton (1807-1873) - French surgeon and urologist, developed a probe for lithotripsy, an endoscope for examining the urethra, a catheter for emptying the bladder;⁷
- XIII. Henry Thompson (1820-1904) - a student of J. Civiale, actively contributed to the development of endourology in Great Britain;⁶
- XIV. Felix Guyon (1831-1920) - the second head of the urology department of the Necker Hospital, the founder of the International Association of Urologists (1907), for the first time used X-rays to detect a kidney stone (1897);⁸
- XV. Maximilian Karl Nitze (1848-1906) - the inventor of the prototype of the modern cystoscope (1877), actively contributed to the development of endourology, "The first creator of cystoscopy" - in the words of SP Fedorov⁶

- XVI. James Israel (1848-1926) - the founder of upper urinary tract surgery, the author of the fundamental work "Experience of renal surgery".⁶

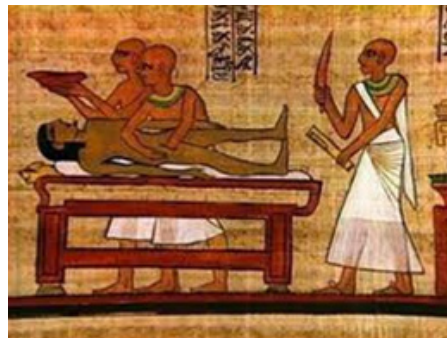


Figure 6 Medicine in Ancient Egypt.



Figure 7 Conductor F. Bozzini.

The eighteenth century can be seen as a breakthrough period in the development of urology. Bright surgical stars appear on the «urological horizon». So, for example, the doctor of the Catherine hospital, the «stone disease operator», I.P. Venediktov (1740-1806), who had colossal experience (more than 3000 operations) and many students. A certain milestone in the development of urolithiasis surgery was «Guide to teaching surgery» by I.F. Bush (1771-1843), the founder of the first surgical clinic in Russia. The author criticized medicinal methods of treatment of urolithiasis and outlined the leading priorities of the operational direction. The accumulated knowledge about the anatomical features of the urinary system made it possible to actively revise the operational tactics and improve the methods Figure 8, 9.⁴

Further development of urolithiasis surgery was facilitated by the following inventions and improvements in instrumentation and surgical techniques - the deflecting mechanism and ureteral catheterization,⁶ retrograde ureteropyelography (A. Lichtenberg, F. Voelcker, 1906), excretory urography (M. Swick, A. Lichtenberg, 1929), extraction of ureteral stones with basket extractors (E. Dormia, 1978) Figure 10, 11. Since the beginning of the 20th century, specialized urological departments have been organized in a number of European countries. Further development of urology and treatment of ICD was facilitated by L. Mercier, F. Legueu, G. Marion, R. Couvelaire (France), L. Casper, G. Kelling, P. Alken (Germany), Ch., W. Mayo (USA) E. Dormia (Italy), G. Thompson, P. Freyer (Great Britain), I. F. Bush,

N. I. Pirogov, S. P. Fedorov (Russia).⁹ Theoretical knowledge and practical experience were accumulated, the circle of curious urologists was expanded, and the operative technique was improved. Taking into account new knowledge of the pathophysiological mechanism of urolithiasis, original conservative methods of treating KSD were developed, methods of dissolving bladder stones with a solution of opium (A.L. Lefler, 1798) and tartaric salt (T.M. Mitrofanov, 1801) found their place.¹⁰



Figure 8 & 9 M. Nitze, 1848-1906, German urologist, Nitze-Leiter cystoscope.



Figure 10, 11 I. Albarran, 1860-1912, French urologist of Cuban origin, designed a catheterization cystoscope.

Gradually, the so-called «kamneseki» (lithotomists) and previous methods of operations, for example, sectio perinealis (perineal section of the bladder), gradually lost their role in the treatment of urolithiasis. The development of urology has been facilitated by the work and practical achievements (mentioned above) of many other famous surgeons. A notable phenomenon in the middle of the 19th century was the doctoral dissertation of F.I. Inozemtseva (1802-1869) «De lithotomiae metode bilateralis», 1833, dedicated to various methods of lithotomy.¹¹ Inozemtsev considered the best method of bilateral lateral section of the French surgeon Guillaume Dupuytren (1777-1835).

I.V. Buyalsky (1789 -1866) owns the first Russian manual on the surgery of urolithiasis - «Anatomical-surgical tables explaining the production of operations for cutting and breaking urinary stones» (1822). In 1823 K.I. Grum-Grzhimailo, with difficulties in perineal stone cutting, was the first in Russia to successfully complete the operation with epicystolithotomy. In 1866. the first urological clinic in the country was opened at the Moscow University. By the beginning of the 20th century, the clinic was already a center for the study of urological problems.¹⁰ The priority topic (more precisely, one of the leading) for many years has been urolithiasis, the study of which is associated with the names of world-class scientists - F.I. Sinitzyn, V.A. Basov, F.A. Rein, S.P. Fedorov, R.M. Fronshtein, S.I. Spasokukotsky and others. M. Brodel in 1902 proved the presence of the characteristic features of the angioarchitectonics of the kidneys in the form of avascular zones of the parenchyma on the border of the anterior and posterior zones of blood supply, the prerequisites for the development of anatomically grounded approaches and new surgical techniques appeared, which became a new stimulus for further searches.

Figure 12 In 1910 S.I. Spasokukotsky developed, revolutionary for that time, transabdominal access to the ureter in ICD. A talented surgeon and organizer S.P. Fedorov (1869-1936) proposed original methods of access to the kidney and ureter, the technique of subcapsular nephrectomy and pyelolithotomy, developed new types of instrumentation, wrote the fundamental manual «Surgery of the kidney and ureter» (1925).¹¹ Since the 40s of the XX century, an trophic nephrolithotomy began to be introduced - removal of calculus by dissecting the renal parenchyma in the area poor in blood vessels, at the same time, work on improving the methods of parenchymal hemostasis continued.¹² Until the eighties, the generally accepted method of removing urinary stones remained open intervention, the indication for which was the development of certain complications of urolithiasis. Over the years of using open access, many methods of a surgical approach to the zone of stone localization and its extraction have been developed (according to Fedorov, Pirogov, Nagamatsu, Bergman-Israel, Pogorelko, Frumkin, Chaklin, Tsulukidze, Southwick-Robinson, Pfannenstiel, Maylard, Keyu and Dr.). Of course, this is not a complete list of scientists and practitioners with colossal experience in scientific research and solving surgical problems, including urolithiasis. Figure 13 S.P. Fedorov wrote in 1930: «Currently, there are two methods of stone treatment in use - either section alta, with which this stone is removed, or stone crushing. The previous methods, for example, section perinalis, have been completely abandoned, are not applied, because this operation presents the inconvenience that it results in urinary incontinence.»

Today, the young generation of specialists is not very familiar with the fundamental works of our wonderful predecessors. Unfortunately, the achievements of domestic and world urological luminaries are not studied in the originals. Perhaps this gap, at least to some extent, will fill the true description of S.P. Fedorov's methods.

«The patient is placed on a healthy side with a roller. The leg of the healthy side is bent at the knee and hip joints; the leg of the affected side is straightened. The incision of the soft tissues of the lumbar

region begins at the level of the XII rib from the lateral edge of m. erector spinae and is carried out in an oblique-transverse direction towards the navel to the outer edge of the rectus abdominis muscle. The skin, subcutaneous tissue, superficial fascia are dissected. After a layer-by-layer dissection of the muscles (external, internal oblique and transverse) and transverse fascia along the skin incision, the first layer of retroperitoneal tissue is exposed. The peritoneum is bluntly separated from the renal fascia and displaced downward and anteriorly. Then a leaf of the retroperitoneal fascia is dissected in one of the sections of the posterior surface of the kidney. It is isolated bluntly from the perineal fat in the following sequence: the posterior surface of the kidney, the lower pole, the anterior surface and the upper pole. The mobilized kidney is removed into the wound. Some surgeons, however, do not recommend dissecting the muscles, but stupidly spread them apart. With a high kidney, the XII rib is resected without damaging the pleura. A significant advantage is the ability, if necessary, to switch to intraperitoneal access.¹³

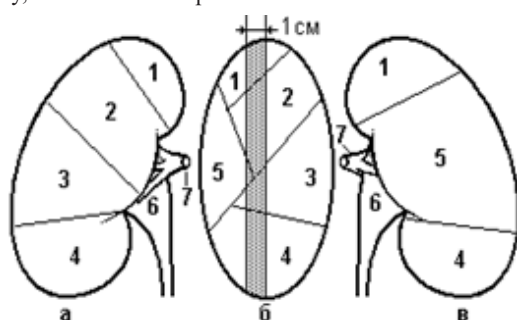


Figure 12 Brodel-Zondec Avascular Zone.

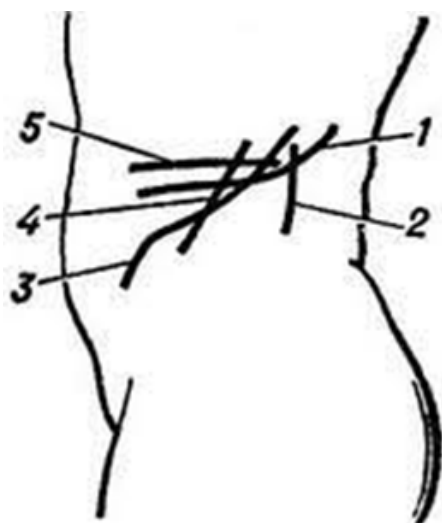


Figure 13 Surgical approaches to the urinary tract - Simon, Pean, Bergman-Israel, Fedorov, Nagamatsu.

At the end of the last century, against the background of the cautious attitude of the world community to the use and determination of the place of endoscopic methods of lithotripsy, the ICD was routinely considered the only open access to the zone of interest in the surgical strategy. To diagnose calculous lesions, only two-dimensional radiography of the urinary system was used - plain, excretory urography, retrograde and antegrade pyeloureterography. Identification of large stones, in most cases, did not cause difficulties and determined the optimal possible (at that time) surgical tactics. The diagnosis of stones of small size, low density and X-ray-negative structure in most cases was difficult and not reliable. For

the differential diagnosis of urgent situations and the exclusion of calculous obstruction, it is not rare. The situation changed dramatically when ultrasound came to the aid of diagnostics. It all began with the discovery in 1880 by Pierre and Jacques Curie of the piezoelectric effect (the formation of electricity in crystals), which served as the basis for the invention of ultrasound detectors.¹⁴ Years passed for the realization of the idea. In 1941 the Austrian neurologist K.F. Dussik made the first ultrasound examination of the brain, then the American surgeon D. Wald used a portable device with a movable scanner to determine the thickness of the intestinal wall.¹⁵ A modern apparatus combining a scanner and a receiver of ultrasonic waves was created in the United States in 1963 (ultrasound was introduced into the practice of Soviet medicine only by the end of the 1980s).¹⁵ Paying tribute to domestic scientists, it must be said that experimental studies of the use of ultrasound in surgery were begun at the Institute of Acoustics of the USSR Academy of Sciences in the early 50s.

The ultrasound location method marked a new (diagnostic) stage in the development of urology. Expanding the visual capabilities of determining the localization, size of stones, the degree of involvement in the pathological process of the urinary system, the degree of impairment of urodynamics, structural changes in the parenchyma, accelerated the process of diagnosis and adoption of optimal tactics, reduced the need for X-ray screening, and allowed for dynamic control over the course of urolithiasis. In the future, the introduction into clinical practice of new and minimally invasive methods of treating KSD, the creation and widespread use of semi-rigid and flexible endoscopes, various types of lithoextractors and systems that facilitate access to calculus (percutaneous and ureteral sheaths), as well as the introduction of laser technologies in surgical urology will significantly change the approach to the treatment of patients with urolithiasis.¹⁶ The situation has historically changed once again after the introduction into practice of equipment for «x-ray» (X-ray apparatus designer Russian physicist A. Popov), the use of endoscopic techniques for visualization of the upper urinary tract (installation of a metallized catheter and the introduction of liquid (gaseous) contrast agents), as well as the introduction of anatomical -justified access to the kidney and ureter.¹⁷ At the same time, the fears of unreasonable use of new developments were justified. No wonder that N.I. Pirogov, the famous surgeon P.P. Zablotsky-Desyatovsky (1814-1882) wrote: "Always and of all methods of operation, one should choose the one that is least dangerous for the patient's life, gives the greatest hope for success, causes the least pain and suffering. When all three conditions are satisfied, it is great happiness for both the patient and the surgeon. « Nevertheless, based on realities, these thoughts remain so modern and how important they are for young emerging surgeons.

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

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