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Surgical treatment of patients with strictures of the ureteropelvic junction: historical aspects

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The review article is devoted to the history of surgical treatment of the ureteropelvic junction obstruction. The data on the main stages of development and improvement of the operative technique are presented, the main methods of restoring the outflow of urine from the kidney with strictures of the ureteropelvic junction are described. The analysis of modern methods of surgical treatment of this category of patients has been carried out.

Keywords: hydronephrosis; ureteropelvic junction; reconstructive surgery; ureteral stricture.

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Оперативное лечение пациентов со стриктурами лоханочно-мочеточникового сегмента: исторические аспекты

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Обзорная статья посвящена истории оперативного лечения пациентов со стриктурами лоханочно-мочеточникового сегмента. Приведены данные об основных этапах развития и совершенствования оперативной техники, описаны основные методы восстановления оттока мочи из почки при стриктурах лоханочно-мочеточникового сегмента. Проведен анализ современных методов хирургического лечения данной категории больных.

Ключевые слова: гидронефроз; лоханочно-мочеточниковый сегмент; реконструктивная хирургия; стриктура мочеточника.

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Strictures of the ureteropelvic junction (UPJ) and associated complications represent an urgent problem in modern urology. According to various sources, congenital UPJ strictures are detected in 1 of 1000–2000 newborns, and bilateral lesions are present in 10%–15% of cases [1]. In adults, UPJ strictures are also most often unilateral; however, bilateral lesions are diagnosed in about a quarter of patients [2]. Thousands of plastic surgeries on the pyeloureteral segment are performed annually worldwide to restore urine outflow. More than 50 types of such surgical interventions using various approaches have been described, including open, laparoscopic, robotic-assisted, and endoscopic surgeries.

UPJ stenosis was first mentioned in 1641 when Nikolas Tulp, a Dutch surgeon, described the obstruction of the upper urinary tract discovered during autopsy [3]. In 1747, Samuel Glass, an English surgeon, removed an enlarged kidney from a 23-year-old woman during a postmortem examination, and with incision, "about 30 gallons" of fluid were released [4]. In 1785, to describe this condition, which is now known as hydronephrosis, Philipp Martineau, an English doctor from the Norwich Hospital, proposed to use the term "hydrops renis"; in 1800, Frederick Walter called it "hydrops renalis"; and in 1816, James Johnson, an Irish surgeon, called it "hydrorenal distension." The term "hydronephrosis" was first proposed in 1841 by Pierre François Rayer, a famous French doctor [4]. However, the above concepts indicated only the presence of an excess amount of fluid in the renal pyelocaliceal system, but had no relation to the causes of this condition. Frank Hinman, Sr., an American surgeon and scientist, was one of the first to study in detail and reveal a causal relationship between ureteral obstruction and hydronephrosis [4].

Surgical reconstructive interventions for ureteral strictures have been performed since the end of the nineteenth century. In 1888, Friedrich Trendelenburg, a German surgeon, first performed pyeloplasty by resection of the narrowed UPJ with the imposition of an end-to-end anastomosis. This surgery can be considered the start of the era of restorative surgical treatment for hydronephrosis. The patient operated on by Trendelenburg was diagnosed with obstruction caused by an impaired development of the urinary system, that is, a high ureteral outlet. Unfortunately, the patient died in the early postoperative period due to peritonitis caused by intestinal wall damage [5]. In 1891, Ernst Georg Ferdinand Kuster, a German surgeon, performed successful resection of the narrowed UPJ with the formation of an anastomosis between the pelvis and the ureter. A year after this surgery, Christian Fenger, a renowned surgeon who was born in Denmark, but who lived most of his life in the USA, proposed to perform a longitudinal dissection of the narrowed UPJ with interrupted sutures in the transverse direction [4]. However, after this surgery, deformity of the UPJ associated with plastic surgery on one side of the ureter was often noted; therefore, T.E. Gibson suggested dissecting the ureteral constriction on both sides [6]. Reconstructive surgery for strictures of the UPJ of various etiologies, using a graft from the renal pelvis, was introduced by A. Schwyzer in 1923, introducing the use of the method of graft plastic surgery for UPJ strictures. He recommended continuing the longitudinal incision of the ureter up to the pelvis, cutting out a graft from its wall, turning it down to the incision of the ureter, and performing an anastomosis between them. Later, this technique was partially modified by Frederick Foley, an American urologist, who cut a graft from the lower part of the pelvis [7]. For this reason, the Foley pyeloplasty method is optimal for high ureteral outlet from the pelvis. This surgery is also used by many urologists nowadays. For the surgical treatment of UPJ strictures, many options have been proposed for the plastic repair of the UPJ, such as Y-plastic repair (Foley surgery); plastic repair with the pelvis graft (Kulp–de Vird surgery), ureterotomy with ureteral intubation (Devis surgery), and Kuster surgery (a method of applying ureteropyeloanastomosis, which consists in transplanting the ureter into the lower part of the pelvis, with the end of the ureter dissected longitudinally over 1 cm), but many of them are only of historical interest. In 1949, English urologists James Christie Anderson and Wilfred Hynes proposed an original method of stricture resection with a wide anastomosis between the ureter and the pelvis, which has become one of the most commonly used techniques nowadays [8]. In 1963, J. Kucera, a Czech urologist, modified this surgical technique, proposing to replace the narrowed part of the ureter with a graft from the lower half of the pelvis. For this purpose, it was proposed to dissect the pelvis in the transverse direction obliquely and upward. The lower segment of the pelvis was pulled downward, and the ureter was sutured with its lumen "side to side." The rest of the opened pelvis was sutured. The method is applicable only for large pelvis. This surgery is called "Anderson–Hynes–Kuchera plastic repair of the ureteropelvic junction" [9].

In 1966, S.D. Goligorsky and A.M. Katsyf proposed to divide all reconstructive plastic surgeries in impaired UPJ patency into four types [10]:

1. Plastic surgeries performed to eliminate external causes of impaired UPJ patency (such as resection of an additional lower-polar blood vessel, creation of an adipose pad between the vessel and the ureter according to B.V. Klyucharev, nephroplication, and ureterolysis).

2. Plastic surgery performed on the UPJ (i.e., extramucosal ureterotomy, Marion–Devis intubation ureterotomy, external pyeloureteroplasty, and internal pyeloureteroplasty).

3. Plastic surgeries performed with excision, displacement, or replacement of a part of the pelvis or

ureter (such as excision of the lower segment of the hydronephrotic sac and stricture of the adpelvic part, plastic repair by Kulp–Ackilitz, Bischoff, and S.I. Spasokukotsky). During the last surgery, the enlarged pelvis is resected, two ribbon-like flaps are left, which are then sutured together, thereby forming a new pelvis, and ureteropyeloanastomosis is performed at the lower pole of the kidney. The Anderson–Hynes–Bischoff method consists of subtotal resection of the hydronephrotic sac with the formation of an anastomosis on a rubber tube inserted through the nephrostomy. This group of surgeries also includes Neuwirth's ureterocalicostomy.

4. Combined plastic surgery performed simultaneously with the removal of stones, excision of dilated calyces, or resection of the kidney.

For a long time, ureterolysis was the most frequent, but least effective, surgery. Removal of the external obstacle did not always eliminate the consequences of its pressure on the ureteral wall. Owing to the prolonged compression of the ureter by a commissure or an additional vessel, scars appeared in the thickness of its wall, which caused narrowing of the lumen of the ureter and disrupted the urine passage. In such cases, it is advisable to combine ureterolysis with resection (removal) of the narrowed segment of the ureter and plastic repair, especially if after dissection of the commissure or cord, a "groove" is clearly visible on the ureteral wall. In this regard, ureterolysis, previously performed by many surgeons, is almost not used nowadays.

In 1897, Joaquín Albarran, a French urologist, designed a catheterization cystoscope, which made it possible to perform ureteral catheterization. In 1903, J. Albarran described the technique of intubation ureterotomy, which consisted of dissection of all layers of the ureter, followed by intubation and suturing of the defect already on the ureteral drainage or without suturing [11]. Intubation ureterotomy, proposed by J. Albarran, combined both open and endoscopic techniques. Contemporaries accepted this surgery without enthusiasm, and it was not widely used, but works in this field continued. Thus, in 1923, Russian outstanding surgeon-urologist S.P. Fedorov after the imposition of a nephrostomy bougienated the UPJ stricture through a nephrostomy fistula. In 1943, D. Davis developed the technique of J. Albarran and proposed a longitudinal dissection of the ureter simultaneously with its intraluminal intubation (internal intubation ureterotomy) [12]. In 1983, J. Wickham and M.J. Kellet modified the surgery of D. Davis and performed puncture endoscopic dissection of the UPJ stricture [13]. These works formed the basis of contemporary X-ray endoscopic methods of surgical treatment of UPJ strictures [14].

In patients with nephrolithiasis in the presence of strictures of the UPJ, combined pyelolithotomy and pyelourethroplasty surgeries are performed. Anterior pyelolithotomy with UPJ plastic repair is more often performed. A significant contribution to this field of surgery was made by Russian surgeons S.P. Fedorov, A.P. Tsulukidze, A.P. Frumkin, I.P. Pogorelko, and others [14]. When performing pyeloplasty, as well as in some types of pyelolithotomy, many urologists did not suture the renal pelvis, but a drainage tube was placed at the incision site, and the wound was sutured. This was fraught with a long stay of the drainage in the retroperitoneal space and, in general, increased the patient's recovery period after surgery. In addition, various infectious and inflammatory complications often developed. The possibility of catheterization of the ureter with thin PVC tubes, which is also associated with J. Albarran, became an important milestone. In the early twentieth century, the term "stent" was first used in the medical literature. Its origin is connected with the British court dentist Charles Thomas Stent (1807–1885) [15]. He left his mark in history by creating a special composition for making dental impressions from gutta-percha with the addition of stearin and talc, which hardened and retained its shape for a long time. Gutta-percha is a natural latex sourced from tropical trees native to Southeast Asia and Northern Australia. After his death, this material was used Johannes Essner, a Dutch plastic surgeon, for plastic surgery of oral wounds. In continuation of this idea in urology, intubator catheters were developed from various materials (latex and polymeric materials) as well as of various shapes (J, J-J, pigtail, with variable length). In the urological literature, the term stent was not widely used until the 1970s. Prior to this, terms such as "ureteral tubes," "splints," or "catheters" were used. For the first time, the term "stent" was mentioned by W.E. Goodwin, an American urologist, in 1972 in the article "Splint, Stent, Stint," which relates him to the name of the British dentist.

The correct choice of suture material is of great importance in reconstructive surgeries in urology. The success of pyeloureteroplasty is ensured by the properties and characteristics of the threads, along with adequate alignment of the edges of the pelvis and ureter and the absence of tension. In about A.D. 100, the Ayurveda treatise "Caraka Samhita" described the importance of approximation of the wound edges. Later, Susruta, an Indian surgeon, described the first suture materials. In 175, the famous surgeon Galen used catgut, but only in the nineteenth century that Joseph Lister, an English surgeon and scientist, described methods of sterilizing catgut threads. Silk threads were introduced as suture material by Theodor Kocher, a Swiss surgeon, in the early twentieth century. Also, in the twentieth century, there were attempts to use body tissues of animals, for example, P.M. Preobrazhensky suggested using dog nerves. However, none of the proposed methods was used in surgery. In the early twentieth century, nylon

was invented in America, and in the 1930s, capron (polyamide) and lavsan (polyester) were invented. Vicryl was synthesized in 1974. In 1980, monofilament synthetic absorbable sutures Maxson and PDS appeared [16]. In 1991–1996, a new generation of synthetic suture materials was obtained, including polysorb, biosin, and monocryl [17]. When we analyzed the history of the emergence of new suture materials, we can conclude that until the middle of the twentieth century, surgeons formed an anastomosis using catgut sutures. Their use has certain disadvantages, including the development of aseptic inflammation of the tissues surrounding the thread, difficulty in thread sterilization, complex production technology, and short absorption time (up to 15 days). Catgut is not recommended in cases when long-term tightening of wound edges is required, or the wound edges are exposed to tensile stress, which is the reason for the high incidence of early anastomotic leakage when catgut was used for UPJ plastic repair. After the appearance of synthetic threads with greater strength and long-term absorption (up to 110 days), they nearly ubiquitously displaced catgut from plastic surgery of the urinary tract, which was accompanied by a decrease in the incidence of complications of the intervention and recurrence of strictures. Even greater advantages were obtained after the appearance of V-lock sutures, which was associated with their self-fixation mechanism and a special suture configuration that prevents dehiscence and disruption of the anastomotic integrity [18]

The development of reconstructive surgery for UPJ is currently closely associated with minimally invasive surgeries such as laparoscopic and endoscopic surgeries performed retrogradely and antegradely using a "cold" knife or laser applicator [19–22]. If both UPJ stricture and nephrolithiasis are present, simultaneous surgeries are performed, including pyeloplasty and pyelolithomy [23–25]. Laparoscopic pyeloplasty was first performed by William Schuessler in 1993 in the USA [26]. In endovideosurgical pyeloplasty, both transperitoneal and retroperitoneal approaches are used. With a significantly pronounced expansion of the pelvis on the left, transmesenteric access is also possible. When choosing an access, the peculiarities of the anatomy of each patient are taken into account. The renal vessels are adjacent to the anterior surface of the pelvis; therefore, some surgeons believe that, in this situation, retroperitoneal access is more convenient and is accompanied by fewer complications. With this approach, 3 or 4 endoports are installed in the incision projection according to Fedorov, namely, 10 mm along the midaxillary line for the laparoscope, 10 mm dorsal to the posterior axillary line, 5 mm along the mid-clavicular line, and a (in difficult cases) 5 mm for the retractor by 2 cm below the costal arch along the mid-clavicular line [18]. The first puncture of the retroperitoneal space with a 10-mm trocar is performed through the skin incision at the point of intersection of the Fedorov incision and the middle axillary line; the port is not required to be sealed. Pneumoretroperitoneum is created by the laparoscope tube against the presence of constant gas insufflation with a pressure of 10–12 mm Hg. The parietal peritoneum is exfoliated from the muscles of the anterior abdominal wall; instrumental trocars are installed into the formed primary cavity under visual control. After dissection of the Gerota fascia, the surface of the kidney, pelvis and upper third of the ureter are exposed [18]. In some cases, the transperitoneal access is preferable. The first insertion of a trocar for a laparoscope (10 mm) with this approach is performed along the border of the rectus abdominis muscles at the level of the umbilicus after applying a pneumoperitoneum using a Veress needle. After insufflation with a pressure of 10–12 mm Hg and performing laparoscopy, instrumental trocars are inserted into the abdominal cavity under visual control, namely, 5 mm in the hypochondrium along the mid-clavicular line and 5 mm in the iliac region on the side of the surgery. In addition, insertion of a 5-mm port is sometimes required along the mid-axillary line on the right to guide the retractor holding the liver. For antevasal pyeloureteral anastomosis, nearly all surgeons prefer an anterior approach to the renal hilum and use laparoscopic access for convenience. The positioning of the patient and placement of the endoports for the trans-mesenteric technique are similar to those for the transperitoneal approach described above. The pelvis and ureter are contoured through the mesenterium, the peritoneum above the pelvis is dissected with a monopolar hook, and the anterior and lower parts of the pelvis are mobilized. Subsequently, the plastic repair of the ureteropelvic junction is performed with the imposition of pyeloureteroanastomosis. The implementation of this technique is possible in patients with a body mass index of 30 kg/m^2 or lower. Nearly all known options for plastic surgery are named after the authors who proposed these techniques. However, sometimes, the differences between the individual methods of surgeries are so insignificant that it is very difficult to determine the authorship, especially if it is not related to a drawing on paper, but to the practical implementation of a technique in the operating room. Based on this, surgeons cannot give preference to one of the methods, and the decision on the possibility of a particular method or technology is often made intraoperatively. If we compare the duration of the first laparoscopic surgeries on the pyeloureteral segment, then at the end of the 1990s, the duration of surgeries performed by surgeons, including V. Schuessler, was 180–420 min. Currently, the duration of surgeries has been reduced to 60–90 min. A similar trend was noted for open surgeries, as in the 1970s and 1980s, they lasted an average of 180 min, and at present, their average duration is 90 min.

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We should also bear in mind innovations in medicine, namely, robotic technologies. In 1988, the robotic system Probot was developed to perform automated transurethral resection of the prostate [27]. A group of American urologists performed a number of automatic endoscopic system for optimal positioning (AESOP) surgeries, including pyeloplasty, nephrectomy, retroperitoneal lymphadenectomy, Burch surgery, orchopexy, and nephropexy [28, 29]. The authors noted that the use of robotic technologies is accompanied by great convenience for the operating surgeon, while the total surgery time remains practically unchanged. The AESOP robotic system ushered in the era of robotic-assisted reconstructive surgery [30, 31]. By 1999, more than 80,000 surgical interventions were performed using AESOP technology. The next step was the development of telerobotic remote surgery. The surgeon is at the console, and the computer translates his movements to the manipulators located in the patient's body [32]. Currently, ZEUS and Da Vinci are two robotic surgical systems most widely used. Robotic surgery continues to develop rapidly, nearly all urological surgeries are performed using this technology, and pyeloureteroplasty is not an exception [26]. Nowadays, there are more than 5500 robots worldwide, and 34 of them are used successfully by urological surgeons in the Russian Federation [33–35].

Thus, despite the wide choice of surgical treatment methods for UPJ strictures, laparoscopic reconstructive surgeries are now preferred. They have a number of important advantages over traditional open surgeries, including minimally invasiveness, reduced blood loss, early rehabilitation, better cosmetic effect, and reduced number of bed days. Compared with robotic surgery, laparoscopic surgeries are more economical, which is important for most clinics. Despite this, robotic-assisted pyeloplasty is gaining an increasing number of devotees, which is associated with greater functionality and convenience for the surgeon. Owing to accumulation of experience by surgeons, regardless of the surgical method, when performing pyeloplasty, the surgery time is significantly reduced, the number of complications decreases, and a greater efficiency of treatment is achieved. These circumstances are the basis for the motivation of surgeons to continue permanent improvement and development in the world of operative urology.

ADDITIONAL INFORMATION

Conflict of interest. The authors declare no conflict of interest.

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