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Epochs in Endourology

Early History of Endoscopic Treatment of Bladder Tumors From Grunfeld's Polypenkneipe to the Stern-McCarthy Resectoscope

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INTRODUCTION

UROLOGISTS TODAY ARE ACCUSTOMED TO USING a dazzling array of sophisticated endoscopic instruments to diagnose and treat bladder tumors. Modern digital flexible cystoscopes and video-assisted resectoscopes combined the essentials—access, superior optics, working elements, and energy—to detect, decipher, and destroy tumors growing in the bladder. Current endoscopes provide magnified (and magnificent) views of the bladder interior and tumors, permitting removal or targeted destruction by electrocautery or laser energy.

The methods, means, and skills we enjoy today did not just appear, of course. Such artistry began in the 19th Century and was refined further in the 20th owing to the collective genius and ingenuity of many urologists, scientists, inventors, and visionary thinkers in industry.

WHY THE 19th CENTURY?

The science and treatment of cancer is largely a 20th Century phenomenon, but the modern practice of surgical and medical oncology stems from developments in the 19th Century. The 19th Century was noteworthy for the acceleration of the Industrial Revolution, for the age of European empires, and for profound social and political change in Europe and beyond. Repeated conflicts between the major powers and the shift from a rural, agrarian society to an urban, industrialized society acted as a stimulus to technology and fostered scientific advances. In the 18th Century, the French Revolution, Parliamentary reforms of Britain, and the concept of electoral democracy founding the independent United States unleashed immense creative and economic powers of both Europeans and Americans.

During the 19th Century, scientific universities, academies, and postgraduate institutions were established throughout Europe and the United States. A more open approach to the dissemination of knowledge through meetings and journal publications overturned earlier habits of trade secrecy, accelerating scientific advancements and growth of the professions. By 1990, the foundations of modern medical practice and the social, cultural, and economic framework of the modern industrial world were well in place. The status of the professional surgeon was established, and the structure of modern institutional practice was discernible. Cancer was emerging as a major cause of morbidity and mortality in a healthier population with greater longevity and expectations (a pattern we are witnessing with greater urgency today). Endoscopy and the endoscopic management of bladder tumors emerged from this creative environment predicated on many scientific and technical developments coupled with improved understanding of cancer biology.[1]

BLADDER TUMORS FROM ANTIQUITY TO THE ENDOSCOPIC ERA

Although they were probably recognized in antiquity, bladder tumors were mentioned first in work by Lacuna in 1551 and Ferry in 1553. Despite scattered reports of excision of an occasional tumor found during lithotomy, the first operations specifically for bladder tumor were performed in the 16th and 17th Centuries. In 1561, Franco performed a suprapubic incision to extract a tumor he could not reach through the urethra, and in 1639, Couillard also deliberately opened the bladder to remove a polyp. Most surgeons, however, extracted tumors blindly through the urethra, as described by Le Roy d'Etiolles, Civiale, Thompson, and Clado.

The first operations were limited to women, in whom the urethra was dilated and a tumor presenting in the urethra or bladder neck could be grasped and amputated. This was more feasible in cases of tumors with a long pedicle, and only such treatment as could be effected by sounds, catheters, and lithotrites was attempted. In 1874, Billroth popularized open suprapubic removal of bladder tumors, reviving the method

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adopted by Franco more than 300 years previously. Thereafter, tumors were excised through suprapubic or lateral perineal incisions by ligatures, ecrasement (steel-wire loop ligature), arrachement (tearing out), enucleation, or cauterization (Paquelin cautery).

Surgeons were slow to abandon the perineal approach, however, and up to 1885, there were only nine cases of bladder tumor reported that had been removed through the suprapubic route. Even as late as 1909, Fordyce removed a villous papilloma from the bladder by vaginal cystotomy, and Thompson made perineal and urethral incisions in male patients to remove bladder "polyps."

During the 18th Century, the so-called *carnosities* of the bladder became more clearly understood in scattered works on the pathological anatomy of bladder tumors, polyps, ulcerations, and carcinomas. The first landmark in the history of bladder tumors was Chopart's classical 1791 work, "Traite des Maladies des Voies Urinaires." Largely on the basis of autopsy studies, Chopart was able to distinguish between tumors of the neck of the bladder (including prostatic hyperplasia) and those of its interior. He noted essential differences between various kinds of tumors and considered the "fungosities of the bladder" as benign tumors subject to cancerous degeneration. As a result, the 19th Century witnessed a marked advance in the knowledge of the pathology of bladder tumors soundly based on histologic structure. For example, Civiale differentiated the papillary fungoid type of growths from solid cancerous tumors. Definition of these lesions, now described as low-grade papillary tumors to distinguish them from high-grade invasive neoplasms, was highly relevant because the more common papillary growths were the only tumors early endoscopists could treat successfully. Invasive bladder tumors usually were far too advanced, and there certainly were no effective treatments for them at the time.[2]

EARLY ENDOSCOPIC ERA

Table 1 lists landmark developments in the endoscopic treatment of urethral and, later, bladder tumors. In 1806, Philipp Bozzini (dubbed the "Father of Endoscopy") made the first attempt to examine body cavities, including the bladder (his aim was to treat stones), when he created the Lichtleiter or "light conductor." Simply a speculum with candle and mirror, the Lichtleiter failed in patients because the instrument was large and painful, reflected candlelight was a poor and uncontrollable light source, and there were no optics. Although Bozzini's instrument was soon forgotten, his concept and construction principles were not.[3]

Surgeons learned endoscopic anatomy by practical exploration. The urinary tract was first explored by inspection through crude specula inserted into the urethral meatus. Next came urethroscopy, performed chiefly in women. After the urethra was dilated, a visible pedunculated tumor could be extracted and its pedicle tied off. With such instruments, developed by the French and English schools, attempts were made to seize growths transurethrally and tear off as much as could be pulled away, usually with unsatisfactory results.

Early methods and instruments proved unsatisfactory because they used indirect external light and did not allow routine operations inside the bladder. Moreover, prior to 1876, there was no comprehensive therapy of bladder tumors. Of necessity, diagnostic and therapeutic endoscopic procedures were done in a more or less blind and usually unreliable manner. The possibility of effective treatment of growths in the bladder became a reality only after the introduction of direct viewing of the urethra and bladder.

In the mid-19th Century, Desormeaux (also called the "Father of Endoscopy") introduced his endoscope, and endoscopy became better established as a practical, although difficult, method of clinical investigation. He designed his instrument around a paraffin flame that was made to burn more brightly by the addition of turpentine. In 1853, Desormeaux was able to perform the first true endoscopic operation when he extracted a papilloma through the urethra using his urethroscope.[4] Because the quality of illumination was crucial for success, Trouve (inventor of electroendoscopy) made a critical contribution to endoscopy in 1873 when he moved the light source (a glowing hot platinum wire) to the inner tip of his "Polyscope."[5] In 1876, Rutenberg also attempted to improve vision within the female

Table 1. Landmark Innovations in Endoscopic Treatment of Bladder Tumors

Individual	*Year*	*Innovation*
P. Bozzini	1806	Lichtleiter
A.J. Desormeaux	1853	First endoscopic operation—extraction of a urethral papilloma
G. Trouve	1873	Polyscope—electroendoscopy
D. Rutenberg	1876	Blasenspiegel—air cystoscopy
M. Nitze	1877	Cystoscope
J. Swan and T. Edison	1878	Incandescent lightbulb
J. Grunfeld	1881	Polypenkneipe—first removal of a bladder papilloma
M. Nitze	1894	Operating cystoscope
R. Wappler	1908	Monopolar high-frequency Oudin current—the Resonator
E. Beer	1910	Electrocoagulation of bladder tumors
E. Frank	1911	Bipolar electrocoagulation of bladder tumors
M. Stern	1926	First resectoscope
A. Bovie	1928	Electrosurgical device—separate current for coagulation and incisions
J. McCarthy	1931	Improved Stern resectoscope for bladder tumors

FIG. 1. Polypenkneipe, developed by Joseph Grunfeld in 1885.

bladder with his "Blasenspiegel." This "cystoscope for women" was an open speculum that had a window, a channel for a mirror, and a carrier for a distal light source. Rutenberg was the first physician to observe the larger surfaces of the bladder. He stretched the anesthetized urethra with Simon specula and then inserted the endoscope, filled the bladder with air, and examined it with the warmed mirror. The light was conducted via a concave mirror into the bladder.[6]

A few years later, the dermatologist Joseph Grunfeld improved endoscopic surgery in the urethra and bladder. He developed a urethroscope, as well as endoscopic loop threaders, scissors, forceps, and knives, and was the first to operate in the bladder under direct control of the eye when he removed a bladder papilloma through his urethroscope in 1881. In 1885, Grunfeld developed the "Polypenkneipe" (Fig. 1), the first endoscope specifically designed to remove tumors from the urethra and bladder.[7]

MAX NITZE AND THE OPERATING CYSTOSCOPE

Maximilian Nitze of Berlin was a shy and often irascible loner who reportedly did not care much for society or politics, yet he was pegged as brilliant at a young age.[8] Influenced by the work of Julius Brueck, a dentist, who performed diaphanoscopy of the bladder using an incandescent water-cooled platinum wire inserted in the rectum, the young urologist decided to reopen the whole field of endoscopy. Since it was first conceptualized by Bozzini in 1806, practical uses and advances of endoscopy had been hampered by poor vision. One day, after cleaning the dusty eyepiece of his microscope and confirming it to be clear by looking across at his assistant in the dimly lit room, he realized the answer. The field of view could be enlarged with an optical system, and the light source had to be placed at the tip of an instrument in the same way that "to light up a room one must carry the lamp inside." He combined the concepts of Bozzini and Trouve into two fundamental ideas: first, to use lenses, in the form of miniature telescopes, to magnify the image down the endoscope, and second, to illuminate the bladder by a water-cooled electric platinum filament lamp. Built with the aid of technicians and opticians in Berlin, the first direct-vision cystoscope was introduced by the 28-year-old Nitze on October 2, 1877.[9]

Although heat from the platinum filament proved to be a limiting factor in cystoscopy, a fortuitous technical advance appeared almost simultaneously in England and America. In 1878, Joseph Swan produced a lamp that, in a vacuum, was neither too hot nor liable to burn out. A few months later, Thomas Edison, using a carbon filament in a vacuum, invented a similar lamp, resulting in mass production of a small incandescent lightbulb that could be inserted into the end of a cystoscope in a water-filled bladder. This cold Mignon lamp was reliable and did not damage the patient's bladder by heat.

Although the advent of cystoscopy markedly improved endoscopic operative procedures, Nitze was never satisfied and realized that better instruments were needed. Between 1891 and 1894, he designed and constructed the first practical operating cystoscope (Fig. 2), became the first to coagulate a bladder papilloma using the hot lightbulb of his cystoscope, and subsequently constructed cold and hot wire loops for galvanocautery.[10] Nitze initiated the systematic treatment of bladder tumors and reported 150 cases of bladder tumors removed cystoscopically with only one death and 20 recurrences. Using a curette, cutting forceps, cautery, and wire loop, he was able to remove many papillary tumors cleanly. Others followed his lead, and in 1905, Weinrich reported treating 101 cases of bladder tumors by the Nitze method with 71% recoveries without recurrence. The procedure was mostly excision of a pedunculated tumor with a portion of the mucosa or else twisting off the pedicle at its base. For most European and American urologists, however, the Nitze cystoscope was difficult to manipulate, and galvanic cautery using the wire loop proved to be an unreliable treatment for bladder tumors. With the advent of diathermy in the United States, surgery of bladder tumors through the Nitze operating cystoscope was practically abandoned.

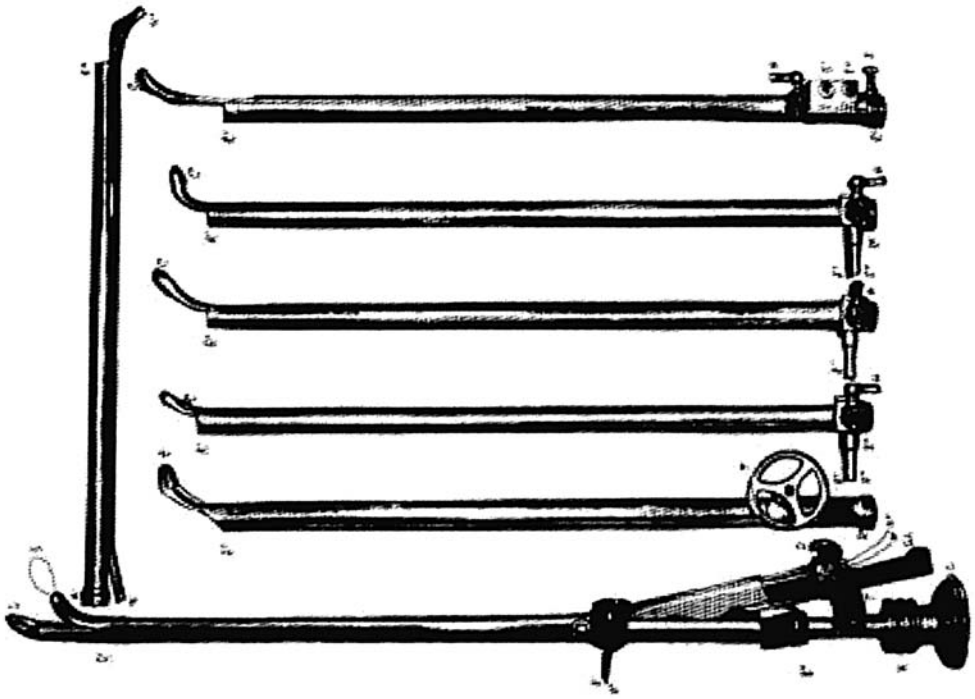

FIG. 2. Operating cystoscope, developed by M. Nitze in 1891–1894.

CYSTOFULGURATION

Nagelschmidt and Doyen in the United States were the first to advocate the use of diathermy to treat cancer. Doyen suggested the destruction of tumors by electrical currents, and in 1908, Nagelschmidt devised an adequate apparatus for this purpose and is credited with originating the term *diathermy*. But it was Edwin Beer (1910) and E.L. Keyes (1910) of New York and Ernst Frank (1911) of Berlin who founded electrosurgery of the bladder.

In 1908, Beer, convinced that Nitze's earlier transurethral treatment of bladder tumors was superior to open surgery, conceived the idea of using high-frequency electric current through a catheterizing cystoscope to coagulate bladder tumors. Reinhold Wappler, the American cystoscope maker, told Beer that his idea would not work in water because an air gap between the tumor and electrode was essential to create a coagulating current, and the current would burn out the cystoscope. Undaunted, Beer found he could fulgurate skin warts under water before testing his method against bladder tumors. At first, he used a two-channel Nitze cystoscope (one channel for a 6F copper electrode and the other for irrigation of the bladder) and a monopolar (Oudin) current derived from a resonator made by Wappler for bladder tumors. Direct current was applied at various points to papillary growths for 15 to 30 seconds at a time, while the bladder was distended with sterile water. Beer treated two women and saw no spark when the full current was thrown on without resistance. Tumor tissue was dessicated at cautery points, and the patients experienced no more discomfort than during ordinary cystoscopy. Beer concluded that coagulation was simpler than loop treatment, and on May 28, 1910, he reported his successful cases in a landmark article, claiming fulguration to be "proven effective in the cure of bladder papilloma."[11]

Beer's innovative new method revolutionized the treatment of papillary bladder tumors. Urologists, especially in Europe, were skeptical at first, but they soon joined their American counterparts and endorsed the approach. Keyes in this country and Heitz-Boyer in Paris; Kutner, Bucky, and Frank in Berlin; and Bachrach in Vienna quickly adopted the method and reported favorable results. Casper made skeptical remarks about the new method at Beer's 1912 lecture in Berlin (without having tested it) but later accepted it. In 1911, Frank together with Keyes and Bucky introduced bipolar electrocoagulation with D'Arsonval currents and in 3 years treated 25 patients. Keyes abandoned bipolar coagulation in 1916 and applied the more explosive and destructive Oudin monopolar current.

For the next 25 years, Beer devoted much of his time to the study of bladder neoplasms and continued to develop and improve his method of treatment. In 1981, Hugh H. Young proposed that "benign papillomas should be treated by endoscopic fulguration," long before Beer reported his aggregated experience of cases in 1935. After Beer died in 1938, Reed Nesbit wrote, "Development of this technique by its brilliant discoverer marked one of the greatest advances in the history of urology; it led not only to radical change in the therapeutic management of bladder tumors, but also paved the way for subsequent electroresection methods by proving that high-frequency current could be employed effectively under water." It did all that and more. Today, largely on the basis of Beer's work, cystofulguration of recurrent papillary bladder tumors remains common practice.[12]

TRANSURETHRAL RESECTION

As aphorism of Beer was that transurethral coagulation worked best for papillary tumors. In the early 1900s, urologists recognized at least two types of bladder tumors, one definitely benign and the other malignant (or at least, papillary tumors tended to behave in indolent fashion, whereas cancerous tumors were invasive and lethal). Reporting in 1905 on the results in 653 tumors of the bladder, Watson found that 29% of "benign" tumors recurred and that 46% of malignant tumors recurred. Although cystofulguration was used around the world to destroy benign papillomas and small papillary carcinomas, it was well known that not all papillary tumors were benign. Compounding the problem was that pathologists could not always distinguish between benign and malignant or invasive papillary tumors. By 1935, even Beer was pessimistic about the efficacy of endoscopic diathermy because it was applicable only to small tumors, did not prevent recurrences, and was ineffective against invasive bladder tumors. It became clear to all investigators that a more effective means to remove and destroy bladder tumors completely was needed.

In 1926, a urologist in New York named Maximilian Stern introduced a revolutionary new instrument he called a *resectoscope*. Stern's resectoscope consisted of a sheath and working parts assembled in a compact bundle made up of a direct-vision telescope, a light carrier, a water conduit, and a cutting loop or active electrode using a bipolar current. Stern devised a manually controlled gear mechanism to slide a tungsten wire loop back and forth through a fenestra with even movement and control (Fig. 3). Designed as a punch operation for the prostate, the moveable wire was able to whittle away obstructing prostatic tissue with ease. But the instrument lacked flexibility and was cumbersome to use in the bladder because it was difficult to engage bladder tissue in the recessed fenestra. However, the cutting loop offered the obvious advantage of removing rather than simply fulgurating bladder tumors.[13]

In 1931, Joseph McCarthy, also of New York, made significant improvements in the resectoscope. McCarthy fashioned a lens system that widened the visual field, used a nonconducting Bakelite sheath, added a lever to move an electric-arc cutting loop, incorporated separate currents for coagulation and cutting developed in 1928 by H. Cushing and W.T. Bovie, and, perhaps most importantly, moved the wire loop and cutting window to the tip of the instrument. The chief difference was that with the Stern instrument, cutting was done toward the bladder (amputating tissue away from the operator), while using the McCarthy resectoscope, one cut from within the bladder outward. McCarthy found that his modifications were better adapted to resect vesical neoplasms because with the extended loop, it was easier to engage bladder tumors to cut long spaghetti-like slices of tissue back toward the operator under direct vision and with better control.[14]

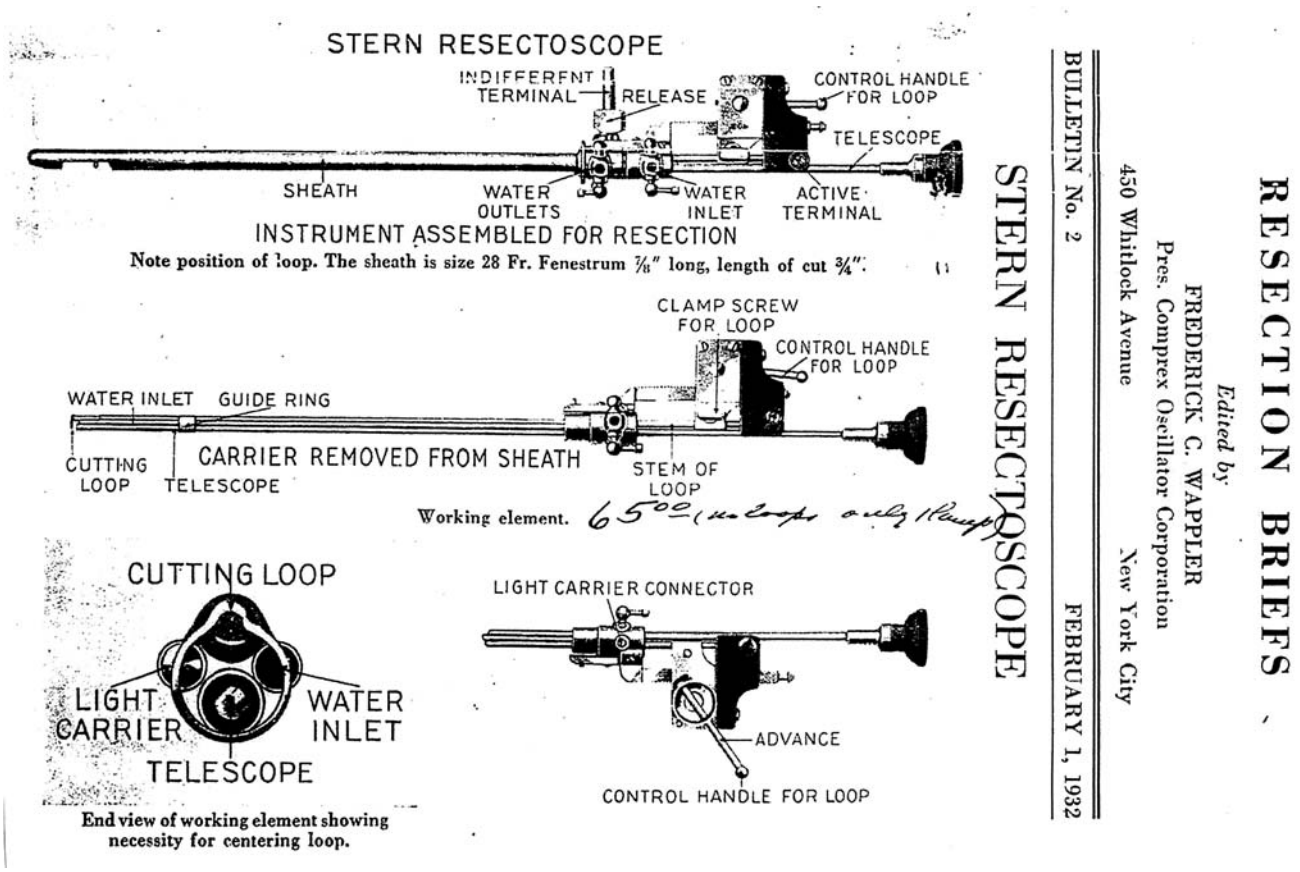

FIG. 3. First resectoscope, developed by Maximilian Stern, 1926.

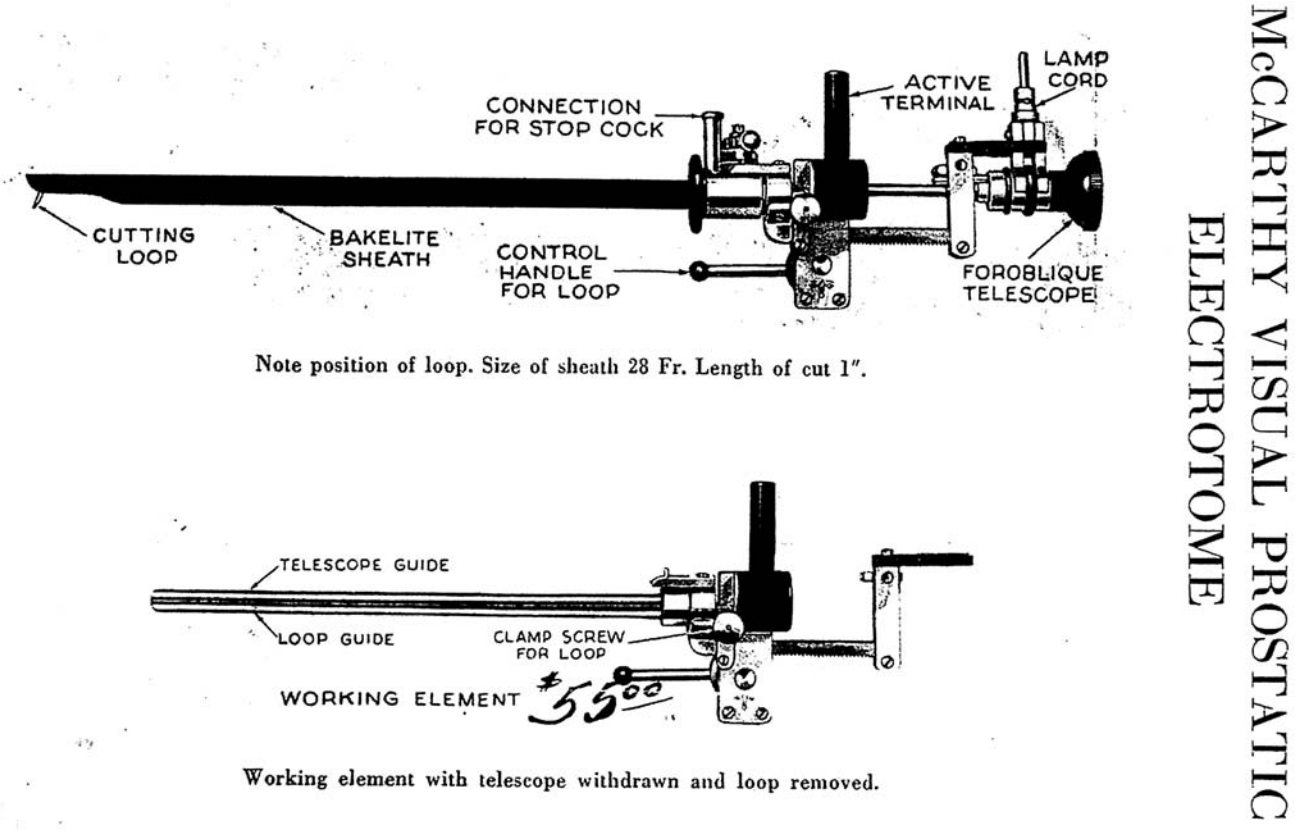

FIG. 4. Stern-McCarthy resectoscope, 1931.

The Stern-McCarthy resectoscope, as it became known (Fig. 4), was the first practical cutting-loop resectoscope, and it quickly replaced fulguration to become the dominant method used to diagnose and surgically treat bladder neoplasms for the rest of the 20th Century. Numerous modifications of the Stern-McCarthy resectoscope followed, but they were all based on the original design. And whereas transurethral resection of the prostate (TURP) has given way to newer methods, transurethral resection of bladder tumors (TURB) became (and remains today) a standard operation for these lesions. The reasons are obvious: tumors are better removed by resection than destroyed by fulguration alone, tissue is provided for accurate pathologic evaluation and staging, and the method can be repeated indefinitely to access the bladder to assess and to control recurrent tumors.

PAST, PRESENT, AND FUTURE

Successful management of localized cancers requires accurate diagnosis, reliable staging, and effective treatment. In the case of bladder tumors, transurethral resection using the resectoscope accomplishes all three. What other procedure in urology, or for that matter, in medicine in general, provides that?

Over the century and a quarter since endoscopy was first conceived in 1806 to the development of the first resectoscope in 1931, endoscopic surgery of bladder tumors advanced from an idea to practical reality. Only the most noteworthy innovations and individuals are mentioned here. Each built on the discoveries of the past to advance endoscopy to treat bladder tumors in their own time. Multiple individuals from diverse disciplines in science, medicine, engineering, and industry contributed to the early history of endoscopy, and that was only the beginning. Other innovations would follow, resulting in better instrument designs, focused light delivery, superior energy sources, videoendoscopy, and the like, all poised to take advantage of the unraveling molecular secrets of bladder cancers. But that is another remarkable story for another time. Suffice it to say none of it would have happened (nor would developments happen in the future) without the genius displayed by Grunfeld, Nitze, Beer, Stern, McCarthy, and many others in the 19th and early 20th Century, who transformed Bozzini's novel idea into successful endoscopic treatment of many urologic diseases. Arguably, bladder tumors are among the most significant of these, and patients suffering from bladder tumors are the ultimate beneficiaries of their discoveries.

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