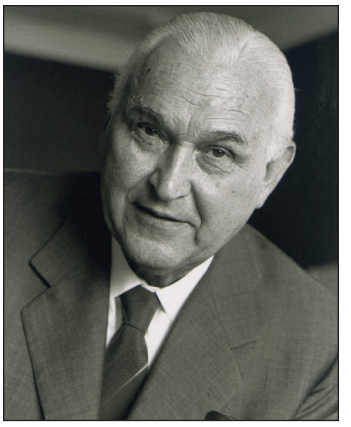
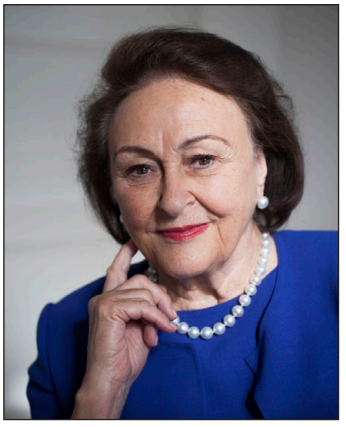
LEGENDS IN UROLOGY



Karl Storz, Doctor honoris causa (1911-1996)
Entrepreneur, inventor, and artisan
KARL STORZ Endoskope, Tuttlingen, Germany



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When Professor Demetrius Bagley (Philadelphia, USA) and Dr. Gabriel Haas asked me to write a contribution on my father Karl Storz, the company KARL STORZ Endoskope, and medical technology developments in urology, I felt very honored – on the one hand, because our company has been active in urology since the early 1960s and on the other, because I know how happy my father would have been about this request. However, his modesty and humility would never have allowed him to consider himself a "legend."

The summary below is primarily based on my personal memories of my father, whom I was privileged to learn from and work with from the late 1950s until his death in 1996. With his quality standards, inventive spirit, and straightforwardness, he strongly influenced me personally as well as the company, which is still family-owned and is now managed by my son Karl-Christian and myself. In addition to my memories as his daughter, I also had access to various quotes of my father from an interview he gave in April 1996, one month before his death.

In urology, like in many other medical specialties, medical progress goes hand-in-hand with technical advancements, and a medical pioneering spirit is combined with technical know-how and creativity to create better solutions for physicians and patients.

This direct communication between physicians and engineers was one of the important principles pursued by the entrepreneur and master instrument maker Dr. h. c. med. Karl Storz (1911-1996): after completing his schooling, he underwent an instrument maker apprenticeship at his father's company. But soon, he wanted to leave Tuttlingen and his parents' company. There may have been several reasons for that, including his desire to achieve something independently from his parents as well as the awareness that he could not fully comprehend the wide spectrum of medical technology at his parents' company alone. In 1928, he therefore left for Leipzig – an important German university center at the time – and worked as a medical instrument salesman at the well-established health care supply store Frenzel. In retrospect, he considered this time a particularly important one in his life because in many respects, it created the foundation for his later work. Contact with many manufacturers' medical devices, which he carefully analyzed, and perhaps more importantly, direct contact with physicians in his role as a salesperson not only expanded his understanding of the art of instrument making but also his awareness of the issued faced by physicians.

Shortly before the end of World War II, Karl Storz returned to his home town of Tuttlingen, and as early as 1945, he and his wife established their own company, producing and selling instruments for otorhinolaryngology. At the time, it was unusual for medical device manufacturers to maintain direct contact with medical users; instead, medical instruments were exclusively sold by manufacturers to dealers who in turn sold the products to physicians.

At his company, Karl Storz changed this distribution channel because receiving direct feedback from physicians was important to him to find out which tools physicians needed to perform their work. In 1996, Karl Storz retrospectively summarized this attitude as follows: *"However, anyone manufacturing products for the medical technology sector – and particularly in such a sensitive area as endoscopic surgery – should not be manufacturing for a dealer market, rather he should be going to the physicians in order to get to know their problems, to be present at operations and to learn where something is lacking and what can be even further improved. … Fulfilling customer demands was always the most important motto for me."*[1]

This close dialog between medicine and technology as well as the continuous effort to create ever better instruments that are superior to the previous generation in quality, functionality, and intuitive design characterized the entrepreneurial actions of Karl Storz. Karl Storz thought in terms of networks and across individual specialties. In this manner, he created solutions that decisively impacted and technologically advanced urology as well as endoscopy as a diagnostic and therapeutic procedure.

In 1945, Karl Storz started to produce and sell instruments, headlamps, and binocular loupes for ENT and thereby demonstrated not only his mechanical expertise but also his great interest in optics. Following this early specialization, Karl Storz already constructed his first endoscope for bronchoscopy in the early 1950s; it still featured a traditional lens system based on the optical principles published by Maximilian Nitze (1879). This step marked the beginning of endoscopy at the KARL STORZ Company. In the following decades, Karl Storz successfully created inventions that advanced the field of endoscopy as a whole, for instance through improved endoscopic light and image transmission as well as through new documentation options, particularly to support medical training.

As early as the 1950s, Karl Storz worked on improving light transmission into the body because he recognized the growing desire of physicians to document findings. He realized that a sufficient supply of light was essential to producing a meaningful diagnosis as well as to taking pictures and videotaping findings. At the time, most manufacturers used a distal light bulb that generated the desired brightness only if overloaded, which often meant that it became defective while it was still located inside the patient. Karl Storz already preferred another solution: he developed an electronic flash that was proximally coupled to the endoscope, with the emitted light then being guided through the endoscope via a quartz rod. This already represented the precursor of the next decisive development step: with the invention of the cold light source – a light source installed separately from the endoscope – Karl Storz created a completely new illumination concept and fully replaced illumination with distal light bulbs in 1960. Today, Karl Storz's idea to install a strong light source separately from the telescope and to guide the extracorporeally generated light via fiber glass bundles (light cable) to the telescope and then inside the body via glass fibers within the endoscope seems to be an obvious solution. At the time, however, this idea revolutionized endoscopic illumination – and endoscopic light transmission is based on this principle to this day.

The second essential invention, the HOPKINS rod lens system, is based on a 1959 patent owned by the English physicist Prof. Harald H. Hopkins and revolutionized endoscopic imaging. This system, which is used to this day, replaced the lens technology of the early 20th century, which had remained essentially unchanged since the invention of the Nitze telescope in 1879. Until Hopkins' invention, short lenses were typically used. The space between the lenses was empty, that is, filled with air. The Hopkins invention changed the relationship between glass and air and was based on the following optical and physical effect: air spaces were replaced by long lenses (so-called rod lenses) because glass is a better conductor of light than air is. As a result, much more light could be transmitted while maintaining the same outer diameter of the endoscope. Better light transmission generated revolutionary image quality with greater contrast, better resolution, improved color reproduction, and a larger field of view. At the time, the scientist Hopkins offered his invention to various medical technology companies, but they rejected his invention. Some of the manufacturers were convinced that their existing endoscopes were already good enough. Others rejected the invention because it did not originate in their preferred country. My father was the only one to recognize the value and potential of this invention, and he cooperated with Hopkins. Karl Storz built prototypes using these new rod lenses and used this opportunity to teach me important optical principles. Initially, I could not share his enthusiasm for the new prototypes because he was the only one to realize that the rod lenses were unparalleled in terms of improved edge sharpness and low distortion. Performing precise development work, Karl Storz refined the prototypes until telescopes with the new rod lens system could be marketed in 1965.

In the 1960s and 1970s, a time when the endoscopic image was visible only to the surgeon via the eyepiece rather than on a monitor, endoscopy was often called the one-eyed art or keyhole surgery. To eliminate this disadvantage, Karl Storz worked with R. Wittmoser to develop the so-called double viewing attachment (1975), which allowed additional physicians or assistants to observe the surgery. In another step, the observation equipment was advanced in such a way that the "split off" image could be used as a source of photo or video recordings. When using this equipment, however, the surgeon had to accept losses in quality since a light splitter divided the light yield between the eyepiece and the observation equipment.

In parallel, Karl Storz developed a KARL STORZ camera in 1976 since the camera manufacturers who would have been suitable for a potential cooperation were unwilling to make the necessary adaptations. Therefore, my father unceremoniously constructed his own camera that was connected with the eyepiece of the endoscope. Using associated electronic flash equipment, endoscopic photos could be generated.

The incipient spread of endoscopy to more applications and specialties was largely characterized by technical advances in documentation and camera technology. Until that time, the use of film cameras was technically complex, not very user friendly, and far from today's quality standards. At the time, the advantages and disadvantages of endoscopy were the subject of intensive discussion; on the one hand, the advantages of minimized trauma for patients were highlighted, but on the other, undesirable compromises were pointed out. These included the fact that the surgeon and the surgical team did not have a direct, shared view of the surgical field and had to perform surgery in ergonomically unfavorable positions.

In the late 1960s, the 8 mm and 16 mm film cameras Beaulieu R8 and R16 were some of those used in endoscopy, which at the time documented the images on rolls of celluloid film. In the 1970s, large film cameras were used like the ones we still know from use on TV. In 1983, Karl Storz marketed the first tube camera. The increasing miniaturization of the so-called CCD chips (charged couple device; image sensor) meant that Karl Storz was able to market the first 1-chip video camera as early as 1988; it was the first to permit ergonomic working conditions while supplying good image quality. This was followed by continuous improvements in the form of the 3-chip camera (1991), high definition cameras (2007), and the current endoscopic 3D camera systems (2011) as well as camera systems with additional visualization modes (2013) that allow homogeneous illumination, hue shifts, etc., to further improve the differentiation of tissue structures. This technological progress improved the ergonomics of performing surgery as well as observing in the OR and is therefore one of the most important prerequisites for the endoscopy training of physicians. At the same time, this sequence of developments represents an example of the general technological progress and the switch from analog to digital image signals.

In addition to these fundamental inventions in imaging, Karl Storz collaborated with leading urologists to develop many instruments and devices that have advanced urology to the current standard. In his contribution on the history of endourology (2004), M. A. Reuter correctly stated that the anatomy determines the further development of medical methods: *"The typical development process of new endoscopic methods was based on the anatomy: first inspection from the outside, then endoscopic viewing of the channel, and finally development of surgical methods."*[2] Following the anatomy and medical research, Karl Storz accompanied this progress since the 1960s. His product range expanded from instruments for cystoscopy to those for transurethral prostate treatment, products for the lithotripsy of urinary stones, the further development of endoscopy of the upper urinary tract and today's use of lasers, fluorescence imaging, and laparoscopic methods.

Equipped with much better light transmission thanks to the cold light source, Karl Storz could offer the first product range for urology with cysto-urethroscopes, resectoscopes as well as optical forceps (biopsy and grasping forceps) and stone forceps for the lithotripsy of small stones as early as 1963. In addition, the product range already included small-caliber instruments for pediatric use. Starting in 1965, the improved HOPKINS telescopes were used in urology.

The further advancement of the product range was achieved following the fundamental Karl Storz principle of engaging in active dialog with leading physicians. For decades, Karl Storz stayed in regular contact with urology departments in Germany, Switzerland, Austria, Italy, the United States, and Spain. I will mention some inventions below as representative examples.

In 1970, together with the urologist W. Lutzeyer (Aachen, Germany), Karl Storz developed the ultrasonic lithotripter, which for the first time allowed the endoscopic application of ultrasound waves for stone destruction in the bladder.

In collaboration with H. Sachse (Nuremberg, Germany), the optical urethrotome was developed in 1973 for the cold-cutting of urethral strictures.

In 1975, Karl Storz marketed the first continuous-flow resectoscope.

Together with the urologist W. Mauermayer (Munich, Germany), Karl Storz constructed the stone punch for lithotripsy under view in 1976, which is to this day a valid method for stones up to 2 cm in size.

By developing the AUTOCON Electrosurgical Unit (1977), Karl Storz in collaboration with G. Flachenecker and K. Fastenmeier (both from Munich, Germany) achieved a sustainable improvement of transurethral resection. This device offered automatic power regulation, which allowed for more precise cutting and coagulation using up to 50% less electricity and reduced the development of deep necroses due to the lower current intensity. At the time, our company did not have the necessary manufacturing know-how and resources to produce this invention initiated by Karl Storz; therefore, we looked for a partner to manufacture these units.

Starting in the 1980s, Karl Storz expanded the urology product range by products for the upper urinary tract. In 1980, he worked with E. Pérez-Castro Ellendt (Madrid, Spain) to develop the first rigid uretero-renoscope, which P. Alken describes as follows: *"The Spanish urologist wanted the impossible: a long, thin, rigid endoscope with which he could look through the bladder and ureter into the pelvicalyceal system and that offered all the options of a cystoscope. The instrument maker Karl Storz understood this physician's vision, and the uretero-renoscope was created. It opened the entire upper urinary tract to transurethral access, and with its advanced models, such as the Flex X^C [a 2010 development of KARL STORZ with M. Grasso (USA)] with a distal CMOS video chip, it is an integral part of today's urological armamentarium."*[3]

In 1981, R. Hohenfellner, P. Alken, and the radiologist R. Günther (all from Mainz, Germany) developed percutaneous nephrolitholapaxy (PCNL), a completely new procedure, which subsequently replaced most open surgical procedures on the ureter and kidney stones. *"Karl Storz travelled to Mainz to listen to physicians' thoughts about the advancement of this technique. With the telescopic bougie set described by the author [P. Alken] and instruments adapted to this set, which Karl Storz adopted from the ENT division of the company, the technique was advanced to become today's international standard. A procedure that formerly required several days to weeks with puncture and incremental bougienage could now be performed in one session without blood loss."*[4]

In 1986, the product range was expanded by the Calcusplit for the electrohydraulic lithotripsy of kidney and bladder stones. In 1988, the first KARL STORZ uretero-fiberscopes for minimally invasive use in the ureter were put on the market.

With a special light source and telescopes for photodynamic diagnostics (PDD), KARL STORZ created a new product line for the early detection of bladder cancer using optical fluorescence technology in 1995.

Even after the death of Karl Storz, the company continued to strive to create technical innovations and advances in urology: in 2005, a compact and space-saving unit was created with the desktop holmium laser Calculase. In the same year, instruments and devices for bipolar resection were introduced. In 2010, KARL STORZ presented the currently thinnest flexible uretero-renoscope with chip-on-the-tip technology. In 2014, a new generation of pressure-controlled PCNL systems was developed in collaboration with U. Nagele (Austria).

Throughout his life, Karl Storz preserved his inventor's creativity, his artisan's quality awareness, his sense for trends, and his intensive contact to medical opinion leaders. In more than 50 years of professional activity, Karl Storz had more than 400 patents granted. His work as an inventor and entrepreneur was recognized through numerous awards, among which two particularly stand out: the honorary doctorate degree by Marburg University Medical School (1985) as well as the SAGES "Pioneer in Endoscopy" award (1995).

The business legacy that Karl Storz leaves to us, the next generation, can be summarized by the following key points:

- For his entire life, Karl Storz preserved a joy and willingness to learn.
- He was equally inspired and motivated by constantly advancing the technical possibilities of endoscopy.
- Never being satisfied with previous accomplishments inspired his creativity and his effort to achieve progress.

In 1996, he summarized his entrepreneurial principles as follows:

"What we all need if we want to get ahead is modesty. By that I mean openness, which is synonymous with the ability to learn. Anyone who is no longer able to learn has long since passed his peak. …Thoughts frequently occur spontaneously, that is true, but the basic requirement of creativity is always having a real interest in a thing. If something is really part or your life and you are fascinated by it, everything else will follow automatically. One wants to improve objects, perfect them, their potential for application should become broader and more universal. They are like children for whom one does everything so that they can develop their ability. The mastery of one's subject is, of course, a prerequisite. Ideas do not come to one out of

the blue. They grow from carefully nurtured ground. …At no time during the phase of growth we did expand our production resources to the detriment of quality however. Rather we decided to turn away potential business. … I only stopped working on an item when I was totally convinced that the required quality was achieved, when I was able to say to myself that I would have no misgivings about allowing members of my family to be treated with this instrument."[5]

Until his death on May 23 1996, Karl Storz came to work every day, continued to develop products, and prepared the next generation to take responsibility for the company, customers, and his employees. Karl Storz was grateful for the mutual trust and respect that grew between him and many physicians in the course of over 50 years. Starting from a two-person operation, he created a successful company that employed 1700 people worldwide in 1996. On the basis of his principles, I have been managing the company since 1996 and have been able to develop it into a global endoscopy specialist with 7100 employees in more than 40 countries.

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