History of the Rigid Bronchoscope

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Introduction

O. Kollofrath, assistant to Gustav Killian at the Poliklinik of Freiburg University, Germany, wrote in his article titled: "Entfernung eines Knochenstücks aus dem rechten Bronchus auf natürlichem Wege und unter Anwendung der directen Laryngoskopie" (Münchener Medicinische Wochenschrift No. 38, September 1897), "On March 30th of this year I had the honor to assist my admired principal, Herrn Prof. Killian in extraction of a piece of bone from the right bronchus. This case is of such peculiarity with respect to its diagnostic and therapeutic importance that a more extensive description seems justified." In order to understand this statement one has to consider the state of the art of airway endoscopy at his time.

The Pre-endoscopic Era

Access to the airways in the living patient was tried by Hippocrates (460–370 BC), who advised the introduction of a pipe into the larynx in a suffocating patient. Avicenna of Buchara (about 1000 AD) used a silver pipe for the same purpose. Around 1542, Vesalius observed that the heartbeat and pulsation of the great vessels stopped when he opened the chest of an experimental animal, but it returned, again, after he introduced a reed into the airway and inflated the lungs by the use of bellows. This made him assume that the trachea was part of the circulating system. This is why he called it "the rough artery" ("τραχυσ" in Greek language or arteria aspera in Latin).

Desault (1744–1795) advised nasotracheal intubation for the treatment of suffocation and removal of foreign bodies. Still in his time, inhalation of a foreign body in over half of cases resulted in death or chronic illness due to purulent infection, abscess, fistulas, and malnutrition. Several instruments had been designed for blind removal from the airways via the larynx or a tracheotomy (called "bronchotomy"), which was also used for the treatment of subglottic stenosis in diphtheria. But until far into the second half of the nineteenth century tracheotomy had a high mortality of up to more than 50%. This is why methods were developed for blind intubation. But when Horace Green in 1846 presented his "Treatise on the Diseases of the Air Passages" to the Commission of the New York Academy of Medical Sciences, he was blamed for presenting "…a monstrous assumption, ludicrously absurd, and physically impossible,…an anatomical impossibility and unwarrantable innovation in practical medicine" and was removed from the society. It was Joseph O'Dwyer who persisted and introduced the method for emergency intubation of diphtheric children.

The Development of Endoscopy

Instruments for the inspection of body cavities such as mouth, nose, ear, vagina, rectum, urethra, and others had been in use for ages, and descriptions are found in Egyptian papyri, Greek, and Roman texts. Yet, Porter in 1838 still stated: "There is perhaps no kind of disease covered by greater darkness or posing more difficulties to the practitioner than those of the larynx and the trachea," because till then the larynx could be only insufficiently inspected by forceful depression of the tongue with a spatula, a so-called glossokatochon. Nobody had ever looked into the living trachea. It was only after three major inventions, direct inspection of the airways and visually controlled treatment became possible: (1) Dedicated instruments for inspection, (2) suitable light sources, and (3) efficient anesthesia.

The Laryngeal Mirror

Experiments for the inspection of the larynx by mirrors had been performed among others by Latour (1825), Senn (1829),

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Belloc (1837) Liston (1840), and Avery (1844). However, it was not a physician but a singing teacher in London, Manuel Garcia, who first observed his own larynx in 1854 with the help of a dental mirror that he had seen at the world exhibition in Paris and bought from the French instrument maker Charriére. Almost at the same time, without knowing his work, in 1856 the laryngologist Ludwig Türck in Vienna performed first experiments with a similar device. In winter when the illumination by daylight was no longer sufficient for continuation of his studies, he lent the device to the physiologist Czermak in Budapest, then part of the Austro-Hungarian Empire. Czermak published results in laryngeal inspection before Türck, which resulted in a long fight over rights of priority, the so-called Türkenkrieg (Turks war).

By the application of the laryngeal mirror, diagnosis and treatment of laryngeal diseases became much easier, so that G.D. Gibb in 1862 said: "It has fallen to my lot to see cases of laryngeal disease…that have existed for 10 or 20 years, and submitted to every variety of treatment, without the slightest benefit, at the hands of some of the foremost amongst us, wherein the symptoms have depended upon a little growth attached to one or both vocal chords, which was recognized in as many seconds as the complaints had existed years. The nature of the malady thus being made out, the plan of treatment to be persued became obvious." And it was also in 1862 that the German surgeon Victor von Bruns in Tübingen, with the help of this laryngoscopic mirror, could remove the first polyp from the vocal chord in his own brother. Without suitable anesthetics, the procedure needed weeks of preparation by stepwise suppression of the gagging and coughing reflexes on the patient's side, who had to repeatedly introduce a probe into the pharynx, while the physician rehearsed the procedure with a little knife by training on a severed head from a corpse that was hung on the wall. Later he rehearsed with blunt instruments on larynxes of volunteers. Also his report was rejected as "…a daring deed that should not be imitated and the practical importance of which seems less as there would be hardly another opportunity for its repetition." One of the major problems was the indirect and reverse view of the image, which added to the difficulties.

The First Endoscopes and Light Sources

In contrast to other fields of endoscopy, where daylight or candlelight could be introduced for inspection of the vagina, rectum, urethra, etc., it was only after Philipp Bozzini, general practitioner at Frankfurt, had developed his "illuminator" in 1805 that a suitable light source became available. The device consisted of a box with a candle inside, the light of which was reflected by a hollow mirror into a "conductor," a split metallic tube that could be spread by a simple mechanism. For the inspection of organs that could not be visualized by direct inspection, he used a tube with a mirror inside the tip of the tube, for reflection of the light and image.

The first really suitable successor after Bozzini's illuminator was the instrument of Desormeaux, who in 1853 also introduced the word "endoscope" for his instrument to inspect the body cavities. By applying Desormeaux's endoscope, A. Kußmaul in 1867/1868 performed the first inspection of the esophagus. The illumination by spirit, however, was insufficient for the inspection of the stomach. The first suitable gastroscope, constructed by Leiter in Vienna, was used in 1881 by von Mikulicz. It was a closed optic with lenses and prisms. Illumination was provided by an electric glowing platinum wire at the tip of the instrument which had to be cooled by a constant flow of water and thus was not suitable for application in the airways, because of its dimensions.

Esophagoscopy was performed mainly by the use of hollow tubes and spatulas that were connected to proximal illumination sources. It was also the Viennese Endoscope maker Leiter who in 1886 produced the first so-called panelectroscope, a tube that was connected to a handle that contained an electric bulb and a prism for illumination. The instrument was modified by many specialists, such as Gottstein, who was the first to attach a metal tube in 1891, by Rosenheim, who accidentally first passed into the trachea. Kirstein in Berlin intentionally started to intubate the larynx with the esophagoscope, and after his first experience in 1894 began systematic direct inspection, which he called "autoscopy" (Greek: "αυτοσ", by himself, meaning directly without help of a mirror). "…I convinced myself… that one can pass the vocal chords intentionally with a middle sized esophagoscope into the cocainized trachea and right down to the bifurcation; this experience should be eventually fructified." But "The region of the lower trachea is a very dangerous place!… The rhythmic protrusion of its wall is…a regular and awe inspiring phenomenon, which gives cause for utmost care in introducing rigid instruments," and he did not "fructify," i.e., expand his experiments. It was the rhino-laryngologist Gustav Killian of Freiburg University who on June 4, 1895, attended Kirstein's lecture in Heidelberg at the second Congress of the Southern German Laryngologists, who immediately recognized the importance of Kirstein's observation for the diagnosis and treatment of laryngo-tracheal diseases and began his experiments with the new method.

In 1877, the urologist Nitze in Dresden and the instrument maker Leiter in Vienna together had constructed the first lens optic in which electrical illumination was performed by the glowing platinum wire at the distal end. It had to be cooled by a constant flow of water, such as in von Mikulicz' first gastroscope, when not used inside the urinary bladder. In 1879, T.A. Edison invented the electric bulb, which was further miniaturized by Mignon; distal electric illumination could be applied to endoscopes for inspection of the airways.

The Development of Local Anesthesia

In his first report on the invention of direct bronchoscopy Killian said: "Whether one stops inspection with the rigid tube at the bifurcation or passes on for some distance into a major bronchus does not matter for the patient. If he is sufficiently cocainized he does not even realize it." Before the detection of cocaine, many attempts had been made to anesthesize the airways by the use of potassium-bromide, ammonia, belladonna, iodine solution, chloroform, morphine, and others. Nothing proved sufficient, and the patients had to be desensitized by weeks of rehearsing to touch the pharynx and the vocal chords by themselves before a procedure could be performed. The examiner had to be extremely skilled, and operations had to be performed within seconds before the view disappeared. Von Bruns advised training on an excised larynx and on a head that had been severed from a corpse and hung from a hook before training on a volunteer "…who certainly could be found rather easily for a little amount of money and would suffer such not really pleasant but not at all painful or dangerous experiments."

Although Morton in Boston had introduced general anesthesia by chloroform already in 1848, its use was so dangerous that it was only rarely applied in laryngoscopic operations. In 1882, a young scientist at the pharmacological institute of Vienna, Sigmund Freud, experimented with cocaine, a sample of which he had bought from Merck Co. He was eager to make a fortune by an important invention in science to impress and marry his fiancé. But to his later dismay his experiments in withdrawing morphinists from their addiction resulted in disaster. Although he had advised his colleague Koller, an eye specialist to use cocaine solution for pain relief when he suffered from severe conjunctivitis, he failed to recognize the importance of his observation himself that cocaine caused numbness when he put it to his tongue. Koller, however, immediately realized the immense potential of this observation and after feverishly experimenting with this new "miracle drug" on rabbits and patients inaugurated local anesthesia in his lecture on September 15, 1884, at the Annual Congress of German Ophthalmonologists in Heidelberg, Germany. At the same time the Viennese laryngologist Jellinek introduced cocaine as a local anesthetic for the inspection of the airways: "By eliminating the reflexes of the pharynx and the larynx it was possible to perform some of the operations in which even the most skillful artists in surgery had failed. The procedure completely changed. Virtuosity gave way to careful methodology, skill to exactness and the former almost endless preparation that so often tried the patience of the physician as well as of the patient could be almost completely abandoned." Thus the way was paved for Gustav Killian to pursue his experiments with bronchoscopy after he had attended Kirstein's lecture in Heidelberg.

Gustav Killian and the Invention of Bronchoscopy

Gustav Killian was born on June 2, 1860, at Mainz on the Rhine, Germany. After graduation from high school in 1878, he began to study medicine at the university of Strassburg where one of his teachers was Adolf Kussmaul. After 1880 he continued clinical education at Freiburg, Berlin, and Heidelberg where he passed his final examination in 1882. Afterward he started clinical work at the municipal hospital of Mannheim, Germany, close to Heidelberg and later in Berlin to get an education in ENT medicine by Hartmann and Fraenkel. As he could not find employment Killian settled down as a practitioner in Mannheim in 1887. Four months later, when his teacher in Freiburg, Germany, had died by an accident, he was offered to become the head of the section of rhino-laryngology at Freiburg, which was part of the large faculty of internal medicine, and he left Mannheim again. In Freiburg his scientific career started as a physician and pioneer began.

At the meeting of the Society of South German Laryngologists in Heidelberg in 1889, he gave a short report on a new technique for examination of the dorsal wall of the larynx. Killian learned about Kirstein's new technique at the meeting of the Society of South German Laryngologists in Heidelberg in 1895. Because of the experiences of Pieniazek at Krakau, who had introduced direct lower tracheoscopy via tracheostomy without any complications, Killian at once realized the potentials of this new method of direct inspection of the trachea and in 1896 began experimental work. In tracheotomized patients, he passed the bifurcation with the "bronchoscope," a somewhat modified esophagoscope of Rosenheim, and noticed that the bronchi were elastic and flexible and he was "stopped only when the diameter of the tube was surpassing that of the bronchi."

After he had confirmed his findings in frozen corpses without tracheotomies as well, he dared to perform the first direct endoscopy via the larynx in a volunteer. He noticed the flexibility of the trachea and how easy he could adjust it to the angle of the main bronchi and introduce the endoscope down to the lobar level. "I think I have made an important discovery" he noted afterward. Bronchoscopy was born. In 1897, he removed the first foreign body via the translaryngeal route, which his pupil Kollofrath reported in his paper.

After further experience and removal of two more foreign bodies, Killian felt safe to present his new method of "direct bronchoscopy" at the sixth meeting of the Society of South German Laryngologists at Heidelberg on May 29, 1898, and in the same year his first publication on direct bronchoscopy was published (Münchener Medicnische Wochenschrift No.27, July 5, 1898). The following years at Freiburg were full of technical improvements of the new method and with

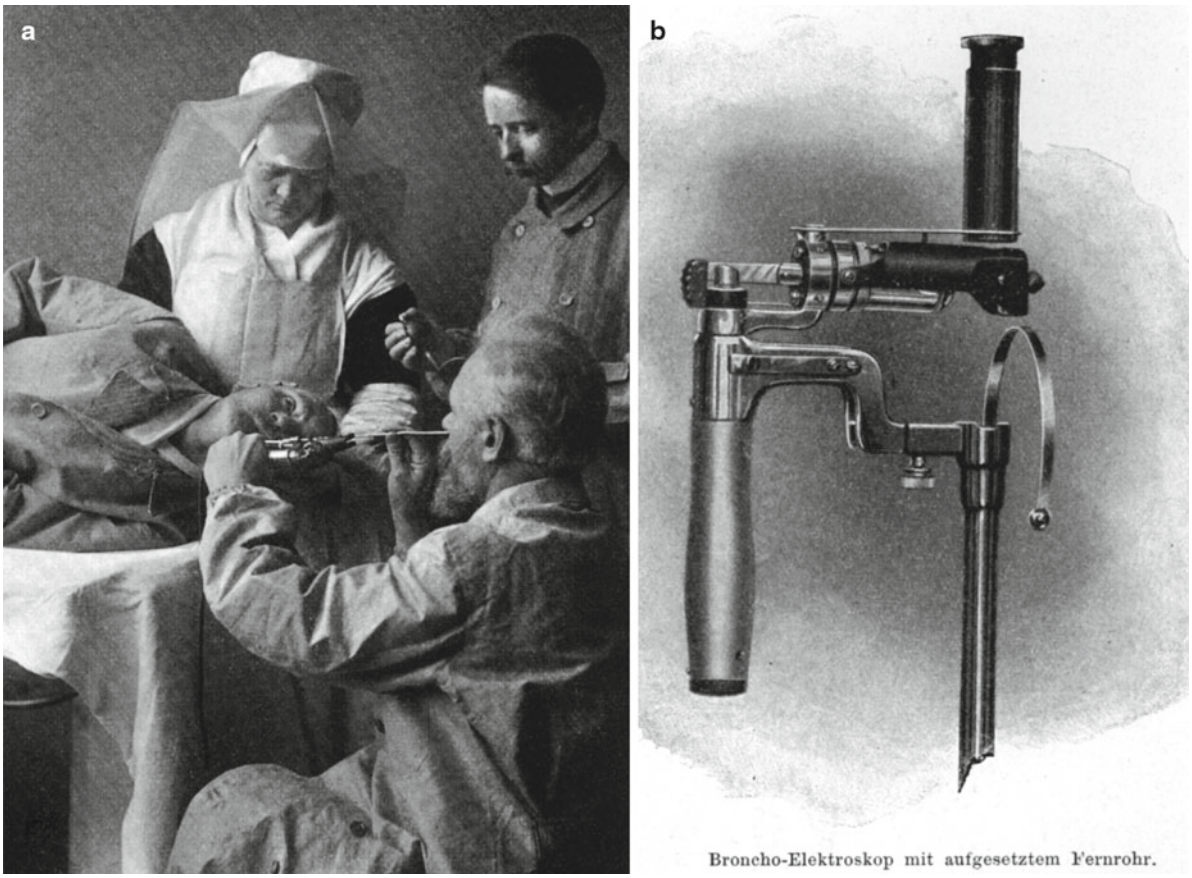

Fig. 1.1 Gustav Killian performing bronchoscopy. He is holding the bronchoscope with his left hand, while guiding a suction catheter with the right hand. His coworker is pumping the balloon for suctioning secretions, while the nurse is attending the patient, who is lying on his left side and has to tolerate the procedure under local anesthesia. (**a**) On the *right* is an illustration of the bronchoscope, modified by Killian's coworker Brünings. On the proximal end of the bronchoscope is a spring with a serrated edge, to which another tube could be attached and forwarded as far as necessary. Attached to the handle is Hacker's electroscope for illumination and onto that a telescope is mounted for enlarging the image (**b**)

the quest for more and more indications of its application (Fig. 1.1). He published 34 papers concerning discovery, technique, and clinical application of his invention. In 1900, he received the award of the Wiener Klinische Wochenschrift for his paper on "Bronchoscopy and its Application in Foreign Bodies of the Lung." Due to his publications and many lectures he was very famous, and Freiburg became the "Mekka" of bronchoscopy. Hundreds of physicians came from all over the world (the list of participants notes 437 foreign guests from all continents, more than 120 from the United States) and up to 20 training courses had to be held every year. He was invited as a very popular speaker all over Europe, and patients were sent to him from as far as South America for the removal of foreign bodies.

In order to fully understand the importance of endoscopic removal of foreign bodies, one has to consider the state of thoracic surgery at Killian's time. Most of the patients fell chronically ill after the aspiration of a foreign body, suffering from atelectasis, chronic pneumonia, and hemorrhage from which half of them died if left untreated. Surgical procedures were restricted to "pneumotomy" when the bronchus was occluded by extensive solid scar tissue, and the foreign body could not be reached by the bronchoscope, which had a very high mortality rate. Lobectomy or pneumonectomy could not be performed before Brunn and Lilienthal developed the surgical techniques after 1910, and Nissen, Cameron Haight, and Graham introduced pneumonectomy after 1930, because techniques of safe closure of the bronchial stump were missing.

Thus for those who were confronted with these patients it must have seemed like a miracle that already briefly after the introduction of bronchoscopy almost all patients could be cured. According to statistical analysis by Killian's coworker Albrecht, of 703 patients with aspiration of foreign bodies during the years 1911–1921, in all but 12 the foreign body could be removed bronchoscopically, although many had remained inside the airways for a considerable time, a success rate of 98.3%. In light of these results Killian's triumphant remarks become understandable when he writes: " One has to be witness, when a patient who feels himself

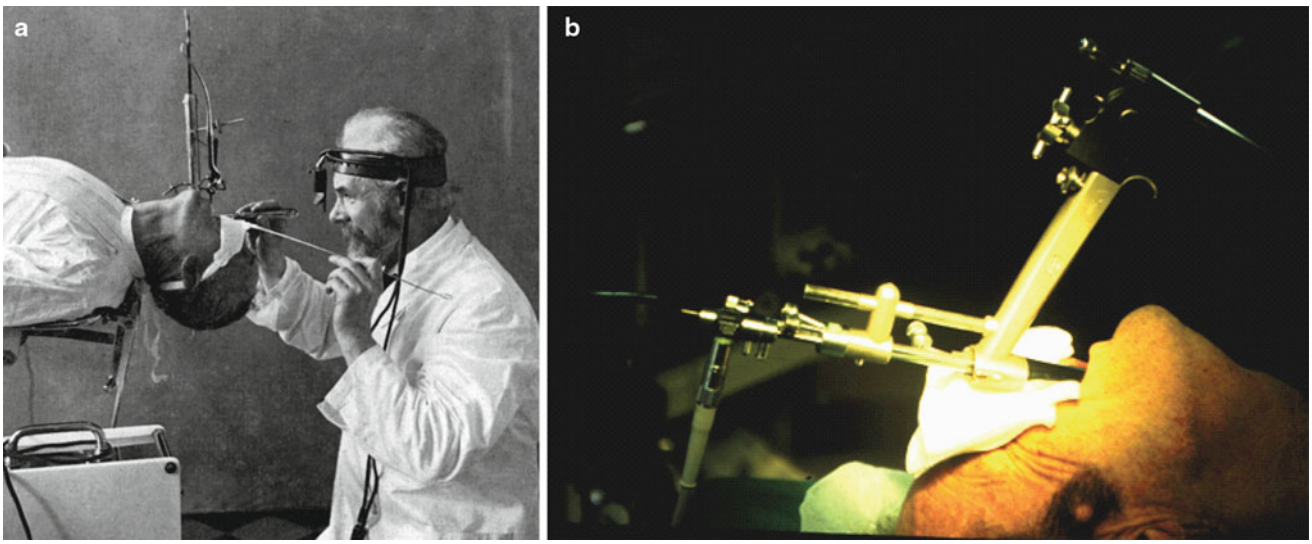

Fig. 1.2 Gustav Killian demonstrating suspension laryngo-bronchoscopy. The patient's head is suspended on a spatula that is fixed to a metal arm at the table. Illumination is provided by an electric head light, connected to the light source in the foreground by cable. Both hands are free for instrumentation. (**a**) Kleinsasser's support laryngoscope is a modern successor that is widely used by today's ENT surgeons. It rests on the chest of the patient or on a table. Microscopic telescopes and instruments for manipulation can be fixed directly to the device for delicate surgery on the vocal chords (**b**)

doomed to death can be saved by the simple procedure of introducing a tube with the help of a little cocaine. One must have had the experience of seeing a child that at 4 pm aspirated a little stone, and that, after the stone has been bronchoscopically removed at 6 pm, may happily return home at 8 pm after anesthesia has faded away. Even if bronchoscopy was ten times more difficult as it really is, we would have to perform it just for having these results."

Besides numerous instruments for foreign body extraction other devices, such as a dilator and even the first endobronchial stent, were constructed. Although further development of bronchoscopy was Killian's main interest, in the years at Freiburg he promoted treatment in other fields too. He developed a method for submucosal resection of the septum of the nose and a new technique for radical surgery of chronic empyemata of the sinuses with resection of the orbital roof and cover by an osseous flap. Around 1906, he began intensive studies of the anatomy and the function of the esophageal orifice and found the lower part of the m. cricopharyngeus to be the anatomical substrate of the upper esophageal sphincter. According to his observations it was between this lower horizontal part and the oblique upper part of the muscle that Zenkers pulsion diverticulum developed, where the muscular layer was thinnest. One of his scholars, Seiffert, later developed a method of endoscopic dissection of the membrane formed by the posterior wall of the diverticulum and the anterior wall of the esophagus.

In 1907, he received an invitation by the American Oto-Rhino-Laryngological Society to visit the United States, and it was on his triumphant journey through the United States on July 3, 1907, he gave a lecture on his findings at the meeting of the German Medical Society of New York, which was also published in *Laryngoscope* in the same year. Lectures were followed by practical demonstrations of his bronchoscopic and surgical techniques and by banquets at night. On his journey he also visited Washington, where he had a brief encounter with President Theodore Roosevelt. At Pittsburgh he met Chevalier Jackson, then already the outstanding pioneer of esophago-broncholgy at the University of Pennsylvania. Killian was awarded the first honorary membership of the Society of American Oto-Rhino-Laryngology and also became honorary member of the American Medical Association and received a medal in commemoration of his visit.

As Killian was the most famous laryngologist of Germany, when Fraenkel in Berlin retired in 1911 he became successor to the most important chair of rhino-laryngology. Although bronchoscopy seemed to have reached its peak, he felt that visualization of the larynx was unsatisfactory. When using Kirstein's spatula for drawing illustrations of pathological findings in corpses, once accidentally the head of a body slipped off the table. This was when Killian realized that inspection of the larynx in a hanging position of the head was much easier. He had a special laryngoscope constructed that could be fixed to a supporting construction by a hook, a technique he called "suspension-laryngoscopy," by which he could use both hands for manipulation (Fig. 1.2). His pupil Seiffert improved the method by using a chest rest, a technique that later was brought to its perfection by Kleinsasser and is still used for endolaryngeal microsurgery.

In 1911, Killian had been nominated Professor at the Kaiser-Wilhelm-Military-Academy of Medicine and as during World War I he had to treat many laryngeal injuries he visited the front line in France where he also met his two sons who were doing their military service. After his return he founded a center for the treatment of injuries of the larynx and the trachea. During this era he was very much concerned with plastic reconstruction of these organs, especially as he could refer to the work of Dieffenbach and Lexer, two of the most outstanding plastic surgeons at their times who had also worked at Berlin. The article on the injuries of the larynx should be his last scientific work before he died of gastric cancer in 1921.

During his last years, Killian prepared several publications on the history of laryngo-tracheo-bronchoscopy. For teaching purposes, already in 1893, he began illustrating his lectures by direct epidiascopic projection of the endoscopic image above the patient's head. Phantoms of the nose, the larynx, and the tracheobronchial tree were constructed according to his suggestions. According to his always cheerful mood he was called the "semper ridens" (always smiling), and in his later years, his head being framed by a tuft of white hair, his nick name was "Santa Claus." He created a school of laryngologists, and his pupils dominated the field of German laryngology and bronchology for years. Albrecht and Brünings published their textbook of direct endoscopy of the airways and esophagus in 1915. Like von Eicken at Erlangen and Berlin and Seiffert at Heidelberg they had become heads of the most important chairs of oto-rhino-laryngology in Germany. It was to his merit that the separate disciplines of rhino-laryngology and otology were combined. When Killian died on February 24, 1921, his ideas had spread around the world. Everywhere skilled endoscopists developed new techniques, and bronchoscopy became a standard procedure in diagnosis and treatment of the airways. His work was the basis for the new discipline of anesthesiology as well, providing the idea and instruments (laryngoscope by Macintosh) for the access to the airways, endotracheal intubation, and anesthesia.

Throughout all his professional life Gustav Killian kept on improving and inventing new instruments and looking for new applications. He applied fluoroscopy, which had been detected by K. Roentgen in Würzburg in 1895, for probing peripheral lesions and foreign bodies. To establish the X-ray anatomy of the segmental bronchi he introduced bismuth powder. He drained pulmonary abscesses and instilled drugs for clearance via the bronchial route and he even used the bronchoscope for "pleuroscopy" (thoracoscopy) and transthoracic "pneumoscopy," when abscesses had drained externally. Foreign bodies that had been in place for a long time and had been imbedded by extensive granulations were successfully extracted after treatment of the stenosis by a metallic dilator and in case of restenosis metallic or rubber tubes were introduced as stents. Although cancer was comparatively rare (31 primary and 135 secondary cancers disease in 11,000 postmortems), he pointed out the importance of pre- and postoperative bronchoscopy. Already in 1914, he described endoluminal radiotherapy in cancer of the larynx by mesothorium, and in the textbook of his coworkers Albrecht und Brünings published in 1915, we find the first description of successful curation of a tracheal carcinoma after endoluminal brachy-radiotherapy. Taking special interest in teaching his students and assistants to maintain high standards in quality management by constantly analyzing the results of their work and always keeping in mind that he himself was standing on the shoulders of excellent pioneers, he kept up the tradition of the most excellent in his profession like Billroth of Vienna. In his inaugural lecture in Berlin on November 2, 1911, he pointed out that it was internal medicine from which the art of medicine had spread to the other faculties and that patience and empathy should be the main features of a physician, but on the other hand to persist in following your dreams because "to live means to be a fighter". He ignited the flame of enthusiasm in hundreds of his contemporaries who spread the technique to other specialties thus founding the roots for contemporary interventional procedures like microsurgery of the larynx (Kleinsasser) and intubation anesthesia (Macintosh, Melzer, and Kuhn).

Rigid Bronchoscopy in the Twentieth Century

Main Schools

Due to the enthusiastic activities of Killian and his assistants in teaching and spreading the new technique, hundreds of specialists all over the world were educated in performing bronchoscopy, and many improvements were added to the instrument. Thus, by 1910, Killian had collected 1,116 papers – 410 on esophagoscopy, 34 on gastroscopy, and 672 on laryngo-tracheobronchoscopy – for his paper on the history of bronchoscopy and esophagoscopy. Back then it was almost impossible to follow all traits in every continent where soon after the introduction by pioneers separate schools developed.

Killian's coworkers von Eicken, Albrecht, Brünings, Seiffert, and others for decades held the chairs of all important departments in Germany. They improved Killian's instruments and introduced new methods such as endoscopic treatment of Zenker's diverticulum by Seiffert, who also developed the chest rest for laryngoscopy (1922), which was perfected by Kleinsasser to the current device for microlaryngoscopy (1964). Unfortunately after World War II the development took separate ways until recently. In Western Germany Huzly in Stuttgart was the most prominent

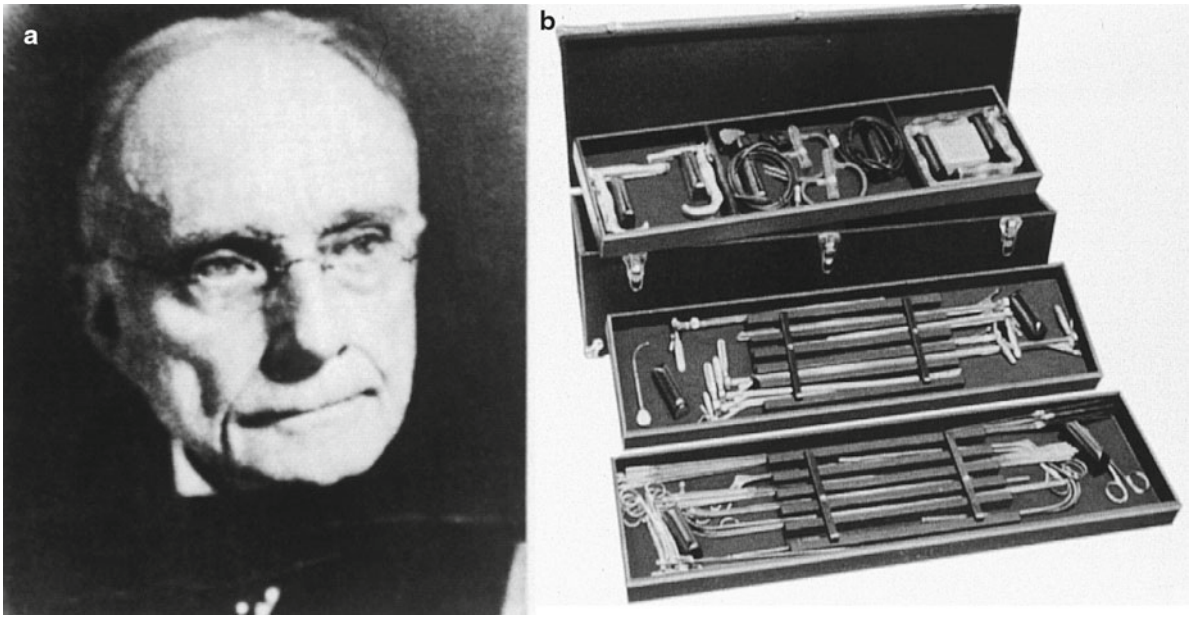

Fig. 1.3 Chevalier Jackson, the pioneer of rigid bronchoscopy in the United States (**a**) with a case of bronchoscopes and accessories in a carrying case, made by the instrument makers Pillings and Sons Co. (**b**)

proponent of rigid bronchoscopy who in 1961 edited his photographic atlas of bronchoscopy. Riecker introduced relaxation by curare in 1952, which was replaced by succinylcholine by Mündnich and Hoflehner in 1953. Maassen introduced bronchography via double lumen catheter in 1956. Two companies, Storz and Wolf, became the most important instrument makers in Germany and introduced new technologies such as the Hopkins telescope and television cameras. In the late twentieth century, Dierkesmann, Freitag, Häußinger, Macha, and Becker in Germany were the proponents of rigid bronchoscopy for the development and performance of interventional procedures such as laser treatment, stenting, and photodynamic laser therapy. In East Germany, Friedel developed the first ventilation bronchoscope (1956) which was modified by Brandt (1963), who edited an extensive textbook on endoscopy of the air and food passages in 1985, in which he reported on more than 100 successful treatments by endobronchial stenting which he already began in the early 1970s. In the same year as E. Schiepatti of Buenos Aires wrote about transtracheal puncture (TBNA) of the carinal lymph nodes, Euler reported on pulmonary and aortic angiography by transbronchial puncture in 1948/1949 and later on the technique of rigid TBNA for mediastinal masses in 1955 which was further perfected by Schießle in 1962. Cavaliere in Italy, Diaz-Jimaneez in Spain, and Dumon in France became the forerunners in Nd-YAG laser treatment via the rigid bronchoscope, and Dumon developed the first widely applied stent with a special application device. Also he invented a dedicated therapeutic rigid bronchoscope.

In the United States, when A. Coolidge on May 11, 1898, performed the first lower tracheo-bronchoscopy at the Mass. General Hospital, it was Chevalier Jackson in Philadelphia, whom Killian had met on his visit to the United States in 1907, who together with his instrument maker Pillings made many improvements in instruments for bronchoscopy and esophagoscopy and became the "father of American bronchoesophagology." During his training to become laryngologist he had visited London in 1886 where he was shown the "impractical device designed by Morel Mackenzie in an effort visually to inspect the esophagus". In 1890, he constructed the first endoscope "worthy of the name" for esophagoscopy and in 1904 he constructed the first American bronchoscope. After Einhorn in New York had added an integrated light conductor and Fletcher Ingals of Chicago had introduced distal illumination to the esophagoscope, Jackson equipped his bronchoscope with a light carrier with a miniaturized electric Mignon bulb at the distal end and with an additional suction channel. Confronted by many patients suffering from aspiration of foreign bodies he invented many instruments for its removal. In 1907, he published the first systematic textbook on bronchoesophagology which he dedicated to Gustav Killian, the "father of bronchoscopy" (Fig. 1.3). In this book he already addressed modern issues

of quality management such as analysis and prevention of complications and rational construction of bronchoscopy suites and arrangement of equipment and staff. Being a thorough philanthropist he constantly refused to have his inventions patented as he wanted them to be spread as widely as possible, and by his persistence in negotiating with the government, he promoted a law for the prevention of accidents by ingestion of caustic agents. He was a perfectionist in techniques and totally convinced that teaching had to be performed on animals before treating patients. Therefore he always refused to go back to England where animal rights activists prevented such training courses. In 1928, in recognition of his "conspicuous achievements in the broad field of surgical science," he was awarded the Bigelow Medal by the Boston Surgical Society which was presented to him by H. Cushing "for his eminent performances and creative power by which he opened new fields of endeavor" and in acknowledgement of his "indefinable greatness of personality." He simultaneously held five chairs of laryngology at different hospitals in his hometown Pittsburgh and Philadelphia. His son Ch. L. Jackson also became laryngologist and was his successor at the Temple University of Philadelphia. He became the founder of the Pan American Association of Oto-Rhino-Laryngology and Bronchology and of the International Bronchoesophagological Society and Co-founder of the World Medical Association. Together with his father he edited the last issue of the textbook.

Their school extends well into our time as many of today's specialists' teachers were trained by the Jacksons, such as E. Broyles in Baltimore, who after additional training by Haslinger in Vienna introduced the telescope optic for bronchoscopy in 1940, the optical forceps in 1948, and fiber illumination for the rigid bronchoscope in 1962. His scholar G. Tucker became professor at Jefferson in Philadelphia where he trained B. Marsh who kept the tradition into our days together with Ch. M. Norris. P. Hollinger and Brubaker who became specialists in pediatric bronchoscopy and introduced color photography in the 1940s. Hollinger's son became a famous pediatric laryngologist. Andersen at Mayo Clinic was the first to perform bronchoscopic transbronchial lung biopsy via the rigid bronchoscope in 1965. Sanders in 1967 introduced jet-ventilation for rigid bronchoscopy.

After staying with Killian in Freiburg Inokichi Kubo of Kyushu University in Fukuoka first introduced bronchoscopy to *Japan* in 1907. He was joined by S. Chiba who after training with Brünings stayed in Tokyo from 1910. Joe Ono who was trained by Jackson in 1934 founded the Japan Bronchoesophagological Society in 1949. Shigeto Ikeda who later developed the flexible fiberscope introduced glass fiber illumination for the rigid bronchoscope in 1962. When Ikeda, who found rigid bronchoscopy under local anesthesia in the sitting position on "Killian's chair" cumbersome, introduced the flexible bronchoscope he still used it in combination with a flexible tube that could be straightened by a locking mechanism so that he was still able to introduce the rigid optic in the same session. In the era of expanding interventional procedures, this method of combining both the rigid and the flexible endoscope regained new attention and became widely spread.

Technical Developments

Illumination

After the advent of the electrical bulb, illumination became sufficient for the illumination of the airways. At first the lamps were installed separately on statives or fixed to a head rest from where the light was reflected into the endoscope. Connection of the light source to the endoscope improved handling considerably. Thus Killian and his coworkers preferred to use Casper's panelectroscope in which the light bulb was integrated into the handle from where it was reflected by a prism to the endoscope because it was not so easily soiled by secretions. Jackson, however, used distal illumination via a light guide with a Mignon bulb at its tip. Already in the late 1880s von Schrötter in Vienna developed a rigid light guide made of Plexiglass which was improved by the introduction of quartz by K. Storz. After Tyndall's first description of the optical properties of glass fibers in 1872, patents for glass fibers as transport medium were almost simultaneously given to Baird in England (1926), Hansell in the USA (1927), and Marconi in England (1930). The first prototype of a fiberscope was presented by Lamm in Munich (1930). After Hansen in Denmark described the first fiber bundles for light transportation in 1930, Van Heel in the Netherlands and O'Brian in the USA developed the first endoscopes for bronchoscopy and gastroscopy in 1953 and 1954. The rod lens and fiberoptic lighting device by Hopkins in London were adopted by K. Storz as cold light illumination source for his rigid endoscopes in 1963. The transition to fully flexible endoscopes with image transport by glass fibers was performed by Hirschowitz and ACMI in 1958 after Curtiss of Ann Arbor had described the first medical fiber instrument in 1955.

Photo-, Film- and Videodocumentation

The first (even stereoscopic) endophotographies were performed by Czermak by the use of a giant laryngeal mirror. Stein in Frankfurt used magnesia illumination for his photographic apparatus, the "heliopictor" ca. 1875, technically the predecessor of the Polaroid-Land camera of 100 years later. Stein's camera was improved by Nitze and Kollmann.

In 1907 Benda introduced color photography which was first introduced by P. Hollinger to bronchoscopy in 1941. Soulas (1949) and Hollinger (1956) also introduced endoscopic film documentation. The first television transmission of a bronchoscopy was performed by Dubois de Monternaud in 1955. Wittmoser constructed an angulated optic for the improvement of image transfer and produced the first video documentation in 1969.

Prospect

With the advent of the flexible bronchoscope after 1966, two developments took place: bronchoscopy rapidly spread beyond oto-rhino-laryngological and specialized thoracic clinics, and the overall number of rigid bronchoscopies declined rapidly until the late 1980s and early 1990s because bronchoscopy had become much easier. But then again, the increasing number of interventional techniques demanded use of the rigid bronchoscope for safety reasons (Fig. 1.4). Special rigid devices were developed by J.F. Dumon for the application of the Nd-YAG-laser and placement of his "dedicated stent" (Fig. 1.5) and by L. Freitag for his "dynamic stent." Consensus task forces of the Scientific Section of Endoscopy of German Society for Pulmonology, of the ERS/ATS, and of American College of Chest Physicians agreed that for many interventional procedures the bronchoscopist and staff should at least be trained in the technique of rigid bronchoscopy and should have the instrument at hand in case of an emergency. Thus, in training courses all over the world handling of the rigid instrument is taught again and future developments are on the horizon (Fig. 1.6).

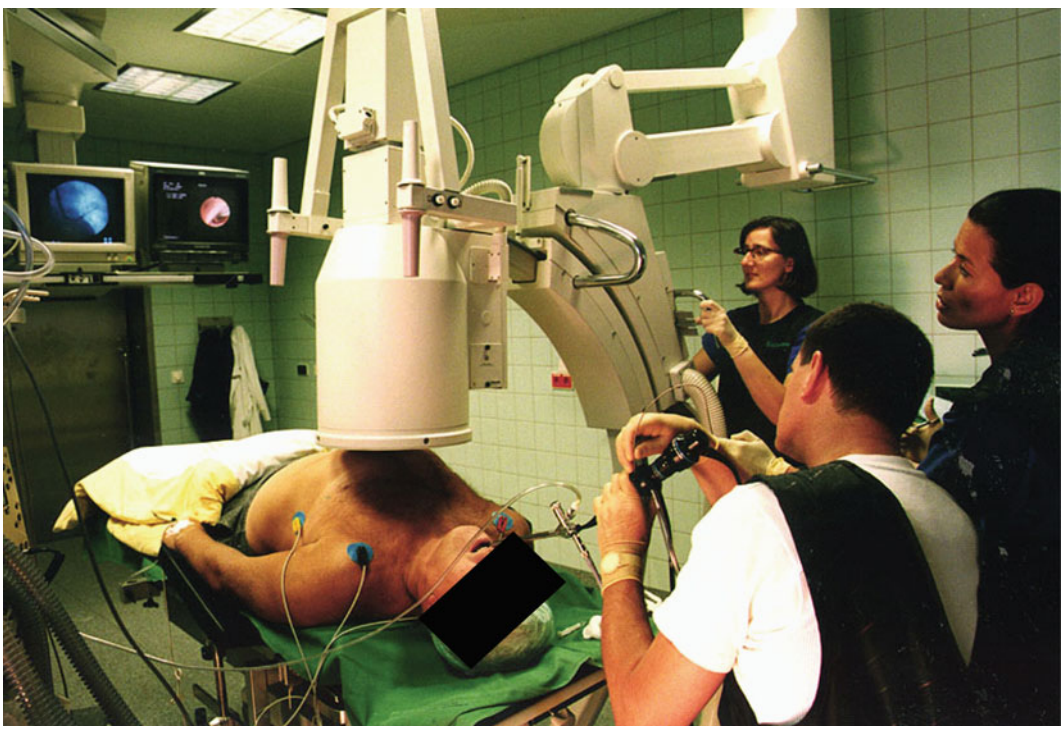

Fig. 1.4 Modern bronchoscopy suite. The bronchoscopist inserts the flexible scope via the rigid bronchoscope for easy manipulation of the biopsy forceps inside the periphery of the airways. Visual control by two monitors, on which the endoscopic and fluoroscopic images can be followed by all the staff for guiding the C-arm and handling of the forceps. At the proximal end of the rigid bronchoscope the jet catheter for ventilation and the glass fiber light cable are attached. The patient is monitored by ECG, pulse oximetry, and automatic blood pressure control

Fig. 1.5 J.F. Dumon (standing on the *left side*, besides the author) (**a**) and his dedicated bronchoscope for intervention (Efer-Dumon). At the entrance port it has three channels for suction and instrumentation and side ports for jet- or conventional ventilation. At the distal end in front end of the telescope optic are two bendable channels for insertion of laser or APC probes and suction (**b**)

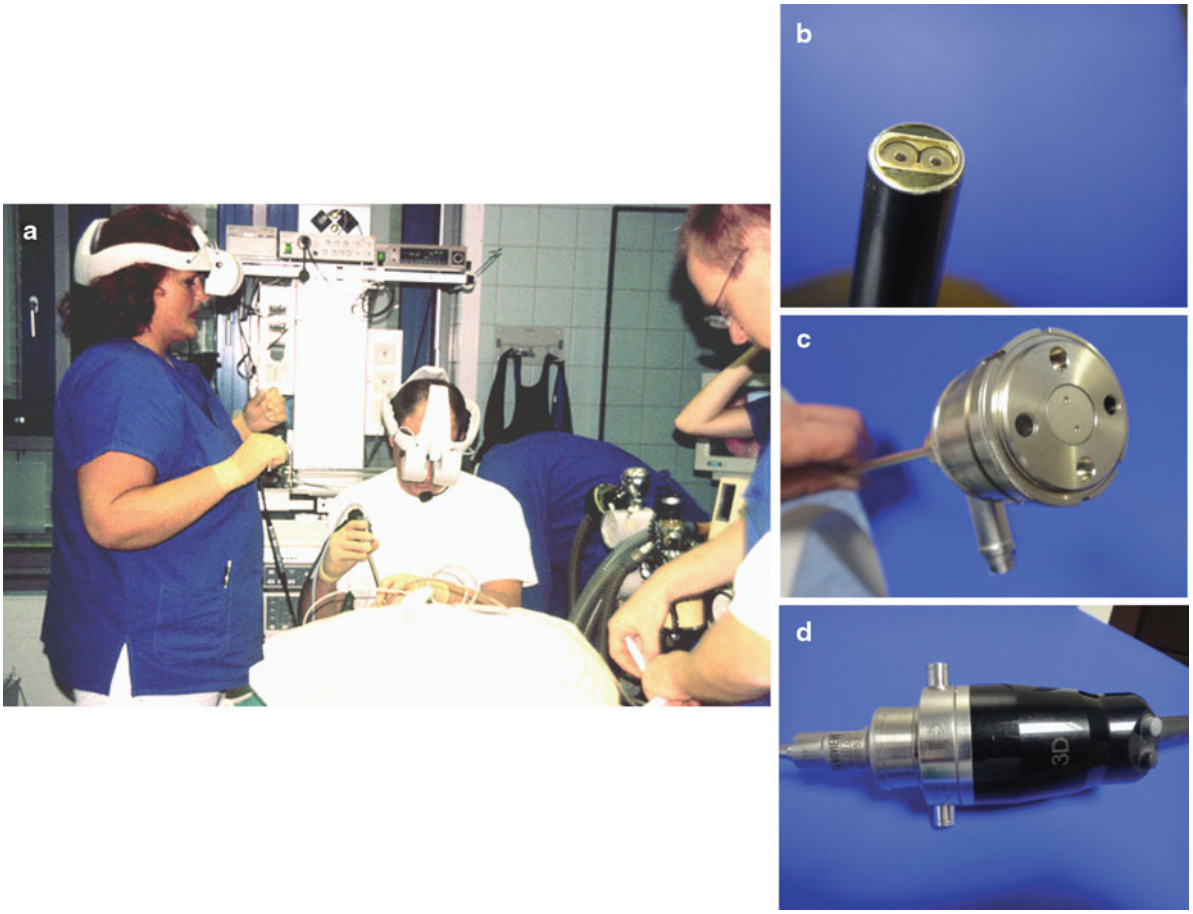

Fig. 1.6 Prototype of a 3D rigid bronchoscope (Panoview, Wolf Co, Knittlingen, Germany). (**a**) The images of two separate lens systems in the telescope optic (**b**) are picked up by a camera head with two chips at the proximal end of the optic. (**c**, **d**) Via a processor they are transferred to head mounted devices (HMD) that have separate monitors for each eye, giving a 3D image of the airways. Each participant in the procedure has to wear a device in order to see the endoscopic image that cannot be displayed on external monitors

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