# Surgery for Gastric Cancer

Sung Hoon Noh
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*Editors*

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*Editors*
Sung Hoon Noh
Department of Surgery
Yonsei University College of Medicine
Seoul
South Korea

Woo Jin Hyung
Department of Surgery
Yonsei University College of Medicine
Seoul
South Korea

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# Contents

# Part I

# History of Gastric Cancer Surgery

# History of Gastric Cancer Surgery

1

Keiichi Maruyama

We have many dramatic and exciting stories in the history of surgery [1–4]. I would like to recommend my colleagues to read such interesting books, for example, *Das Jahrhundert der Chirurgen* (*The Century of the Surgeon* (English edition)) [5] and *Das Weltreich der Chirurgen* (*The Triumph of Surgery* (English edition)) [6] written by Jurgen Thorwald.

## Progress of Supportive Background for Gastric Cancer Surgery

Progress of the following supportive technologies was essential in the development of gastric cancer surgery.

### Anesthesia

The dawn of surgery was broken by development of anesthesia [7, 8]. By the late 1830s, it was widely known that nitrous oxide and ether produced drunken condition, and they were used for amusement such as "ether frolics." An American dentist in Boston Horace Wells (1815–1848) (Fig. 1.1a) used nitrous oxide for a painless dental extraction in 1845 [9]. His business partner and fellow dentist William T. G Morton (1819–1868) (Fig. 1.1b, e) used dimethyl ether also for dental extractions. He expanded the use for general surgery. He demonstrated his method for neck tumor resection to the prominent surgeon John Collins Warren at the Massachusetts General Hospital on the 16th of October 1846 (Fig. 1.1e) [10]. The next year, a Scottish obstetrician James Young Simpson (1811–1870) (Fig. 1.1e) of Edinburgh used chloroform for general anesthesia [11]. Chloroform anesthesia was rapidly popularized after the application for Queen Victoria's labor in 1853. These developments released patients from terrible pain and fear during surgery.

### Aseptic Method

A Hungarian obstetrician Ignaz Fulop Semmelweis (1818–1865) (Fig. 1.1d) noticed that a clean condition reduced maternal death. He reported in 1847 that the death rate went dramatically down by handwashing and rinsing of medical instruments and linens with chlorinated lime solution at the Vienna General Hospital [12]. Semmelweis's work was furthered by a Scottish surgeon Joseph Lister (1827–1912) (Fig. 1.2a). He used phenol (carbolic acid) to clean surgical gauze at the Glasgow Royal

K. Maruyama (✉)
Department of Surgical Oncology,
University of Health and Welfare Sanno Medical Center,
Tokyo, Japan

Department of Surgical Oncology, National Cancer Center Hospital, Tokyo, Japan
e-mail: keiichi-maruyama@rOl.itscom.net


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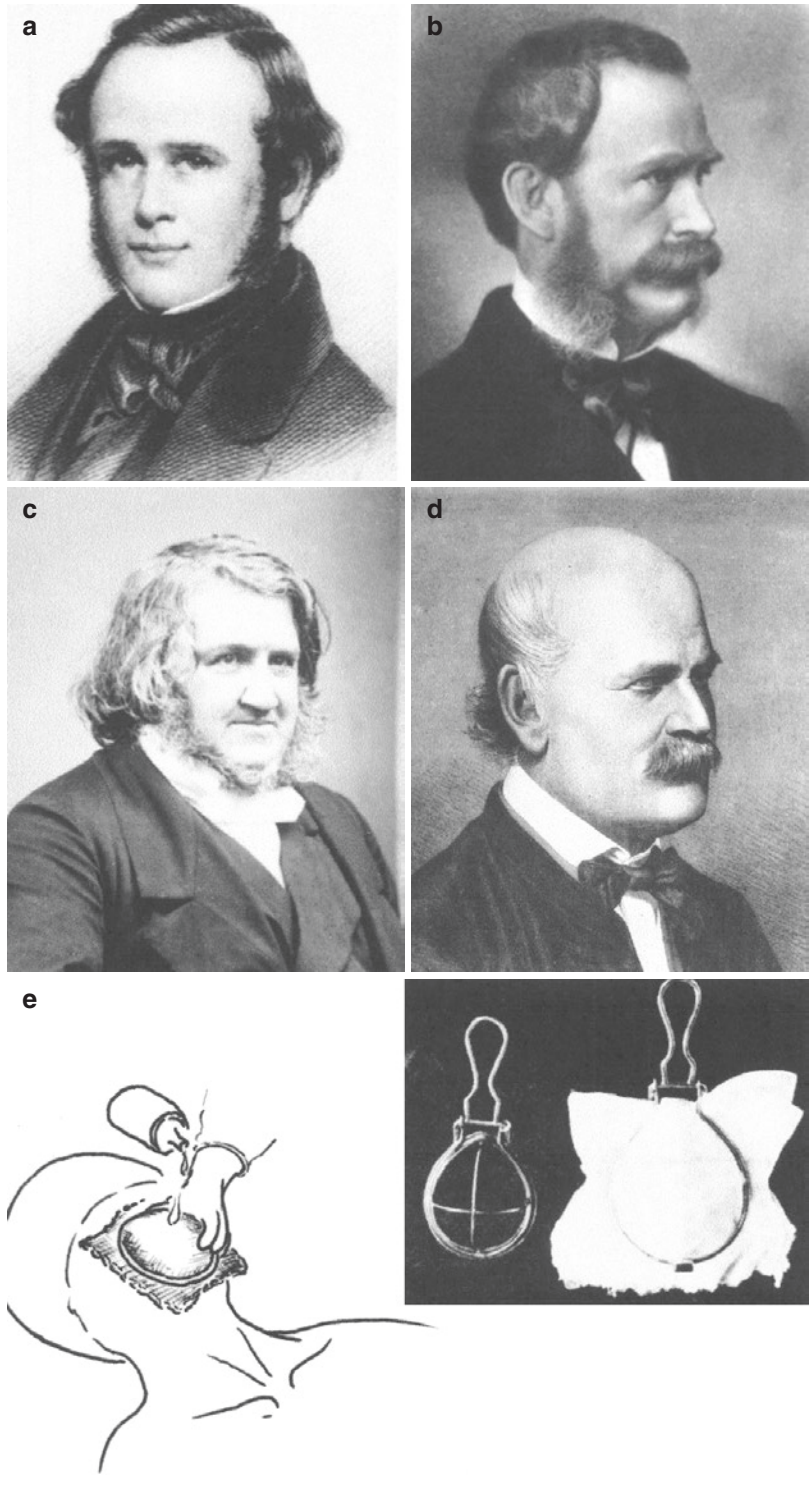



**Fig. 1.1** (**a–f**) Historical leaders, pictures of ether anesthesia, and Lister's aseptic method. (**a**) Horace Wells: nitrous oxide anesthesia, (**b**) William T.G. Morton: ether anesthesia, (**c**) James Young Simpson: chloroform anesthesia, (**d**) Ignaz F. Semmelweis: chlorinated lime wash, (**e**) ether mask for inhalation anesthesia (ether solution was dropped on the mask with gauze), (**f**) Lister's aseptic method (carbolic acid solution was used for washing and spray)


**Fig. 1.1** (continued)

Infirmary of Edinburgh from 1866. And he introduced phenol vapor to clean his operating room (Fig. 1.1f) [13]. Ernst von Bergmann (1836–1907) (Fig. 1.2b), professor of surgery in the University of Berlin, and his coworker Curt Schimmelbusch (1860–1895) developed a heat sterilization method for surgical instruments in 1886 (Fig. 1.2g) [14]. We have a very romantic history in development of the surgical rubber glove. The world famous surgeon, William Stewart Halsted (1852–1922) (Fig.1.2c) of the Johns Hopkins Hospital, USA, used strictly Lister's method using carbolic acid. This antiseptic solution produced severe hand skin damage of the head nurse of the operation theater, Miss Caroline Hampton. He ordered special thin skin rubber gloves for her from the Goodyear Tire and Rubber Company in 1890 [15]. They got married in 1890. An Austrian surgeon Antonio Grossich (1849–1926) (Fig. 1.2d) introduced iodine tincture for rapid skin sterilization of the surgical field in 1908 [16]. These aseptic strategies were scientifically supported by the discovery of "microorganisms." Louis Pasteur (1822–1895) (Fig. 1.2e) of the Ecole Nationale Superieure des Beaux-Arts, Paris, confirmed that the microorganisms caused the fermentation and putrefaction in 1847 [17]. Robert H. H. Koch (1843–1910) (Fig. 1.2f), a Nobel Prize microbiologist in the University of Berlin, found the bacteria which caused various infectious diseases in 1878 [18]. These developments reduced dramatically fatal surgical infections.

## Antibacterial Agents

The next significant progress appeared on antibacterial agents. Bayer chemists (German) Gerhard Domagk (1895–1964) (Fig. 1.3a) and Josef Klarer (1898–1953) synthesized "sulfonamide," a strong anti-gram-positive cocci substance, in 1935 [19]. A Scottish Nobel Prize scientist Alexander Fleming (1881–1955) (Fig. 1.3b) discovered penicillin at St Mary's Hospital, London, in 1928 [20]. He actually opened a new era in medicine. Penicillin was purified by Howard Walter Florey (1898–1968) and Ernst Boris Chain (1906–1979) of the University of Oxford in 1941 [21]. Penicillin showed miraculous effectiveness during the World War II. Nowadays, we have various antibacterial agents.

## Intravenous Infusion Therapy

This treatment offered a non-oral route administration of fluid, minerals, calories, and drugs to the patient. Using the infusion therapy, the patient can stop drinking and eating after surgery. Thomas Latta (1796–1833), a surgeon in Leith, Scotland, developed this technology for patients with cholera in 1832 [22]. Stanley J. Dudrick of the University of Pennsylvania, USA, developed parenteral nutrition in 1968, and this method was widely used particularly through the central venous route [23].

## Suture Materials and Surgical Instruments

In the 1850s, the popular suture materials were linen, cotton, catgut, and silk. They were now completely disappeared except silk. Various synthesized absorbable sutures with atraumatic needle are now in use. Mechanical anastomotic instruments showed remarkable development. The first reliable liner stapler was developed by a Hungarian surgeon Aladar von Petz (1888–1956) of the Trinity Hospital in Györ in 1921 (Fig. 1.3c) [24]. The first circular stapler was developed by Masaru Mine of the Kyoto Prefectural Medical University, Japan, in 1962 [25]. The improved models, SPTU and PKS-25 M, were provided by a Russian company (Fig. 1.3d). An American company, the United States Surgical Corporation, bought the license from Russia and supplied the

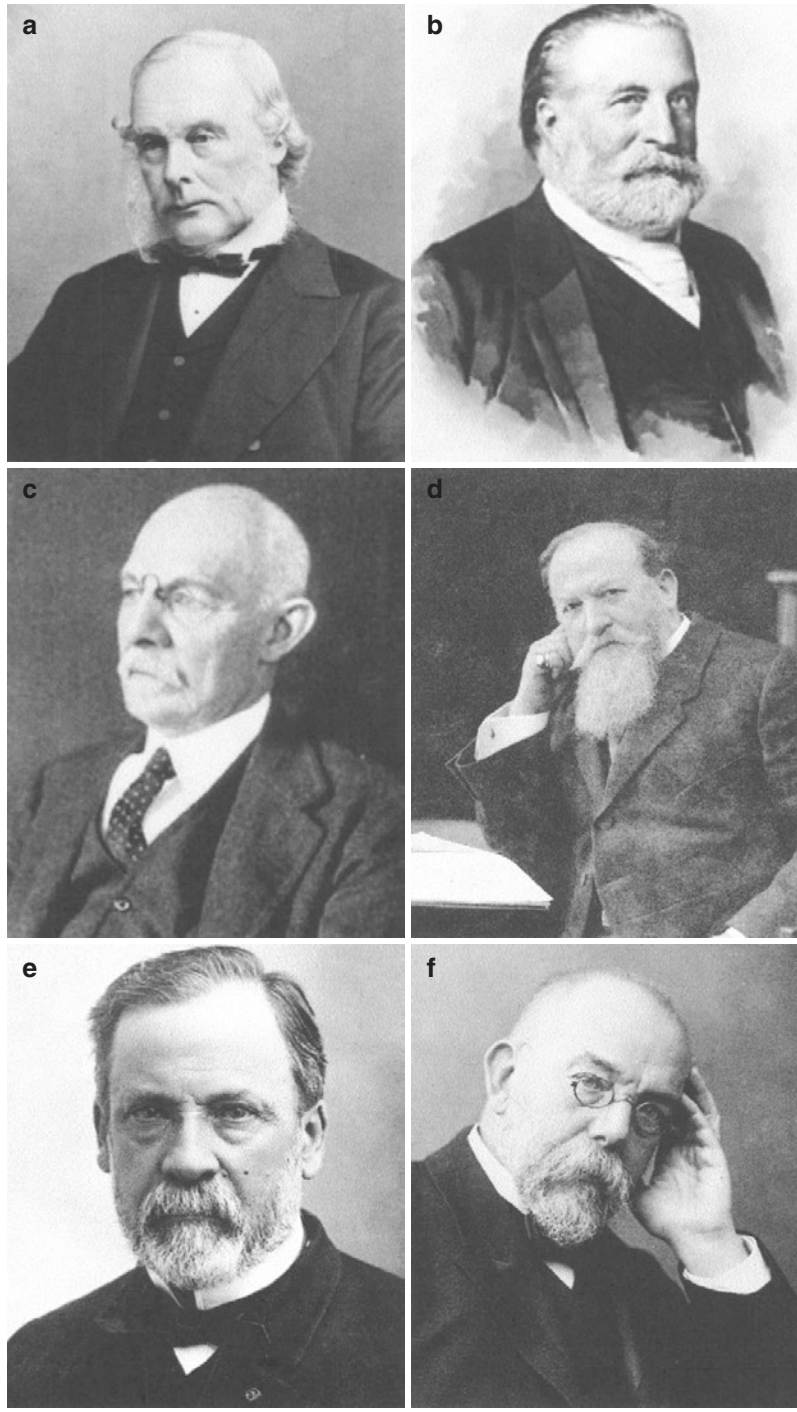
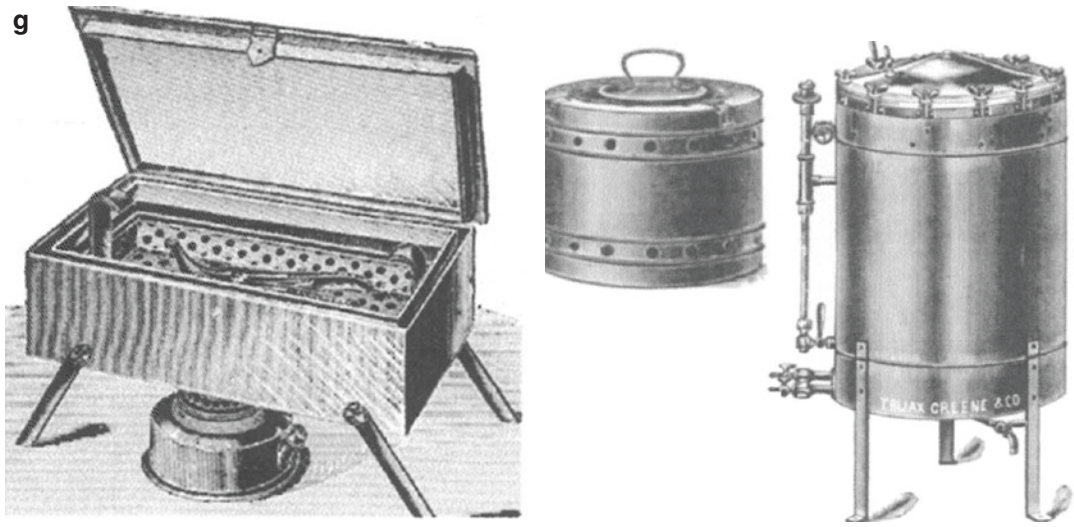



**Fig. 1.2** (**a–g**) Historical leaders and Schimmelbusch sterilization apparatus. (**a**) Joseph Lister: carbolic acid antiseptic, (**b**) Ernst von Bergmann: heat sterilization, (**c**) William Stewart Halsted: surgical glove, (**d**) Antonio Grossich: iodine tincture, (**e**) Louis Pasteur: microorganisms, (**f**) Robert Koch: infectious bacteria, (**g**) Schimmelbusch heat sterilization system: for medical instruments

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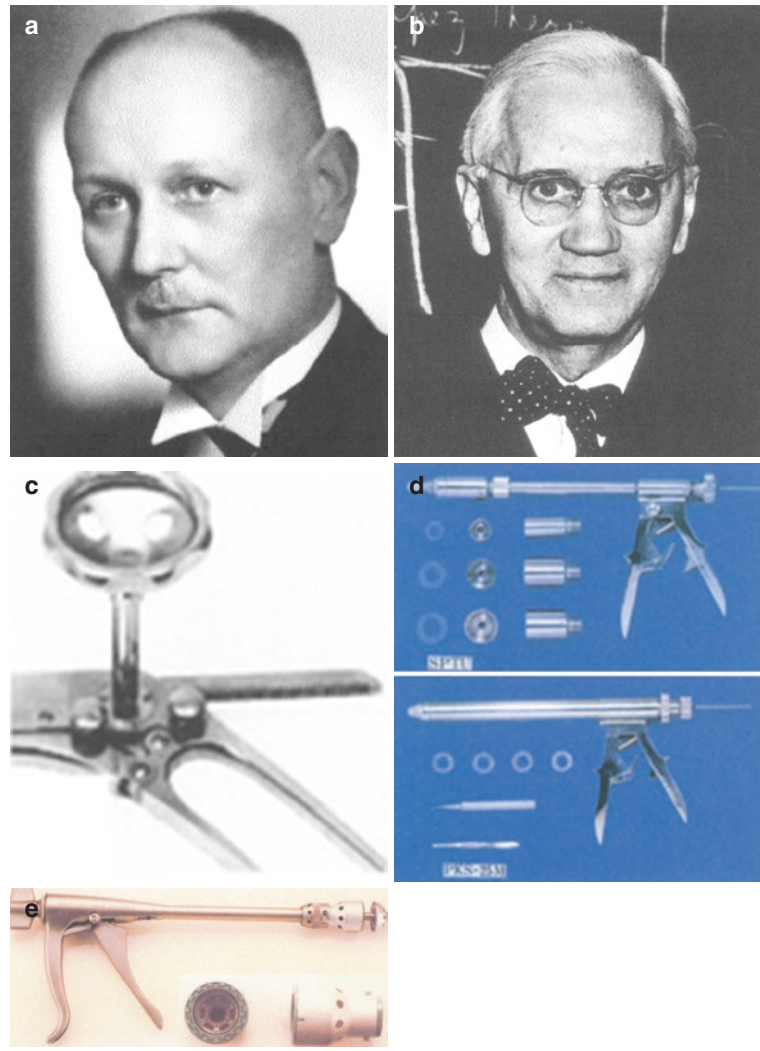



**Fig. 1.3** (**a–e**) Historical leaders and various mechanical staplers. (**a**) Gerhard Domagk: antibiotic sulfonamide; (**b**) Alexander Fleming: antibiotic penicillin; (**c**) von Petz linear stapler; (**d**) Russian circular stapler, SPTU; (**e**) United States Surgical Corporation, EEA stapler

improved and disposable devices of TA, GIA, and EEA (Fig. 1.3e). Electrocautery was also improved, and we have now various devices for different procedures. The other progress was laparoscopic instruments and robot surgery machines. Minimally invasive surgery becomes popular supported by these progress.

### Advancement in Pathological Knowledge

Pathology of gastric cancer showed a remarkable advancement. A German pathologist R. Borrmann in Bremen published a famous textbook about gastric cancer in 1926 [26]. He described the macroscopic-type so-called Borrmann's classification. Detailed and huge follow-up data informed us the characteristics of the disease. The data supported the establishment of rational treatments.

### Progress of Diagnostic Methods

Preoperative assessment of cancer extension and biological characteristics became significantly accurate by endoscopy (Fig. 1.4a, b, c), endoscopic biopsy, double-contrast XP study, CT, ultrasonography, tumor markers, etc. Nowadays surgeons can make the most appropriate treatment plan for each individual patient based on these information.

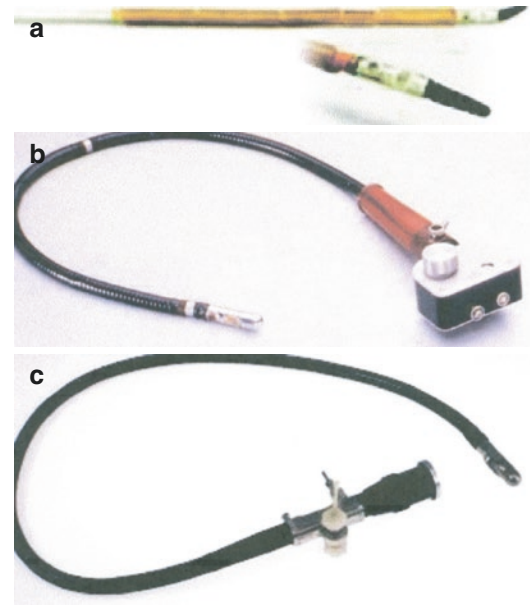



**Fig. 1.4** (**a–c**) Development of gastroendoscope. (**a**) Schindler's prism flexible gastroscope, 1932; (**b**) Olympus gastrocamera, 1950; (**c**) Hirschowitz gastrofiberscope, 1964

## Challengers of Gastric Resection

Before the introduction of anesthesia and antiseptic method, a few successful gastric surgeries were reported. Most of them were removal of foreign body such as swallowed knife from the stomach [27, 28].

Three great pioneers performed the memorial gastric resections for pyloric cancer in the short period between 1879 and 1981. Jules-Émile Péan (1830–1898) (Fig. 1.5a) of St Louis Hospital, Paris, performed the first distal gastric resection (actually a pylorus resection) for a pyloroduodenal cancer with stenosis on 9 April 1879 [29]. The procedures lasted two hours and half under a 13-cm-long paraumbilical incision. The patient died on the fifth postoperative day but autopsy was denied. Pe'an did not leave the detailed medical record, and the cause of death was not clear. But mismatched blood transfusion or anastomotic leakage caused by catgut suture was speculated.

The Polish surgeon Ludwik Rydygier (1850–1920) (Fig. 1.5b) carried out the second gastric resection for a 64-year-old bugle soldier with pylorus stenosis on 16 November 1880. He was a research-oriented surgeon and he left the exact and detailed record [30, 31]. He made a series of animal experiments on gastric resection and reconstruction techniques. He applied Lister's carbolic acid sterilization for hands, instruments, and linens by washing and air spraying. He carried out the surgery at his private clinic with 25 beds in Kulm, Poland. Rydygier performed the surgery very carefully taking four hours and half under an upper midline incision using 60 stitches for gastroduodenal anastomosis (Fig. 1.5c). The

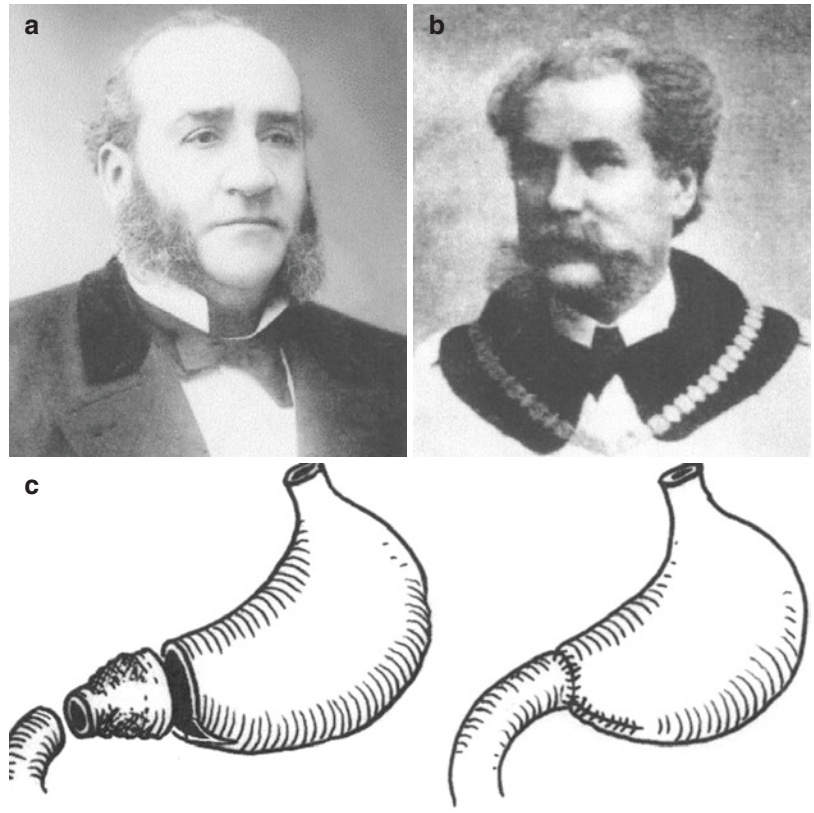



**Fig. 1.5** (**a–c**) Historical leaders and Rydygier's operation. (**a**) Jules-Émile Péan: first gastric resection, (**b**) Ludwik Rydygier: second gastric resection, (**c**) pyloric resection procedure by Rydygier in 1880 (the tumor was located close to the pylorus. It was resected and a two-layer gastroduodenal anastomosis was made at the lesser curvature side). (From S. Sokół's drawing [161])

patient had smooth recovery after the surgery but suddenly died in the early morning of the first postoperative day. The cause of death would be collapse brought by the preoperative poor condition. The autopsy revealed no residual tumor and no infection. Anastomotic leakage was denied by water inflation test of the resected material.

The honor of the first successful gastric resection was given to Theodor Billroth (1829–1894) (Fig. 1.6a), professor of surgery at the University of Vienna and chairman of the Second Surgical Clinic of the Wien Allgemeines Krankenhaus (Vienna General Hospital) (Fig. 1.6c). He prepared his surgery very carefully. His two staffs, Carl Gussenbauer (1842–1903) and Alexander von Winiwarter (1848–1917), made animal experiments on the surgical techniques of gastric resection and anastomosis using dogs [32]. They also made detailed research on pyloric cancer behavior and possibility of curative resection using 542 autopsy records. Gussenbauer was the successor of Billroth at the University of Vienna, and Winiwarter became a professor of surgery at the University of Liege, Belgium. Billroth sent his staffs to the Royal Infirmary of Edinburgh and King's College Hospital, London, for introducing Lister's aseptic method. On 29 January 1881, Billroth performed distal gastric resection on Therese Heller, a 43-year-old Vienna housewife having eight children.

Billroth wrote a letter to Professor L. Wittelshöfer, the publisher of the *Wiener Medizinische Wochenschrift* (*Vienna Medical Weekly*), by himself informing his historical gastric resection [33]. And his operation record was published by his colleague Anton Wölfler (1850–1917) (Fig. 1.6b) [34], and the record was studied in detail by Herbert Ziegler (Fig. 1.6d) [35]. On the day, his team applied Lister's aseptic procedures except carbolic acid vapor spray method. The surgical instruments; suture material, silk thread and linens were sterilized with carbolic acid solution. They did not use catgut. Before starting the operation, her stomach was irrigated

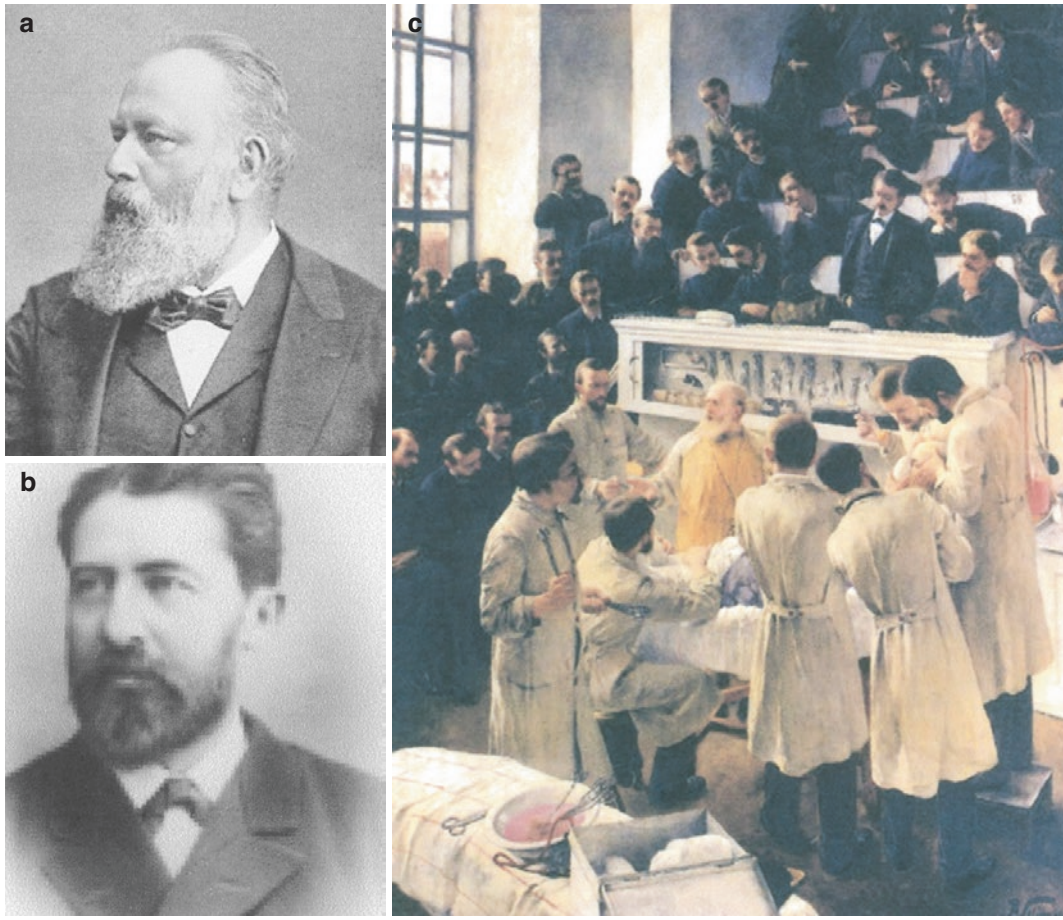



**Fig. 1.6** (**a–f**) Historical leaders and Billroth's first successful gastrectomy. (**a**) Theodor Billroth: third gastric resection; (**b**) Anton Wolfler: gastroenterostomy; (**c**) painting depicting Billroth's operation in 1890 at Wien Allgemeines Krankenhaus by Albert F. Seligmann, Österreichische Galerie Belvedere Palace, Wien; (**d**) the first distal gastrectomy; (**e**) resected material of Therese Heller; (**f**) autopsy material, the duodenum left side (these pathological materials are exhibited at the Josephinum Medizinischen Museum Universität Wien)

with 1.5 liters of warm water consuming one hour. Under chloroform anesthesia, Billroth made an 11-cm-long right transverse incision, crossing the midline just over the palpable tumor. A few hazelnut-size swollen lymph nodes were found, and metastasis of medullary carcinoma was microscopically confirmed on one sample node. Billroth followed the surgical procedures established by dog experiments, and he spent only one hour and 30 minutes for his operation. The duodenum was divided 1.5 cm distal from the tumor mass, and the middle part of the stomach was divided. The divided stomach stump was narrowed by 21 stitches at the greater curvature side for adjusting the anastomotic size. Thirty-three interrupted sutures were applied for gastroduodenal anastomosis not including the mucosal layer. He used carbolized silk for ligatures and sutures (Fig. 1.6d).

The patient took smooth recovery from the surgery. She could drink and eat well from the third postoperative day. The dressing was changed on the 6th postoperative day, and there was no sign of infection. The patient was discharged from the hospital on the 22nd postoperative day.

The patient died of recurrence on 24 May 1881, 4 months after the operation. A pathologist of the Vienna University, Dr. Zemann, made the

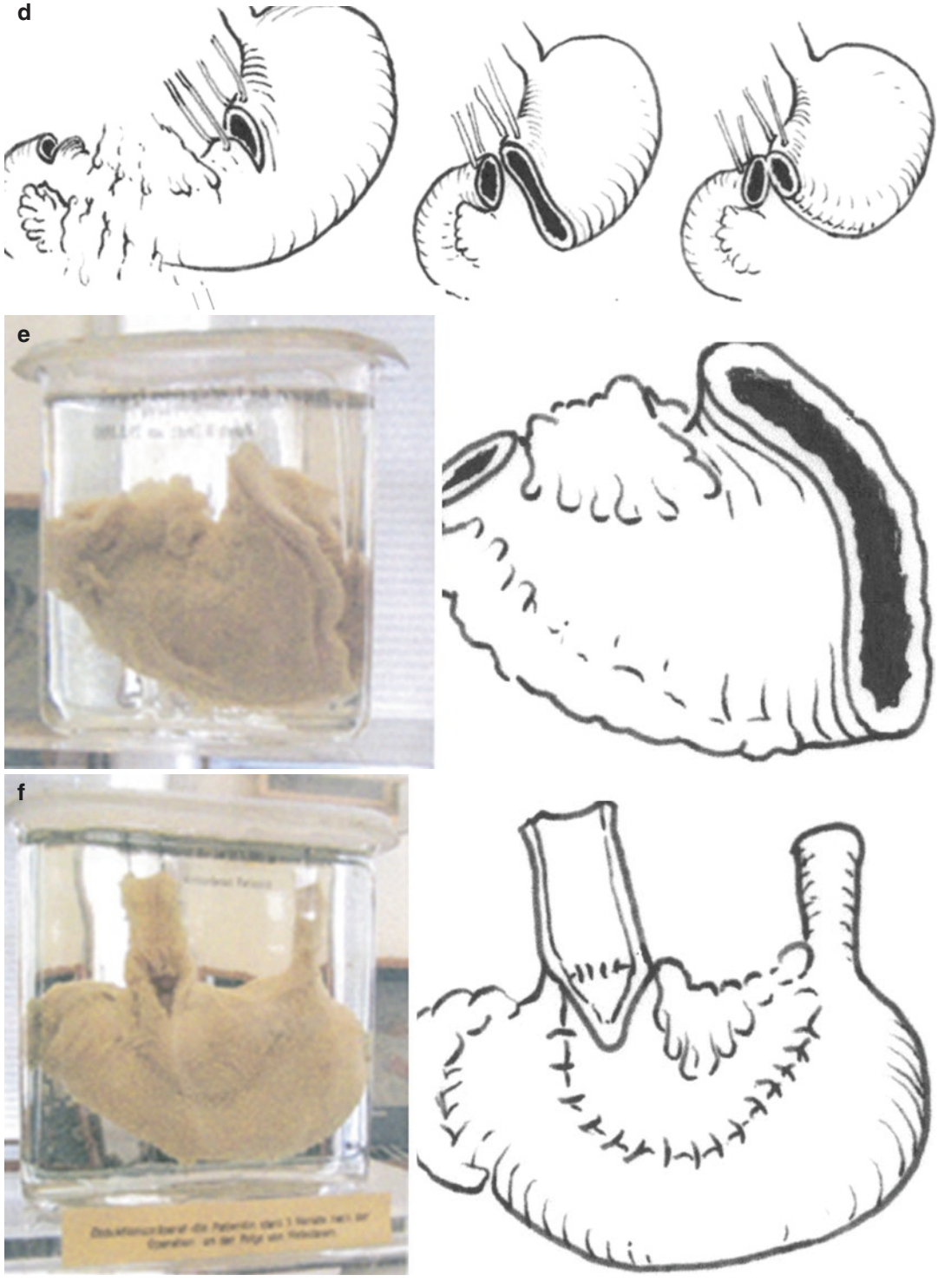



**Fig. 1.6** (continued)

autopsy, and Ziegler made the detailed study [35]. We can see the resected specimen and the autopsy material in the Josephinum Medical Museum of the University of Vienna (Fig. 1.6e, f).

Within 2 months of Billroth's operation, 21 similar gastrectomies had been performed, several of them in Billroth's clinic. Survived cases were only three from them, one by Billroth and the other two by his colleagues, Wölfler and Vincenz Czerny (1842–1916) (Fig. 1.7a) [34]. Czerny was appointed professor at the University of Heidelberg where he founded the German Institute for Experimental Cancer Research in 1906. A Polish-German surgeon from Danzig, Hans

Haberkant, reported that the surgical mortality rate was 69% (72/109 patients) in Europe in 1879–1887. The mortality rate was improved to 43% (42/98 patients) in 1888–1894 [36]. This report informed us that gastric resection remained as a risky surgery even after the first successful operation.

Theodor Billroth placed the gastroduodenal anastomosis at the lesser curvature side (Fig. 1.8a) for his first and second patients, but he changed the anastomotic site at the greater curvature side (Fig. 1.8b) for the third patient [35]. Emil Theodor Kocher (1841–1917) (Fig. 1.7b), a Nobel Prize surgeon from the University of Bern, Switzerland, reported an unique procedure to prevent anastomotic leakage in 1892. He closed stomach stump and inserted the duodenal stump into the new incision of posterior wall of the remnant stomach (Fig. 1.8c) [37]. John M.T. Finney (1863–1942) (Fig. 1.9a) of the Johns Hopkins Hospital, USA, proposed a gastroduodenostomy method with whole gastric stump and lateral wall of the duodenum in 1924 (Fig. 1.8d) [38].

Various reconstruction methods with gastrojejunostomy were proposed after the first successful Billroth I operation (Fig. 1.10). They were named "Billroth II operation," with antecolic or retrocolic and iso- or antiperistaltic anastomosis, with or without Braun's enteroanastomosis, and with partial or whole cut end of the stomach [39]. In 1885 Billroth published his *Billroth II Operation* or the antecolic side-to-side gastrojejunostomy (Fig. 1.10a) [40, 41]. In 1888 this operation was modified by his Austrian staff Anton F. von Eiselsberg (1860–1939) (Fig. 1.9b). This procedure used retrocolic route with anastomosis between the stomach stump and side wall of the jejunum. Furthermore, this procedure was refined by Franz von Hofmeister (1867–1926) (Fig. 1.9c) of the University of Tübingen, Germany, based on a procedure by Eugen Alexander Pólya (1876–1944) (Fig. 1.9d) of Semmelweis University, Budapest (Fig. 1.10e) [42]. It was later refined by Hans Finsterer (1877–1955) (Fig. 1.11a) of the University of Vienna and became known as the "Hofmeister-Finsterer gastrectomy" (Fig. 1.10g) [43]. Here the stomach cut end of the lesser curvature side is

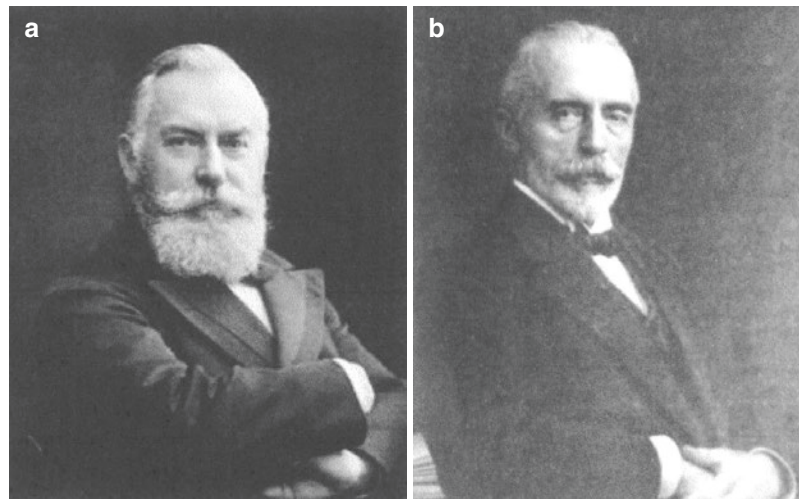



**Fig. 1.7** (**a–b**) Historical leaders. (**a**) Vincenz Czerny: cancer surgery, (**b**) Emil Theodor Kocher: reconstruction

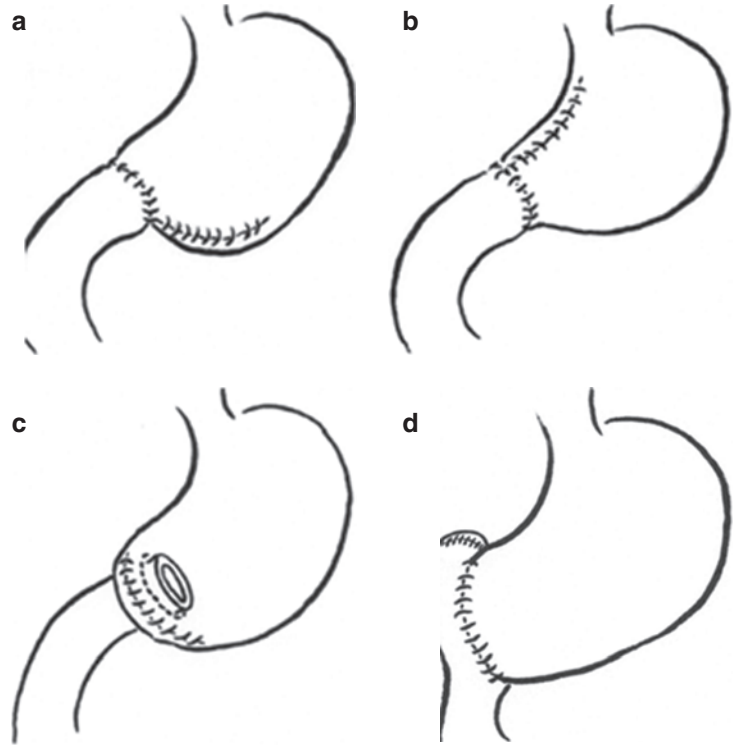



**Fig. 1.8** (**a–d**) Various Billroth I type reconstructions. (**a**) Billroth T, 1881; (**b**) Billroth T, 1883; (**c**) Kocher E, 1891; (**d**) Finney JMT, 1924, and von Habere H, 1922

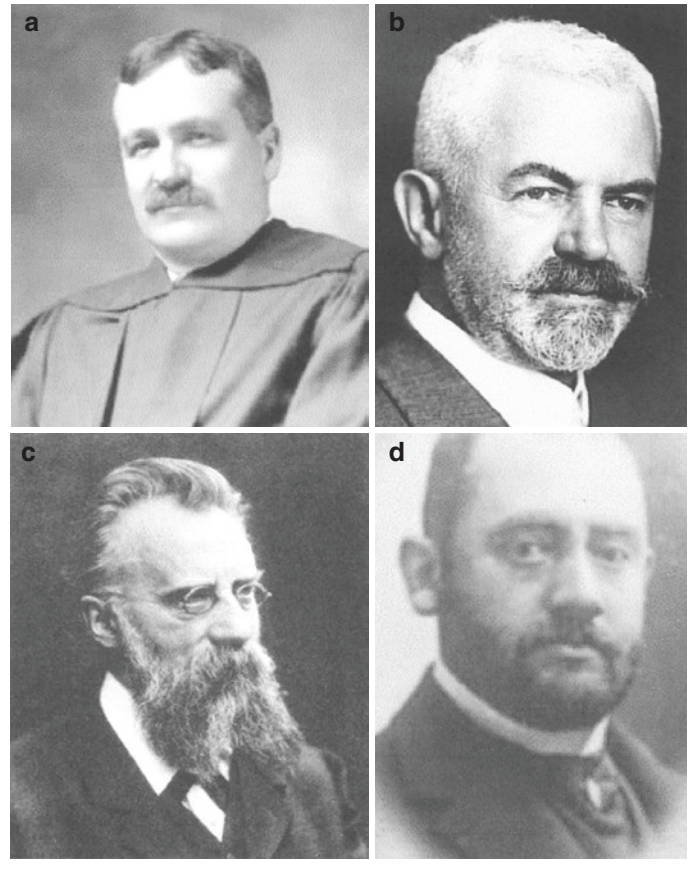



**Fig. 1.9** (**a–d**) Historical leaders of the gastric cancer surgery. (**a**) John MT. Finney: reconstruction, (**b**) Anton F. von Eiselsberg: Billroth II operation, (**c**) Franz von Hofmeister: Billroth II reconstruction, (**d**) Eugen A. Pólya: Billroth II reconstruction

closed, and the remaining greater curvature side portion is anastomosed with the jejunum (Fig. 1.10f). This procedure was popularized by Finsterer based on his huge experiences of more than 10,000 gastric operations. Heinrich Ch. Braun (1847–1911) of the University of Königsberg, Germany, proposed side-to-side anastomosis between the afferent and efferent jejunal loop for better passage of duodenal juice in 1892 (Fig. 1.10g) [44]. Donald C. Balfour (1882–1963) of Mayo Clinic, USA, added Braun anastomosis to Po'lya, called Balfour-Pólya operation, in 1917 (Fig. 1.10g) [45, 46]. But several literatures described that this reconstruction method was previously performed by Hofmeister. A pupil of Kocher, Ce'sar Roux (1857–1934) (Fig 1.11b) of the University of Lausanne, Switzerland, described the Roux-en-Y reconstruction in 1927 (Fig. 1.10h) [47], which can be applied not only for the distal gastric resection but also for the total gastrectomy.

In this period, many Japanese surgeons stayed in Germany, and they introduced the latest surgical technologies. In 1897, 16 years after Billroth's success, the first gastric cancer resection was done by Jihan Kondo (1866–1944) of Tokyo University Hospital [48]. A pupil of Mikulicz, Hayari Miyake (1866–1945) (Fig. 1.11c) of the

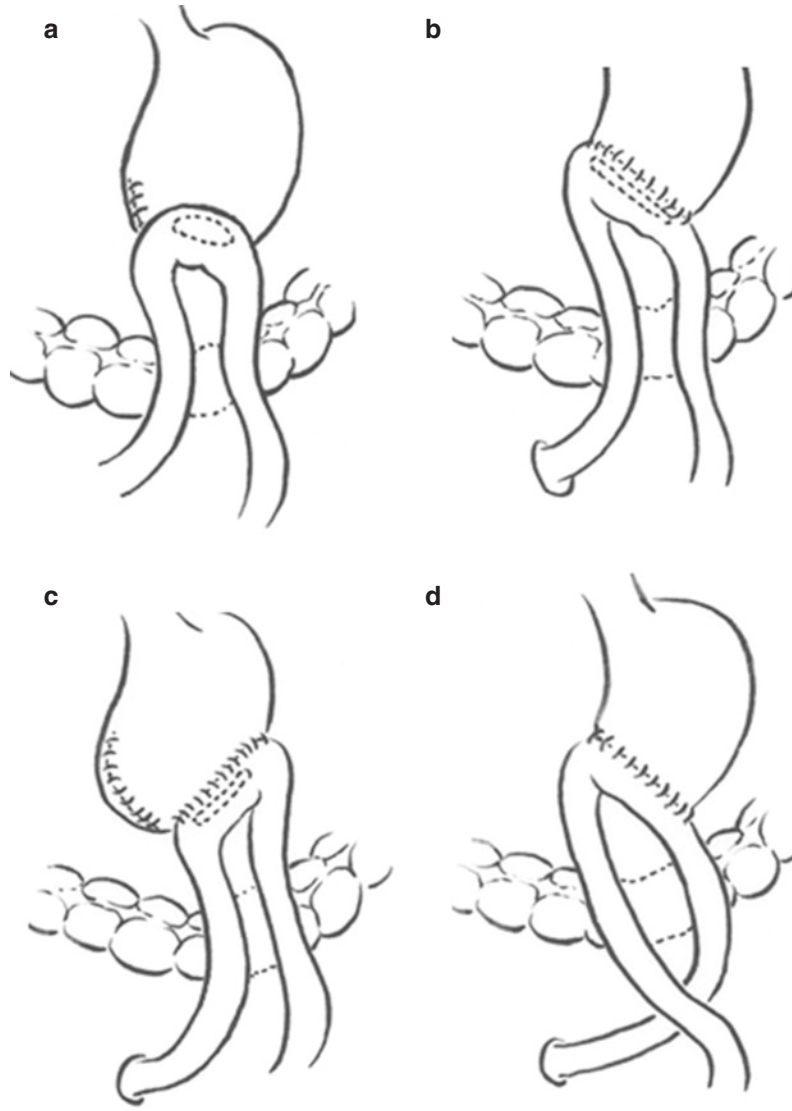
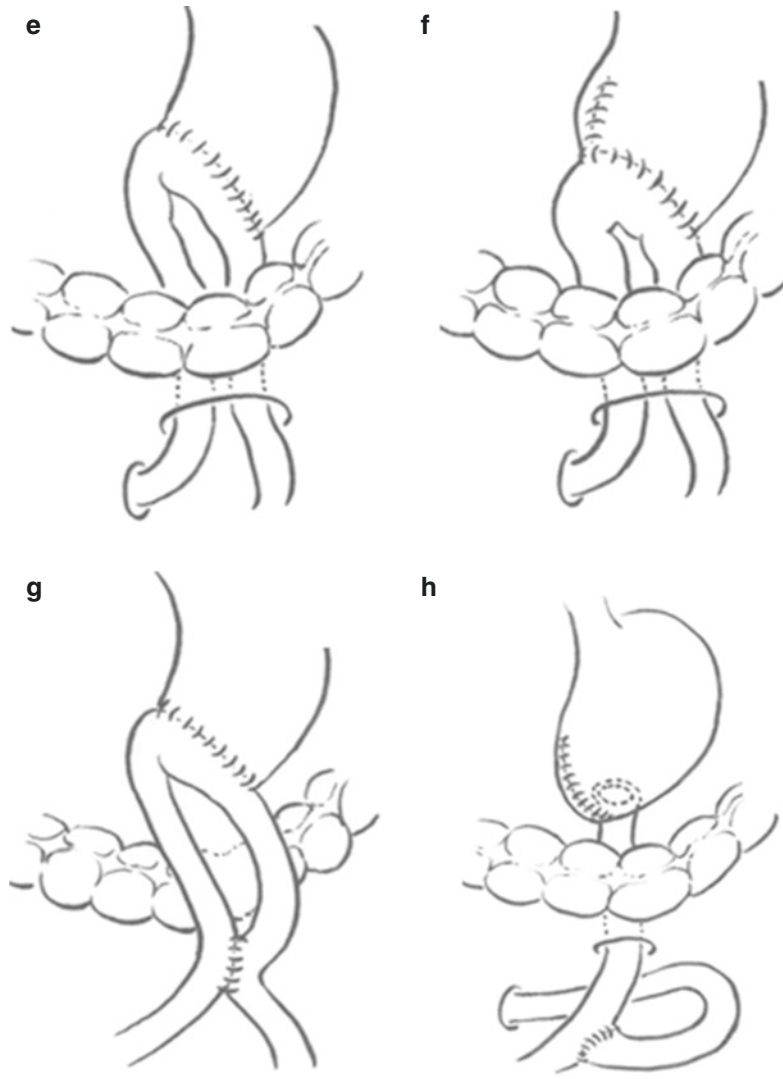



**Fig. 1.10** (**a–h**) Various Billroth II type reconstructions. (**a**) Billroth T, Wölfler A, 1885; (**b**) Krönlein RU, 1888; (**c**) Mikulicz JR, 1897; (**d**) Moynihan B, 1923; (**e**) Polya EA, 1911; (**f**) Hofmeister-Finsterer, 1895; (**g**) Balfour DC, 1917; (**h**) Roux C, 1893–1898

**Fig. 1.10** (continued)




Kyushu University, Japan, reported that 58 patients died of postoperative complication from 177 patients (33%) treated in 1904–1914 in his department. He reported that the surgical death rate was improved to 14.2% (56/395 patients) in 1920–1927. The 3-year survival rate was 31.3% (108/345 patients) in his series [49].

## Powerful Drive for Curability

Billroth's Polish-Austrian associate Johann F. von Mikulicz-Radecki (1850–1905) (Fig. 1.11d) of the Schlesischen Friedrich-Wilhelms Universität Breslau, Germany (now Wroclaw Poland), opened actually the door of scientific oncological surgery in 1898 [50–52]. He described that gastric cancer had four growth directions: (a) local extension, namely, the stomach wall infiltration and adjacent structure invasion, (b) extension through the lymphatic vessels to the regional nodes, (c) extension through the blood vessels to the liver, and (d) peritoneal dissemination. Mikulicz stressed that the cure could be obtained only when these targets were removed perfectly. To remove the direct wall expansion, total gastrectomy was proposed. Combined resection of neighboring organs was


**Fig. 1.11** (**a–d**) Historical leaders of the gastric cancer surgery. (**a**) Hans Finsterer: Billroth II operation, (**b**) C'ésar Roux: Roux-en-Y anastomosis, (**c**) Hayari Miyake: treatment results, (**d**) Jan Mikulicz-Radecki: surgical oncology

applied for invasion to the adjacent structures. Systematic lymph node dissection could remove the metastatic lymph nodes. However, cure from the liver and peritoneal metastases could not be achieved by surgical treatment. Followings are the progress of these surgical treatments.

## Total Gastrectomy

In 1987, 6 years after Billroth's gastric resection, the first successful total gastrectomy for cancer was performed by a Billroth's staff, Carl B. Schlatter (1864–1934) (Fig. 1.13a) of the

University of Zurich, Switzerland [53, 54]. His reconstruction method was the Billroth II reconstruction with antecolic end-to-side esophagojejunostomy without Braun's anastomosis (Fig. 1.12a). The first total gastrectomy was successfully performed in Japan in 1902 by Otojiro Kitagawa (1864–1922) of the Nagoya Koseikan Hospital [55]. The surgical mortality rate was significantly high in this period. Various reconstruction methods were proposed with intention to prevent leakage of the esophagojejunal anastomosis and regurgitation esophagitis (Fig. 1.12).

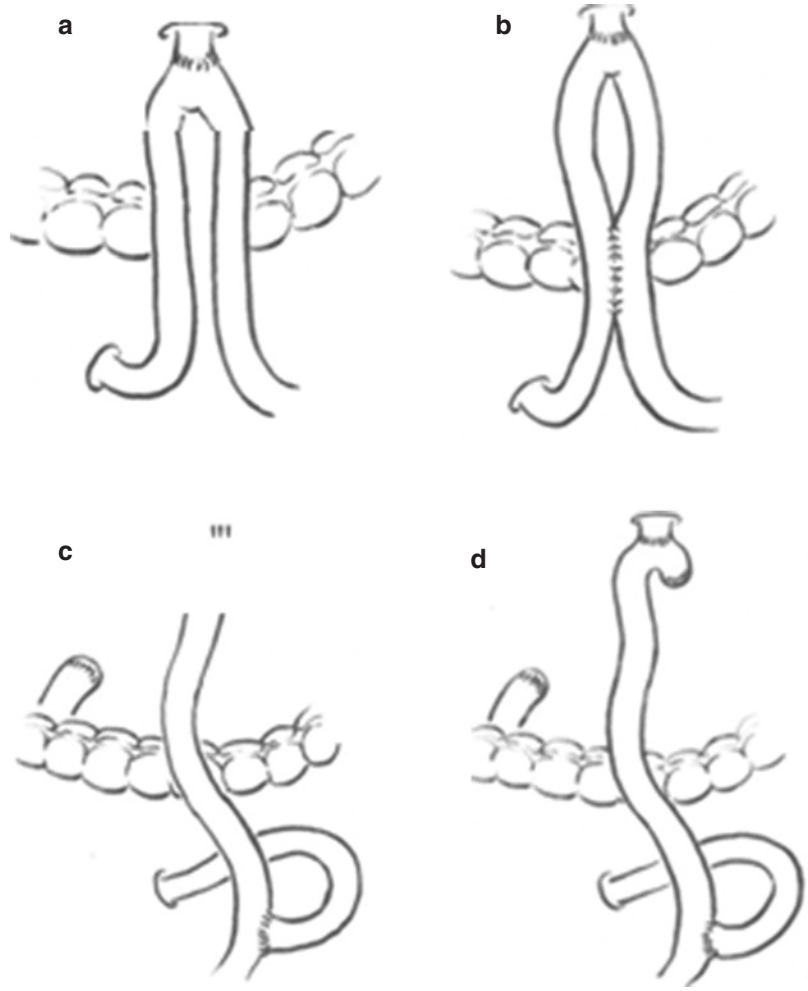
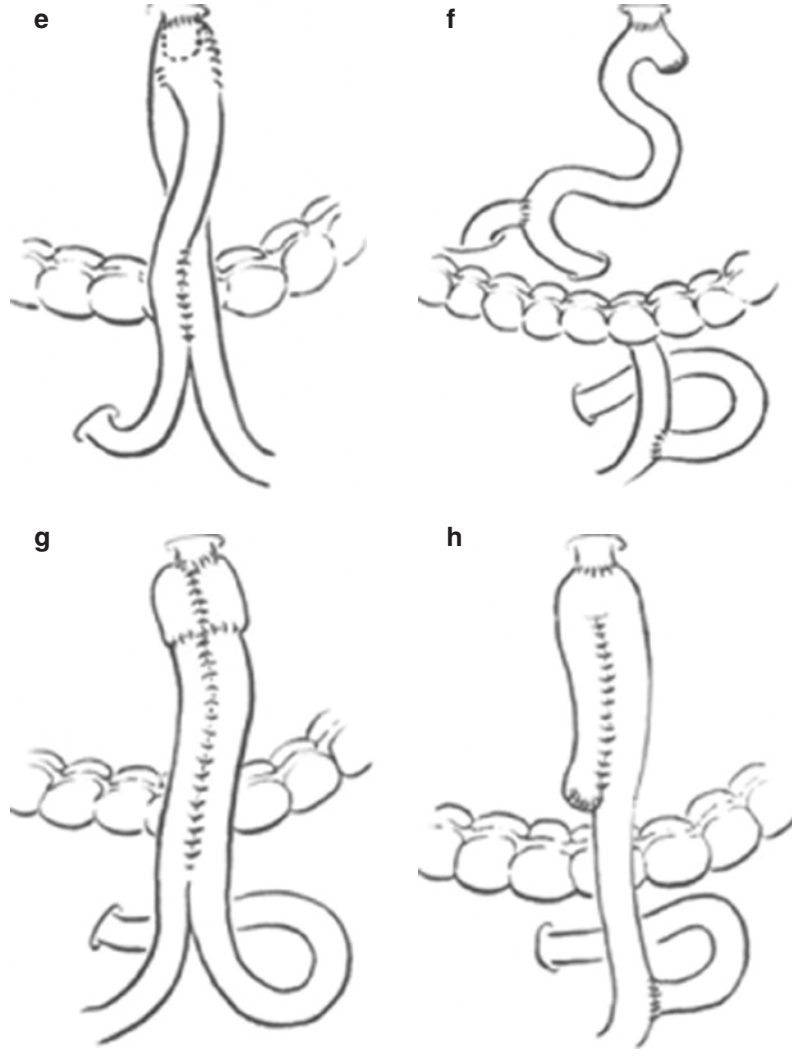



**Fig. 1.12** (**a–h**) Various reconstruction methods after total gastrectomy. (**a**) Schlatter C, 1897; (**b**) Schlöffer H, 1917; (**c**) Roux C, 1907; (**d**) Orr TG, 1943; (**e**) Graham RR, 1940; (**f**) Nishi M, 1972; (**g**) Siewert-Peiper, 1972; (**h**) Hunt CJ, 1952

**Fig. 1.12** (continued)




Hermann Schlöffer (1868–1937) (Fig. 1.13b) of the University of Prague added Braun's jejunojejunostomy to Schlatter's reconstruction in 1917 (Fig. 1.12b) [56]. César Roux applied his "Roux-en-Y anastomosis" for the reconstruction after total gastrectomy in 1907 (Fig. 1.12c) [57]. Thomas G. Orr (1884–1955) (Fig. 1.13c) of the University of Kansas, USA, modified Roux-en-Y reconstruction by end-of-esophagus-to-side-of-jejunum anastomosis in 1943 (Fig. 1.12c) [58]. This procedure became the most popular reconstruction method. Roscoe R. Graham (1890–1948) (Fig 1.13d) of the University of Toronto, Canada, developed a unique anastomotic method in 1940, reinforcement of the esophagojejunostomy using the jejunal stump like a sandwich (Fig. 1.12e) [59, 60]. Mitsumasa Nishi (1925–1998) (Fig. 1.13e) of the Cancer Institute, Tokyo, proposed the so-called double-tract method in 1972 connecting the duodenal

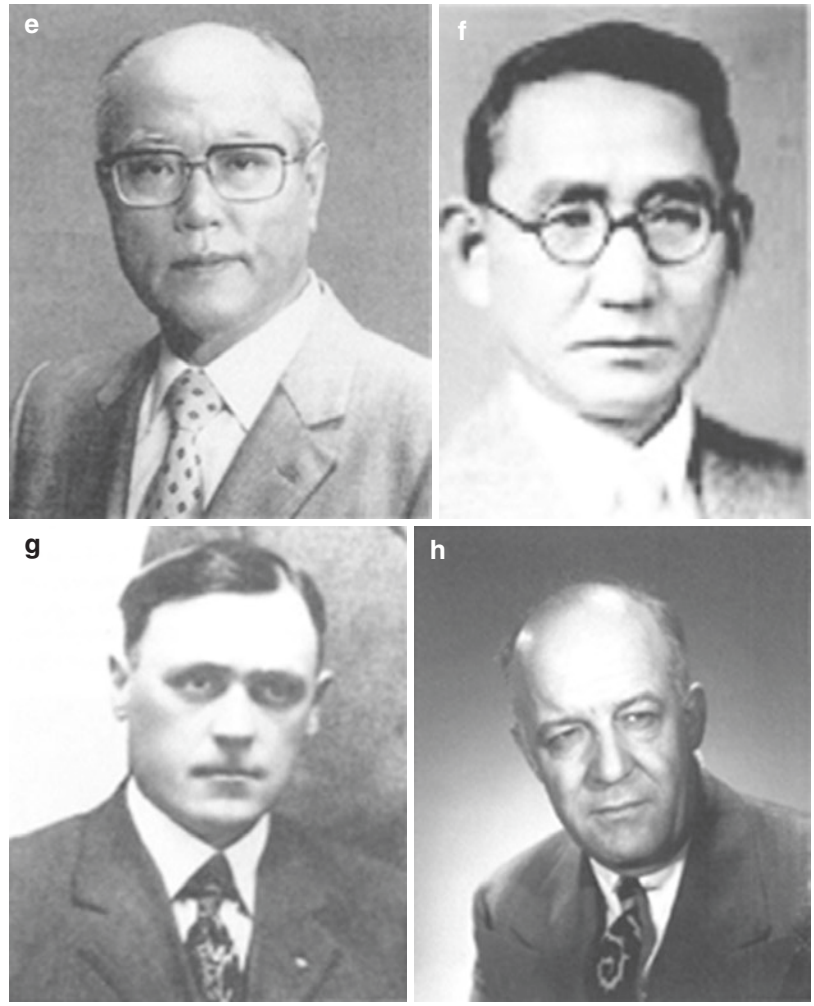
stump to the side of the jejunum in Roux-en-Y reconstruction (Fig. 1.12f) [61]. We have now various reconstructions after total gastrectomy (Fig. 1.12) [62–64].

Reconstruction by the jejunal segment interposition between the esophagus and duodenum (Fig. 1.14a) was developed by Sadanobu Seo (1886–1946) (Fig. 1.13f) of the Chiba University, Japan, in 1941 [65] and by William Polk Longmire (1913–2003) (Fig. 1.13g) of the UCLA Medical Center, Los Angeles, in 1952 [66]. The other trend was building a reservoir in place of the resected stomach. Longmire created a single lumen tube from jejunal loop, like a long Braun anastomosis [67]. We have various interposition methods (Fig. 1.14) [68] including interposition of the ileocolic segment (Fig. 1.14d) [69].

By these efforts, the surgical mortality rate was remarkably improved and total gastrectomy became safer. This improvement led to a new opinion and trend; active application of total gastrectomy for obtaining the better curability particularly in the USA. Gordon


**Fig. 1.13** (**a–h**) Historical leaders of the gastric cancer surgery. (**a**) Carl B. Schlatter: total gastrectomy, (**b**) Hermann Schlöffer: esophagojejunostomy, (**c**) Thomas G. Orr: Roux-en-Y anastomosis, (**d**) Roscoe R. Graham: anastomosis, (**e**) Mitsumasa Nishi: double-tract anastomosis, (**f**) Sadanobu Seo: jejunal interposition, (**g**) William P. Longmire: jejunal interposition, (**h**) Gordon McNeer: extended radical total gastrectomy

**Fig. 1.13** (continued)




McNeer (1905–1967) (Fig. 1.14h) of the Memorial Sloan Kettering Cancer Center, New York, reported that aggressive surgery showed good survival rate in 1948 [70–73]. Frank H. Lahay (1880–1953) (Fig. 1.15a) of the Lahey Clinic, Boston, reported the indication and treatment results of total gastrectomy in 1944 [74]. This idea was accepted by Mayo Clinic [75] and many leading institutions in the USA. Some specialists recommended that total gastrectomy should be applied for any gastric cancer regardless of location and extension [76, 77]. However the total gastrectomy is now indicated in case when the proximal safe margin from the cardia cannot be achieved by distal gastrectomy.

## Combined Resection of the Neighboring Organs

To remove the cancer invasion to the neighboring organs, these organs should be removed surgically. Invasion to the transverse colon and mesocolon and liver is not rare. Resection of these organs is not difficult and is widely per-

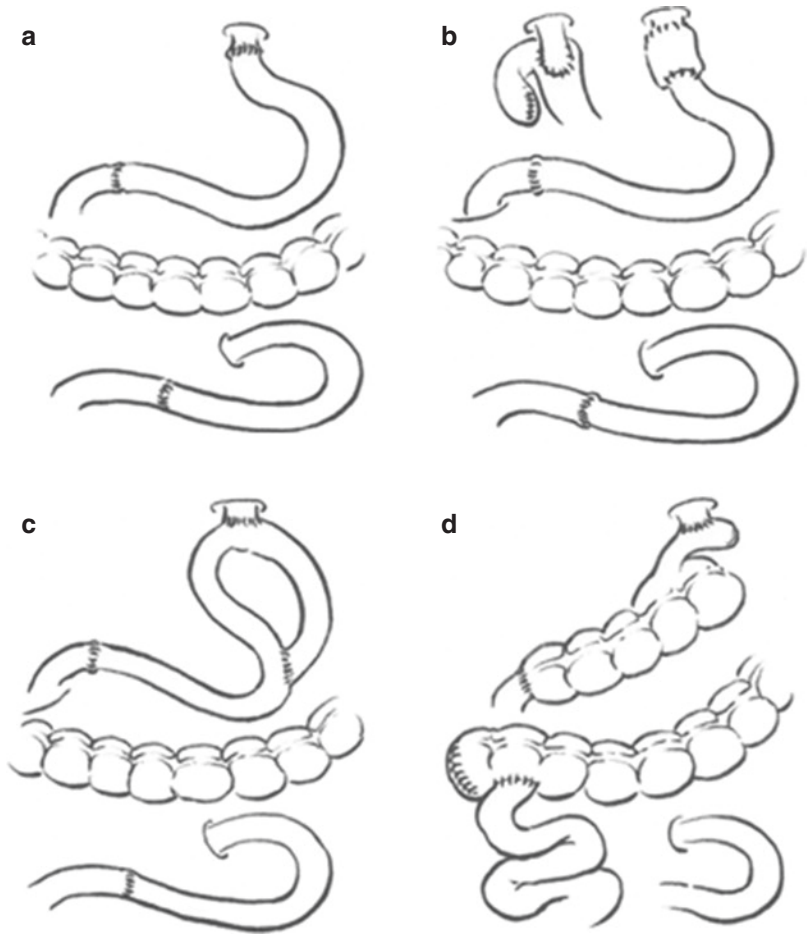



**Fig. 1.14** (**a–d**) Various reconstruction methods with interposition after total gastrectomy. (**a**) Seo T, 1941, and Longmire WP, 1952; (**b**) Schreiber HJ, 1978; (**c**) Henley FA, 1952; (**d**) Longmire/Beal, 1952

formed. Combined resection of distal part of the pancreas was firstly proposed by Mikulicz in 1898 [50]. This surgical technique system was successively established by Alexander Brunschwig (1901–1969) (Fig. 1.15b) of the Memorial Sloan Kettering Cancer Center, New York, in 1948 [78] and Jirou Suzuki (1911–1968) of Chiba University in 1954 (Fig. 1.16a) [79]. The surgical mortality rate of total gastrectomy with splenopancreatectomy was dramatically improved; 1.8% (1/57 patients) in 1955 by Tamaki Kajitani (1909–1991) (Fig. 1.15c) of the Cancer Institute Tokyo [80, 81], and 1.8% (2/113 patients) in 1956 by Komei Nakayama (1910–2005) (Fig. 1.15d) of the Tokyo Women's Medical University [82]. This procedure became much more aggressive. Gordon McNeer demonstrated the combined resection technique of the spleen, distal pancreas, and transverse colon with total gastrectomy in 1948 [83]. Also Frank Lahay reported extensive combined resection of the left lobe of the liver, spleen, distal pancreas, and most part of the colon including the terminal ileum in 1944 (Fig. 1.16b) [84]. In 1991 Mitsumasa Nishi proposed the so-called left upper abdominal exenteration removing the stomach, spleen, pancreas tail, left adrenal grand, transverse colon, and if necessary diaphragm and lower esophagus [85, 86]. However combined resection of the distal pancreas is still

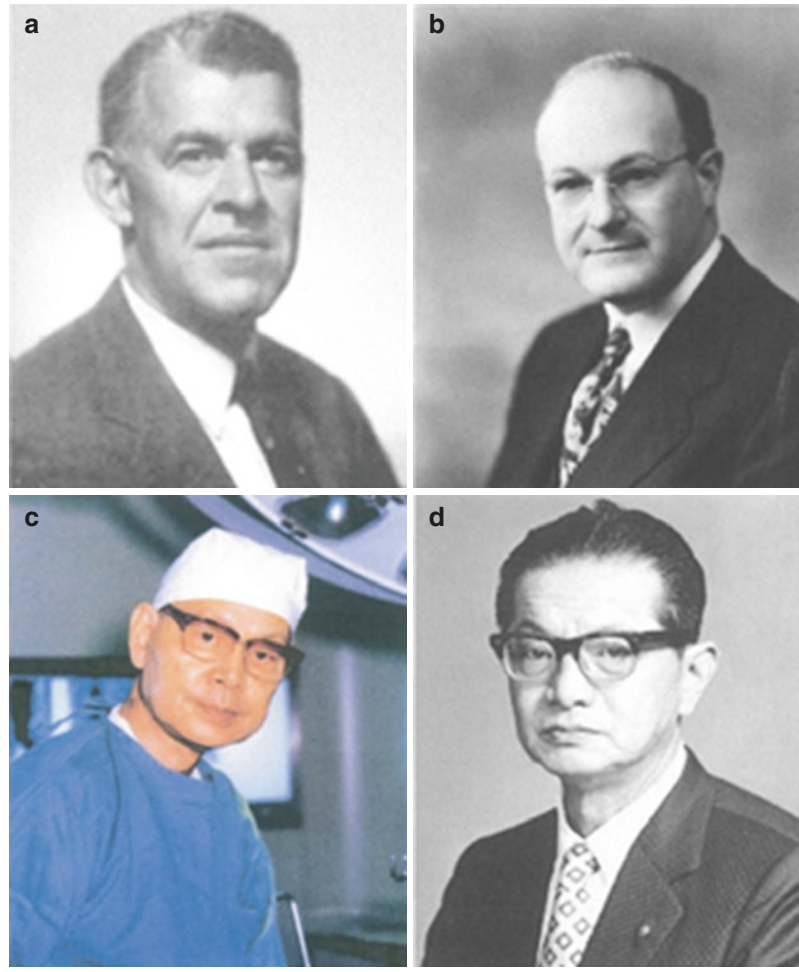



**Fig. 1.15** (**a–d**) Historical leaders of the gastric cancer surgery. (**a**) Frank H. Lahay: radical total gastrectomy, (**b**) Alexander Brunschwig: distal pancreatectomy, (**c**) Tamaki Kajitani: distal pancreatectomy, (**d**) Komei Nakayama: distal pancreatectomy

risky, because control of pancreatic juice leakage from the resection stump is difficult. It causes frequent acute pancreatitis, subphrenic abscess, anastomotic leakage, and rupture of the ligated artery stump. Furthermore, Brunschwig pointed out the postoperative diabetes mellitus occurred after resection of the tail of the pancreas [87]. Management of resection stump of the pancreas is still an important subject to be improved.

## Lymph Node Dissection

The scientific study of the lymphatic system and cancer metastasis was started firstly by the Romanian anatomist Dimitrie Gerota (1867–1939) (Fig. 1.18a) of the University of Berlin in 1895. He developed the so-called Gerota method to visualize the lymphatic network [88]. For demonstrating lymphatic vessels, he produced a new contrast media: mixed fluid of Prussian blue oil, turpentine, and ether. He injected the fluid into the subserosal layer of the bowel [89]. Using the Gerota method, the famous Hungarian surgeon Polya (Fig. 1.9d) demonstrated lymphatic streams from the stomach using 19 miscarried fetus in 1903 [90]. A French anatomist Paul Poirier (1853–1907) (Fig. 1.18b) of the University of Paris and his coworker Adrien Charpy (1848–1911) of the University of Toulouse published a textbook of anatomy in 1902 [91]. The book included the detailed atlas of lymphatic streams and node stations from the stomach

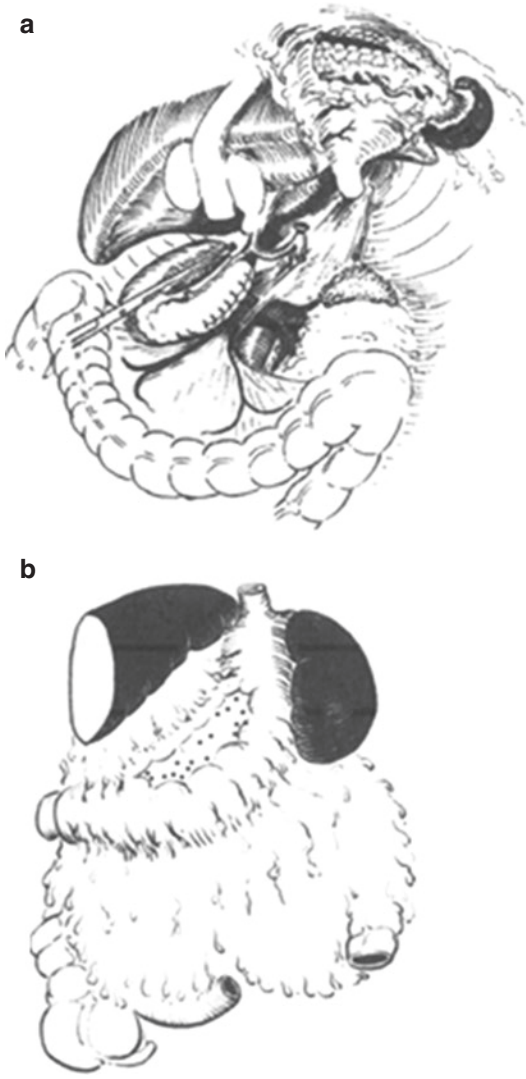



**Fig. 1.16** Schema of splenopancreatectomy (**a**) and resected material of extended surgery by Lahay FH [84] (**b**). Lahay removed the whole stomach together with the abdominal esophagus, left lobe of the liver, distal pancreas, spleen, omentum, terminal ileum, cecum, and ascending/transverse/descending colon

(Fig. 1.17). They used both historical Sappey's mercury injection method [92] and Gerota's method. Anatomist John Kay Jamieson (1873–1948) (Fig. 1.18c) and surgeon Joseph Faulkner Dobson (1874–1934) of the University of Leeds, England, made a detailed study of lymphatic system of the stomach in 1907 [93]. They completed the classification of lymphatic streams and regional lymph node stations of the stomach.

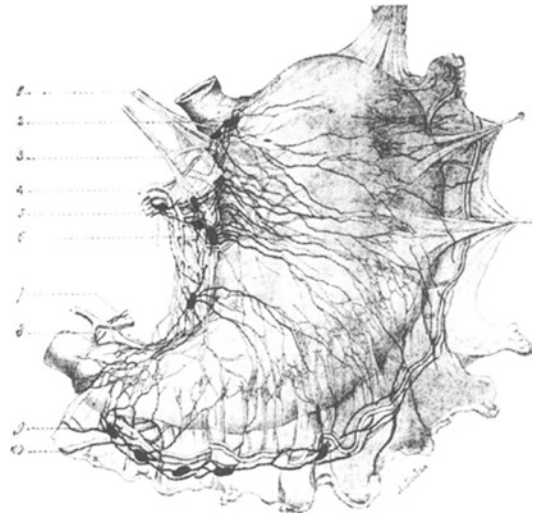


**Fig. 1.17** Lymphatic streams of the stomach (demonstrated by Gerota's method, B. Cunéo and P. Poirier [162])

The next progress was expansion of the regional node area beyond the upper border of the pancreas to deeper area. French anatomist Henri Rouviere (1876–1952) (Fig. 1.18d) of the University of Paris published an important textbook in 1932. He described historical achievements and his own study including the lymphatic system around the celiac artery and the abdominal aorta [94]. Japanese anatomist Inoue Y. of the University of Tokyo made a lymphographic study by an unique contrast media, India-ink, using 104 miscarried fetus in 1936 [95].

Along the idea of Mikulicz, big efforts were paid to develop the effective surgical procedures to remove the metastatic nodes. In 1944 Kajitani stressed the low reliability of macroscopic judgment whether a node is metastatic or not. He found 20 false-negative patients (12%) in his 162 series [96]. That means the extent of node dissection should have enough safe margin based on the lymphatic stream study. Many leading surgical oncologists in Japan (Fig. 1.19a) [61, 80, 82, 97, 98], Korea (Fig. 1.19b, c) [99], Germany (Fig. 1.19d, e) [100, 101], the UK (Fig. 1.19f) [102], and the USA (Fig. 1.19g) [103–105] stressed the importance of systematic lymph node dissection. They conducted multicenter trials in their country for evaluating the systematic lymphadenectomy. The Japanese Research


**Fig. 1.18** (**a–d**) Historical leaders of the lymphatic system study on the stomach. (**a**) Dimitrie Gerota: lymphatic system, (**b**) Paul Poirier: lymphatic system, (**c**) John Kay Jamieson: lymphatic system, (**d**) Henri Rouviere: lymphatic system

Society for Gastric Cancer was established and published the Japanese Manual in 1962 [106]. In the manual, 16 regional lymph node stations were anatomically defined (Fig. 1.21a) [107]. They were classified into N1, N2, N3, and N4 categories according to the occupation of main tumor based on the study of Inoue [95]. Complete removal of N1 and N2 nodes was called "D2 dissection." This procedure was strongly recommended, and it became the gold standard for gastric cancer surgery in Japan and Eastern countries. Systematic node dissection could reduce the local recurrence and lead to better survival. This is the significant effectiveness of this procedure. Japanese nationwide registry of gastric cancer reported that the 5-year survival rate was 37.5% in 1963–1966, which elevated to 70.1% in 2008 [107]. Improvement in survival was remarkable for Stage II, from 47.7% to 73.1%, and also for Stage III, from 26.4% to 44.5%. This improvement was brought by popularization of the D2 dissection.

For complete node removal around the distal pancreas and at the splenic hilum, pancreaticosplenectomy was considered essential (Fig. 1.16a). However this procedure had a high risk, and it produced various pancreas-related complications and elevated mortality rate.