



SPECIAL ARTICLE

The art of pancreatic surgery. Past, present and future. The history of pancreatic surgery[☆]



El arte de la cirugía pancreática. Pasado, presente y futuro

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Introduction

Pancreatic surgery is very often required to treat many pancreatic diseases. This has always represented a challenge for the surgeon, from the first animal tests to pancreas transplantation. These difficulties have arisen due to the complexity of the various surgical techniques—including resection—and the problems associated with the different anastomosis that must be performed for the subsequent reconstruction of the digestive system. Moreover, it has been observed throughout history that the type of surgery must be adapted to the condition, be it cancer, acute or chronic pancreatitis or cysts. Pancreatic surgery continues to be technically complicated and requires significant experience and good clinical judgement. It should be performed by referral centres that conduct at least 50 procedures per year, particularly resections, to guarantee a positive outcome.¹

Besides the technical difficulties that the various pancreatic diseases entail, other historical problems affecting surgery in general, not least pancreatic surgery, have been overcome with the discovery of anaesthesia, the implementation of aseptic measures, identification of the blood groups and the creation of blood banks (to compensate for

the significant blood loss that can arise from this type of surgery), vitamin K synthesis (which has shortened surgery to a single stage in cases of jaundice) and the creation of intensive care units (which have improved the poor post-operative outcomes of these patients).²

This article describes how surgery to treat the various pancreatic diseases has evolved over the last 175 years or so, a period of time which has seen major advances in the optimisation of the different surgical techniques in this field. The paper is divided into different sections based on the complexity of the procedures, with each section arranged in chronological order as is the custom in all historical accounts.

The beginning

Drainage of cystic lesions

The world's first reported operation on the human pancreas concerns large cysts and dates back to November 1841 when Friedrich Wilhelm Wandsleben (Sobernheim [Germany] 1800–1868), a doctor from the small German town of Stromberg, drained a pseudocyst secondary to a non-penetrating abdominal trauma in a previously healthy 28-year-old man with a two-week history of a palpable abdominal mass. Pus and watery fluid exuded from the incision. The patient survived for five months before dying of respiratory failure.³ In 1862, Auguste Le Dentu (Basse-Terre

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[French Guadeloupe] 1841–1926) performed the percutaneous drainage of a large cyst in Paris.⁴

Years later, in 1881, Carl Thiersch (Munich [Germany] 1822–1895) published the first known case of a pancreatic surgery survivor. Cyst drainage was performed on a 38-year-old man, from whom three litres of a chocolate-coloured liquid were drained, with a persistent fistula from the pancreatic tail.⁵ Given the lack of a history of trauma, this cyst may have been a complication of acute pancreatitis, making this procedure one of the first surgical treatments of this disease. In the same year, Diedrich Kulenkampff, a surgeon from Bremen, Germany, performed what can be considered the first biochemical diagnosis of a pancreatic cyst in humans. Having drained a traumatic cyst, he observed how the fistula had macerated the skin. He tested the liquid obtained, which he found to be alkaline, with a high protein content (heat precipitation) and capable of hydrolysing starch, proteins and fats in the absence of bile.⁶ Karl von Rokitansky (1804–1878), a Viennese gynaecologist originally from Bohemia, performed a cystostomy, but his patient died of sepsis 10 days later. On 2 December 1881, while working at the Women's Hospital in New York, Nathan Bozeman (1825–1903), also removed a cystic tumour from a 41-year-old woman with a suspected diagnosis of a giant ovarian cyst. He found the cyst to be hanging from the pancreatic tail, draining five litres of a brownish liquid. The patient was discharged healthy 38 days later.⁷

In December 1882, Karl Gussenbauer (1842–1903), a disciple in Vienna of Theodor Billroth, conducted the first preoperative diagnosis of a pancreatic cyst and described the first percutaneous drainage by marsupialisation of a cyst of the abdominal wall. The patient survived for more than eight years. Gussenbauer went on to perform a further three similar operations during his lifetime. His technique was the gold standard for the treatment of pancreatic cysts until the 1920s and continued to be used until 1950.⁸

In 1887, August Socin (Vevey [Switzerland] 1837–1899), professor of surgery in Basel, drained a pancreatic cyst that was causing bowel obstruction in a 45-year-old woman, who died 24 h after the operation. The cyst was found to be a haematoma of the head of the pancreas, probably secondary to acute pancreatitis.⁹

It was not until 1898 that the German surgeon Werner Körte (Berlin [Germany] 1853–1937) successfully differentiated true pancreatic cysts from pseudocysts and cystic tumours for the first time, marking a huge step forward in our understanding of these lesions.¹⁰

The operation performed by Gussenbauer triggered a dramatic increase in the number of operations performed on the various cystic forms. In the year 1900 alone, 149 cases of surgery on cysts, pseudocysts and cystic tumours were described: 19% mortality in cases of resection was reported, dropping to 3% for marsupialisation.

By means of experimental studies and clinical research, Nicholas Senn (Sevelen [Switzerland] 1844–1908), who emigrated to the USA at the age of eight and worked at the Rush Medical College of Chicago, observed how the percutaneous drainage of pancreatic cysts severely injured patients' skin.¹¹ This observation was taken into account by Louis Ombrédanne (Paris [France] 1871–1956), a surgeon of the *Hôpital des Enfants Malades*, when he performed the first

internal anastomosis of a pseudocyst by means of the first pancreatic cystoduodenostomy in 1911, although the patient unfortunately died eleven days after the procedure.⁹

This triggered the trialling of different types of internal anastomosis, which were gradually found to reduce the risk of infection. In 1921 in Prague, Rudolf Jedlicka (Lysá nad Labem [present-day Czech Republic] 1869–1926) performed what is considered to be the first pancreatic cystogastrostomy¹² (Fig. 1). He resected most of the cyst and anastomosed the remnants to the posterior gastric wall. In 1923, the German surgeon Adolf Henle (1864–1936) performed a cystojejunostomy, although some authors attribute the first published procedure of this kind to O. Hahn in 1927.¹³ Four years later, Anton Jurasz (1882–1961), professor of surgery at the University of Poznan (Poland), published the first transgastric pancreatic cystogastrostomy, performing an anastomosis between the wall of the cyst and the posterior gastric wall.¹⁴ This technique, known as the Jurasz procedure, became the standard approach for the treatment of mature pseudocysts in contact with the stomach due to its practically complication-free postoperative course.¹⁵

Then in 1946, E. Köning combined Roux-en-Y anastomosis with the pancreatic cystojejunostomy technique proposed by Henle, which reduced the risk of infection by preventing the regurgitation of the intestinal contents inside the cyst.¹⁶ Use of the Roux-en-Y procedure had been proposed by Cesar Roux (Mont-la-Ville [Switzerland] 1857–1934) in 1897 for gastric cancer surgery, before being applied to other types of gastrointestinal surgery.¹⁷ In 1994, Constantine T. Frantzides of Rush University in Chicago proposed a laparoscopic approach to drain pseudocysts having successfully performed a laparoscopic pancreatic cystojejunostomy, thereby minimising surgical discomfort.¹⁸

Some years previously, non-surgical endoscopic and radiological approaches for pseudocyst drainage had been put



Figure 1 Rudolf Jedlicka, Czech surgeon who, in 1921, performed what is believed to be the first pancreatic cystogastrostomy.

forward. For example, in 1975 B.H. Rogers of the University of Chicago described the first transgastric needle aspiration of a pseudocyst through the biopsy channel of an endoscope in a woman with a history of alcoholism.¹⁹ In 1989, M. Cremer of *Hôpital Erasme* in Brussels published his experience of pseudocyst drainage by the endoscopic puncture placement of stents through the posterior gastric or duodenal wall.²⁰ Later, H. Grimm of the University Hospital of Hamburg demonstrated the utility of endoscopic ultrasound in identifying the optimal pseudocyst puncture site close to the gastric or duodenal wall, practically eliminating the risk of puncture-related bleeding.²¹ Years before, Hancke et al.²² had demonstrated the utility of ultrasound-guided percutaneous drainage and Van Sonnenberg et al.²³ of computed tomography-guided percutaneous drainage in Copenhagen and San Diego, respectively.

Developments in acute pancreatitis

The debate concerning the benefits of the medical or surgical treatment of acute pancreatitis has raged for many years, including the virtues of early versus late surgery. This discussion dates back to the end of the 19th century to the time of Reginald Fitz and Nicholas Senn, two of the pioneers who described the symptoms and clinical course of this disease for the first time. In 1886, Senn deemed surgery during the early stages of the disease to be ineffective as well as risky.¹¹ However, some years later, Fitz concluded that surgery was a satisfactory treatment during the initial phase.²⁴ Common thinking at the beginning of the last century held that surgery was the best treatment. As such, Arthur William Mayo-Robson (Filey [Great Britain] 1853–1933), Johann von Mickulicz Radecki (Czerniowce [Bukovina, present-day Ukraine] 1850–1905) and particularly Berkeley Moynihan (Malta, 1865–1936) started performing laparotomies with drainage of the lesser sac and gas insertion to effectively clean the pancreatic necrosis and prevent the false closure of the originating cavity.²⁵ Despite its mortality rate in excess of 50%, surgery remained the treatment of choice until the 1930s.

After reviewing 307 cases of pancreatitis, in 1948 John R. Paxton and J. Howard Payne (Los Angeles [USA]) brought to light the poor survival rate of patients after early surgery, which led to the procedure being deemed unnecessary and detrimental.²⁶ In light of poor outcomes following medical treatment, surgeons started re-evaluating their procedures in the 1960s and surgery was once again indicated in the initial stages of the disease. However, given the persistent high mortality rates, pharmacological treatments continued to be trialled and a series of prospective studies conducted in the 1980s showed that the conservative treatment of patients with sterile necrosis could be superior to surgery and that delaying surgery would lead to improved outcomes. This finding marked another change in the therapeutic strategy of this condition. Debridement, sequestrectomy and lavage (continuous or intermittent),²⁷ as well as so-called 'open-packing',²⁸ were proposed in the treatment of infected necrosis. The approach was either abdominal or translumbar.^{27,29}

In 1979, Stephen G. Gerzof of the Veterans' Hospital in Boston made an important breakthrough by demonstrating the utility of drainage of abdominal abscesses guided by ultrasound and computed tomography. In 1987, he went on to implement ultrasound-guided and computed tomography-guided aspiration and the subsequent culture of peripancreatic tissues and collections, which facilitated early diagnosis of the infection.^{30,31}

At the beginning of this century, Pamoukian and Gagner of the New York Mount Sinai Medical Center published the advantages of laparoscopic necrosectomy,³² followed a few years later by the publication by Seifert et al., from Frankfurt's Goethe University Hospital, of a multicentre study with a caseload of 93 endoscopic necrosectomies, although 4% of patients ended up needing open surgery.³³

Adults

Resection and anastomosis techniques

Resection techniques represent another rung on the complexity ladder of pancreatic surgery, particularly solid or cystic tumour surgery, as well as surgery for chronic pancreatitis. As well as the difficulty of the resection techniques themselves, the problem of how to resolve the various anastomoses required to restore digestive continuity in order to prevent certain complications such as different types of fistula (pancreatic, biliary and enteric), must also be taken into account.

The first resection ever recorded dates back to 1867 when the German George Albert Lücke (1829–1884) (the teacher of Emil Theodor Kocher, who would become the first surgeon to win the Nobel Prize in Physiology or Medicine in 1909 for his work on the thyroid gland) performed the first successful removal of a pancreatic cystic tumour in Bern.^{4,34} The second resection ever recorded took place in July 1882 when another German, Friedrich Trendelenburg (Berlin [Germany], 1844–1924) resected a small solid tumour of the pancreatic tail in a 41-year-old female patient. It seems that a distal pancreatectomy with splenectomy was performed due to a surgical lesion of the spleen. The proximal pancreas was closed by ligation. The anatomical pathology suggested spindle cell carcinoma.⁴ The patient died of respiratory failure.

In the same year, Alexander von Winiwarter (1848–1917), student of Theodor Billroth, conducted the first palliative operation of obstructive jaundice secondary to pancreatic adenocarcinoma by performing an anastomosis between the gallbladder and the colon.³⁵ Then in 1887, Otto Kappeller (1841–1909) in Switzerland and Nestor Monastyrski in Russia separately performed the first palliative cholecystojejunostomy due to jaundice in pancreatic cancer.^{36,37} In 1904, Ambrose Monprofit (Saint Georges sur Loire [France] 1857–1922) performed the first Roux-en-Y cholecystojejunostomy,³⁸ and four years later the Swede Robert Dahl performed a Roux-en-Y hepaticojejunostomy.^{39,40} In 1889, Louis Felix Terrier performed the first cholecystoduodenostomy and, in 1891, Oskar Sprengel de Dresde conducted the first successful choledochoduodenostomy.⁴¹ These techniques made it possible to perform the resection of the head of the



Figure 2 Theodor Billroth, father of modern abdominal surgery, operating at the General Hospital (*Allgemeines Krankenhaus*) of Vienna. Oil painting by Adalbert Seligmann painted in 1890. *Österreichisches Galerie Belvedere* (Vienna).

pancreas, together with the portion of the intrapancreatic bile duct.

According to the anecdotal contribution of the British surgeon Arthur W. Mayo Robson in a presentation delivered to the International Congress of Medicine in Paris in 1901, the Viennese surgeon Theodor Billroth (Bergen auf Rügen [Prussia, modern-day Germany] 1829–1894) (Fig. 2), considered to be the father of modern abdominal surgery, as well as an amateur pianist and violinist and a close friend of Johannes Brahms,⁴² successfully performed a total pancreatectomy in 1884.⁴³ One year later, Billroth performed what is considered to be the first central pancreatectomy by removing a large pancreatic cyst but without closing the remaining pancreas. In September 1889, Giuseppe Ruggi (Bologna [Italy] 1844–1925) performed the first enucleation of a pancreatic mass, which turned out to be an adenocarcinoma, in a 50-year-old woman with an epigastric tumour.

On 9 February 1898 at Imola Hospital (Bologna), Alessandro Codivilla (Bologna [Italy] 1861–1912) performed the first pancreaticoduodenectomy on a 46-year-old man with a 20-day history of abdominal distension and vomiting. While conducting the laparotomy, he observed a tumour affecting the head of the pancreas and the distal part of the stomach. He resected most of the duodenum, the distal part of

the stomach and the head of the pancreas en bloc. During the procedure he closed the pylorus, invaginated the distal part of the duodenum and performed a Roux-en-Y gastroenterostomy. The tumour turned out to be pancreatic cancer and the patient died 24 days later. The autopsy revealed metastatic dissemination.^{44,45}

Coincidentally, five days after Codivilla's surgery, William Stewart Halsted (New York [USA] 1852–1922) performed the first resection of a papillary carcinoma in a 60-year-old woman with a six-month history of 'silent jaundice' at Johns Hopkins Hospital in Baltimore. He performed a transduodenal papillotomy with anastomosis of the bile and pancreatic duct, as well as a cholecystectomy.^{45,46}

In 1903, in his book entitled *Mobilisierung des Duodenum*, the aforementioned Nobel prizewinner Emil Theodor Kocher (Burgdorf [Switzerland] 1841–1917) described the surgical manoeuvre that bears his name and is still used today, also known as 'mobilisation of the duodenum'. The technique ensures excellent visibility of the head of the pancreas and greatly facilitates pancreatic surgery.⁴⁷

The first resection of the head of the pancreas with ligation of the pancreatic duct was performed by Domenico Biondi (Calvizzano [Italy] 1855–1914) in 1904. He is therefore considered one of the pioneers in the management of the pancreatic remnant. He removed a fibroadenoma from the head of the pancreas and carried out a reapproximation of the duodenum and the residual pancreas. The patient initially manifested a biliary fistula and then a pancreatic fistula, both of which resolved themselves.⁴⁸ Another pioneer in the management of the pancreatic remnant was Carl Garré (Bad Ragaz [Switzerland] 1857–1928), a student of Robert Koch and Theodor Kocher, who performed complete ligation in the case of a non-penetrating trauma with total separation of the pancreatic borders in 1905. Unlike the pancreatic duct, which developed a fistula that took two months to resolve, the borders were reapproximated and closed with silk sutures. In Paris in 1907, Abel Desjardins published a pancreaticojejunostomy technique with double-layer end-to-end invagination, similar to the telescopic method used today.⁴⁹

In 1909, Walther Kausch (Königsberg [Prussia, now Kaliningrad in Russia] 1867–1928) had a breakthrough in the treatment of tumours of the head of the pancreas, successfully performing in Berlin the first documented pancreaticoduodenectomy using the Kocher manoeuvre in a 49-year-old patient with papillary carcinoma. The operation was performed over two sessions as the patient had jaundice and a bleeding problem (vitamin K would not be synthesised until 1939).² Jaundice was resolved first by conducting a cholecystojejunostomy, performing the resection six weeks later, which involved the removal of the head of the pancreas, part of the stomach, the first and second duodenal portions, the common bile duct and the gallbladder. A pancreatic fistula developed as a complication, which resolved itself. However, the patient died nine months later after numerous episodes of cholangitis.^{50,51}

In 1912, Georg Hirschel from Heidelberg performed a pancreaticoduodenectomy with terminolateral anastomosis in a single session. The patient died one year later, although the cause of death is unknown.

In 1926, Russell M. Wilder (Cincinnati [USA] 1885–1959), who went on to be a member of the Archives of Internal Medicine editorial board from 1932 to 1953 and a prominent doctor and researcher, asked William James Mayo (Le Sueur [USA] 1861–1939), founder of the Mayo Clinic in Rochester together with his brother Charles Horace and another five doctors, to operate on a 40-year-old patient (a surgeon) who manifested frequent episodes of unconsciousness that resolved themselves by eating sugar. Mayo performed what is considered the first published case of resection of a pancreatic neuroendocrine tumour. The tumour was found to be islet cell carcinoma with liver, lymph node and mesenteric metastases. The patient sadly died one month after the procedure.⁵²

On 15 March 1929 in Toronto, Roscoe R. Graham (Lobo [Canada] 1890–1948) successfully performed the first enucleation of an insulinoma on a 52-year-old woman, based solely on the patient's symptoms (recurrent episodes of hypoglycaemia, seizures and coma) and physical findings.⁵³ The tumour had first been described by Nicholls in 1902.⁵⁴

In 1935, Allen Oldfather Whipple (Urmia [Persia, present-day Iran] 1881–1863 [*sic*: 1963]) performed a partial resection of the pancreas over two sessions in a patient with jaundice secondary to ampullary carcinoma at New York-Presbyterian Hospital. A gastroenteroanastomosis and a cholecystogastrostomy were performed during the first session, followed four weeks later by a duodenal resection, with partial preservation of the pylorus, v-shaped excision of the head of the pancreas and suture of the duct.⁵⁵ Two years later, Alexander Brunschwig (El Paso [USA] 1901–1969) performed the first anatomical resection with total removal of the head of the pancreas to the right of the superior mesenteric vein at the University of Chicago Medical Center. The pylorus-preserving procedure was conducted over two stages. The patient had an invasive tumour of the head of the pancreas.⁵⁶ In 1940, Whipple was again the first to perform a pancreaticoduodenectomy with resection of the pancreas in a single session, as the patient was not jaundiced. The pre-operative diagnosis was carcinoma of the antrum, but the surgical specimen confirmed that it was carcinoma of the head of the pancreas. The procedure consisted of a partial gastrectomy, total duodenectomy, removal of the head and part of the body of the pancreas, terminolateral anterior gastroenterostomy and biliary enteroenterostomy.⁴⁵ From that moment, the technique became known as the Whipple procedure. Throughout his life, Whipple performed 37 pancreaticoduodenectomies, 30 for carcinoma and seven for chronic pancreatitis, marking the birth of the modern-day technique for resecting the head of the pancreas, which is why he is considered the father of pancreatic surgery.^{47,57,58}

On 15 July 1942, at the Mayo Clinic in Rochester, USA, James T. Priestley (1903–1979) performed the first total pancreatectomy due to hyperinsulinism on a 49-year old woman as he was unable to find the tumour during the laparotomy. The patient survived five years.⁵⁹ This same procedure had been performed unsuccessfully by Eugene W. Rockey three weeks previously.⁴³

In the 1940s, Oscar T. Clagett (1908–1990) performed a total pancreatectomy to treat pain in a patient with chronic pancreatitis. Together with John M. Waugh, they are

believed to have been the first to conduct a pancreaticogastrostomy following a cephalic duodenopancreatectomy at the Mayo Clinic in Rochester in 1944. Two years later, they published their experience of 30 cases treated using this technique.⁶⁰ This technique involved reduced risk of fistula, probably due to inactivation of the pancreatic enzymes by the gastric acid. Since then, various series with minor modifications to the original technique have been published. In 2008, Laureano Fernández-Cruz (Santiago de Compostela [Spain] 1945-) published a study, conducted at Hospital Clínic de Barcelona, which randomised 108 patients with different benign or malignant lesions of the head of the pancreas and periampullary region. All underwent cephalic pylorus-preserving pancreaticoduodenectomy, but one group then underwent pancreaticogastrostomy with gastric partition, while the other underwent terminolateral pancreaticojejunostomy. Fernández-Cruz found that the first group presented with fewer postoperative complications and fistulae.⁶¹

In 1944, Kenneth Watson published a case of carcinoma of the ampulla of Vater in a 43-year-old woman, which was successfully treated with pylorus-preserving pancreaticoduodenectomy.⁶² However, it was not until 1978 that Louis W. Traverso and William P. Longmire from the University of Los Angeles reported having reduced the length of the operation, the length of hospital stay and improved food tolerance with this technique.⁶³ In 1947, Richard B. Cattell (Martins Ferry [USA] 1900–1964) devised lateral pancreaticojejunostomy with T-tube drainage for patients with unresectable pancreatic cancer.⁶⁴

In 1951, the aforementioned William P. Longmire performed a caudal pancreatectomy and side-to-side pancreaticojejunostomy, a technique that would be popularised by Merlin DuVal three years later to treat pain caused by recurrent chronic pancreatitis. However, this procedure was only effective when there was a single stenosis in the duct of Wirsung, which occurs rarely.⁶⁵

In 1958, Charles B. Puestow (1902–1973) and William T. Gillesby (1905–1989), surgeons at the Hines Veterans Hospital (Illinois), published their experience on the outcomes of a new surgical procedure performed on 21 patients with recurrent alcoholic chronic pancreatitis for the treatment of pain, with dilatation of the pancreatic duct showing a chain-of-lakes appearance whereby the pancreatic duct is completely drained to the intestine. They devised and performed a lateral pancreaticojejunostomy with latero-lateral anastomosis, achieving better outcomes. The technique consists of a longitudinal incision along the anterior face of the duct of Wirsung, onto which a longitudinally opened defunctionalised jejunal loop is sutured. Resection of the tail of the pancreas and splenectomy were also added.^{66,67}

In 1960, while working at the Veterans Hospital in Cleveland (Ohio), Philip F. Partington and Robert E. L. Rochelle published the results of a surgical procedure, which was a modification of the technique described by Puestow-Gillesby two years earlier. This procedure negated the need for splenectomy and resection of the tail of the pancreas. They performed a latero-lateral pancreaticojejunostomy (longitudinal opening of the duct of Wirsung to 1 cm from the duodenal margin followed by Roux-en-Y latero-lateral anastomosis with defunctionalised jejunal loop).⁶⁸

In 1980, Hans Beger (Meissen [Germany] 1936-), professor of surgery at Ulm University Hospital, devised the Beger procedure—duodenum-preserving pancreatic head resection. The procedure negates the need for biliary anastomosis while reducing the aggressiveness of the surgery and avoiding complications. It is used in the treatment of chronic pancreatitis.⁶⁹

While working as a surgeon in Sacramento (California) in 1987, Charles Frederick Frey (New York [USA] 1929-) performed and published what was to become known as Frey's procedure for the treatment of pain in chronic pancreatitis. The procedure involves the focal resection of the head of the pancreas followed by a lateral pancreaticojejunostomy of the body and tail.⁷⁰

In 1988, Andrew L. Warshaw of Massachusetts General Hospital in Boston described a new spleen-preserving distal pancreatectomy technique (the Warshaw procedure). The technique involves separating the pancreas from the spleen and ligation of the splenic artery and vein at the end of the pancreas, so that the spleen is fed through the short gastric and gastroepiploic vessels on the left side. This quick and safe procedure can be used to treat pancreatitis, tumours and trauma.⁷¹

Minimally invasive surgery

The first laparoscopic procedure involving the pancreas was reported by Bertram M. Bernheim (Paducah [USA] 1880–1958) at John Hopkins University in 1911.⁷² In 1978, Albert Cuschieri (Malta, 1938-) of the University of Dundee (United Kingdom) published an article describing the role of laparoscopy in the diagnosis and treatment of pancreatic carcinoma.⁷³ In 1996, he published the first series of five chronic pancreatitis patients with medically intractable pain who had undergone laparoscopic distal 70% pancreatectomy and splenectomy.⁷⁴ In the same year, Luigi A. Sussman published the first case of laparoscopic excision of distal pancreas including insulinoma at Waikato Hospital in Hamilton (New Zealand).⁷⁵ Two years earlier, Michel Gagner (Montreal [Canada] 1960-) performed the first laparoscopic pancreaticoduodenectomy in a case of chronic pancreatitis with pancreas *divisum* at Hôtel-Dieu de Montréal.⁷⁶ In 1995 in Sacramento (USA), Katsumi Amikura⁷⁷ performed the first laparoscopic enucleation of an adrenocorticotrophic hormone-producing islet cell tumour of the pancreas. Laparoscopic surgery has also been used to treat acute pancreatitis. Laparoscopic or retroperitoneal necrosectomies (percutaneous or endoscopic), as well as transluminal endoscopic necrosectomies, have been performed since the 1990s.⁷⁸ It has been shown that the laparoscopic approach minimises surgery-related trauma by reducing the patient's pain, shortening his/her hospital stay and ensuring quicker postoperative recovery. The duration of the operation is the same or longer than open surgery, but with less blood loss.⁷⁸

Other techniques. Removal of pancreatic duct stones, sphincterotomy and pain treatment

As well as some of the procedures described above, other pain management techniques in the treatment of chronic

pancreatitis pain have also been used without requiring resection. These include the various methods used to remove stones from inside the pancreatic duct, sphincterotomy and splanchnic nerve section.

Removal of pancreatic duct stones

In 1891, Alfred Pearce Gould (Norwich [Great Britain] 1865–1922) was the first surgeon to remove stones from the duct of Wirsung at Middlesex Hospital, London. In 1902, Berkeley G. A. Moynihan performed the first transduodenal removal of pancreatic duct stones in Leeds. Then, in 1908, Mayo-Robson proposed the first transpancreatic stone extraction, a technique that was widely used until the development of the fibre-optic endoscope in 1958 by Basil Isaac Hirschowitz (Bethal [South Africa] 1925–2013).^{9,47,79} In 1966, William C. Watson of the Glasgow Royal Infirmary published his endoscopic observations, concluding that the technique was useful for the diagnosis of biliary and pancreatic disease.⁸⁰ He subsequently succeeded in improving accessibility to the pancreas by papillotomy with loop diathermy, thereby facilitating the removal of stones, dilatation of the duct of Wirsung, stent placement, etc.

The surgical procedures referred to above by DuVal, Puestow-Gillesby, Partington-Rochelle and Frey can also be used to remove pancreatic duct stones.

Sphincterotomy

The first classic sphincterotomy ever performed is attributed to Edward W. Archibald (Montreal [Canada] 1872–1945). Conducted in 1919, it was based on experimental studies on the effect of pressure on the sphincter of Oddi in the development of pancreatitis,⁸¹ which in turn were based on Eugene L. Opie's (Staunton [USA] 1873–1971) common channel hypothesis. Then, in 1956, Henry Doubilet and John H. Mulholland from the New York University College of Medicine contributed their extensive knowledge on this type of technique with the publication of their eight-year study.⁸²

Splanchnic nerve section

More conservative treatment techniques to manage chronic pancreatic pain have sometimes been used after partial pancreatic resections or if a less aggressive approach is considered prudent in certain patients. In 1943, Pierre A. Mallet-Guy (1897–1995) was the first person to perform a unilateral left splanchnicectomy to treat pancreatic pain, going on to publish the results of 70 cases of recurrent chronic pancreatitis seven years later.^{83,84} In 1947, G. de Takats and L. E. Walter published the excellent results they obtained having performed this surgery on two patients.⁸⁵ W. E. Rienhoff and B. M. Baker were the first to perform a bilateral splanchnicectomy from the fifth thoracic lymph node to the second lumbar vertebra, with a bilateral vagotomy.⁸⁶ In 1997, Toshiomi Kusano et al. from the University of the Ryukyus (Okinawa, Japan) published their experience of nine cases of chronic pancreatitis with intractable pain who had undergone thoracoscopic thoracic splanchnicectomy with resection and electrocoagulation of the fifth to ninth thoracic lymph nodes. Five unilateral and four bilateral procedures were carried out, with good outcomes after 24 months of follow-up.⁸⁷

Percutaneous methods⁸⁸ and, more recently, endoscopic ultrasound,⁸⁹ have also been used to locate and block the coeliac plexus.

Maturity

Vascularised pancreatic islets transplantation

The aim of a pancreas transplantation was traditionally to control carbohydrate metabolism and to prevent or improve its associated vascular complications (renal vasculopathy, retinopathy and gangrene of the lower limbs). Research into pancreas transplant techniques has looked to sufficiently preserve the endocrine function of the pancreas for diabetes control, prevent thrombosis of the vascular pedicle and establish good drainage of pancreatic exocrine secretions. Immunosuppressive therapy has also played a key role in transplant success.

The first attempt dates back to London in 1893 when P. Watson Williams treated a 15-year-old boy with diabetic ketoacidosis with subcutaneous xenotransplantation of a portion of a sheep's pancreas. The boy died of a diabetic coma three days later.⁹⁰ In 1927, R. Gayet and M. Guillaumie⁹¹ in France, and, two years later, Bernardo Housay (Buenos Aires [Argentina] 1887–1971),⁹² who would go on to win the Nobel Prize in Physiology or Medicine in 1947, conducted vascularised pancreas and duodenum transplants in dogs whose blood glucose could be controlled for longer than 12 h. In the 1950s, many scientists, including J. Brook, L. DeJode and D. Dreiling, conducted numerous animal studies, but it was the Swiss Felix Largiadèr (1930-) who performed the first successful orthotopic transplantation in dogs in 1967.⁹³ In the same year, William D. Kelly (Saint Paul [USA] 1922–2006) and Richard C. Lillehei (1928–1981) from the University of Minnesota published a description of the first simultaneous kidney and pancreas transplant from a cadaver donor in a 28-year-old woman, performed the previous year (Fig. 3). The pancreas was implanted in the left iliac fossa with anastomosis to the coeliac trunk and the portal vein of the common iliac vessels. The pancreatic duct was ligated and the patient irradiated with cobalt (950 rads) to stop exocrine secretion. Azathioprine (marketed in 1962) and prednisone were administered as immunosuppressive therapy. The patient died of a pulmonary embolism three months after the procedure.⁹³ Also in 1966, R. Lillehei performed the second ever total kidney and pancreas transplant in a 32-year-old woman. The coeliac trunk, superior mesenteric artery and portal vein were anastomosed to the left common iliac vessels. The pancreas and the duodenum were implanted into the left iliac fossa employing an extraperitoneal approach. The immunosuppressants azathioprine and prednisone were administered without cobalt therapy.⁹⁴ The outcome of both these and subsequent attempts were not satisfactory.

The main problem to overcome was how to establish adequate drainage of pancreatic exocrine secretions to minimise their corrosive action. In 1973, Marvin Gliedman from New York's Montefiore Medical Center conducted a segmental pancreatic transplantation with ureter-pancreatic duct

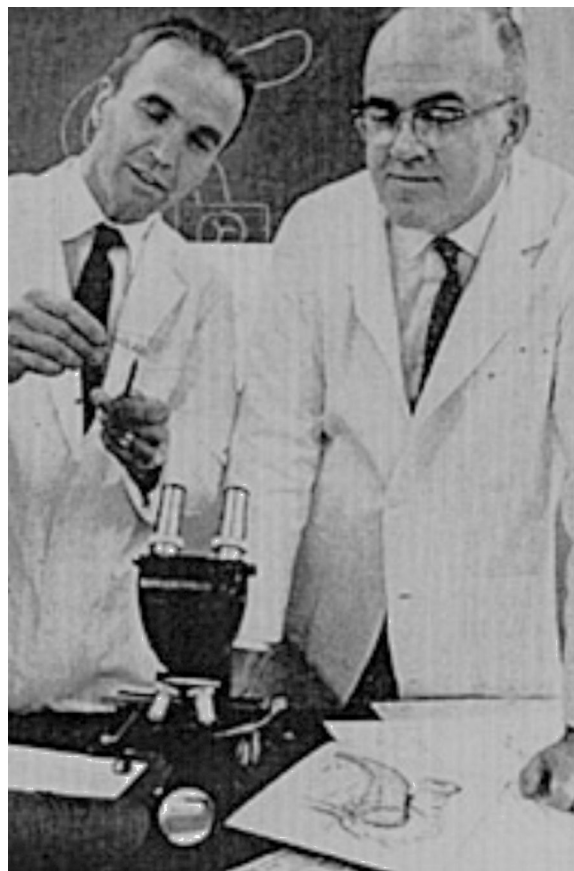


Figure 3 Richard C. Lillehei (left) and William D. Kelly, who performed the first simultaneous kidney and pancreas transplant from a cadaver donor at the University of Minnesota on 16 December 1966.

anastomosis, also administering the immunosuppressants azathioprine and prednisone.⁹⁵ That same year, F. K. Merkel published a segmental pancreatic transplantation with terminolateral duodenojejunostomy.⁹⁶

In 1979, George K. Kyriakides of the University of Miami demonstrated in pigs that drainage of pancreatic secretions to the free abdominal cavity did not cause complications.⁹⁷ In light of these findings, in Minnesota David E. Sutherland performed a segmental pancreatic transplantation in five patients with drainage of the pancreatic duct to the peritoneal cavity, observing fibrosis, adhesions and, in some cases, bowel obstruction.⁹⁸ It was later confirmed that this technique was not superior to simple duct ligation. At almost exactly the same time, in Lyon, Jean M. Dubernard devised a chemical sealing technique of the duct of Wirsung using a polymer (neoprene).⁹⁹ Although this technique was used for many years, in the long term the injection of the polymer was found to cause periacinar fibrosis, leading to islet cell degeneration. In 1980, Sutherland published the first series of segmental pancreatic transplants with living donors.¹⁰⁰

The marketing of a new immunosuppressant—cyclosporin—in 1982 represented an important step forwards in rejection control.¹⁰¹

In 1983, K. Cook drained pancreatic exocrine secretions to the bladder.¹⁰² This technique was subsequently modified by Hans Sollinger of the University of Wisconsin by using a duodenal patch for anastomosis. These techniques facilitated the monitoring of urinary amylase levels, thereby predicting rejection.¹⁰³ However, this type of anastomosis was not without its metabolic (dehydration and acidosis) and urological complications. As a result, duodenojejunal anastomosis, first proposed in 1973 by F. K. Merkel, once again became the approach of choice for many surgeons in the 1990s, as the enteric drainage of pancreatic secretions is the most physiological technique.⁹⁶ In 1983, Laureano Fernández-Cruz of the Hospital Clínic of Barcelona was the first to apply this major advance in Spain.

In 2001, Rainer W. Gruessner of the University of Minnesota performed a laparoscopic simultaneous nephrectomy and distal pancreatectomy from a living donor.¹⁰⁴

Islet cell transplantation

Some authors believed that blood glucose levels could be controlled merely by the transplantation of sufficient numbers of pancreatic islet cells. This was the premise upon which Moskalewski used collagenase to isolate intact islet cells from the pancreatic tissue of Guinea pigs in 1965.⁴⁵ In 1972, Ballinger and Lucy demonstrated that islet cells isolated from adults could lead to a long-term improvement in experimental diabetes induced in rats.⁹ The implantation of these cells was trialled in various organs, but it was Velimir Mirkovitch who observed in Lausanne (Switzerland) in 1976 that experimental diabetes induced in dogs by pancreatectomy could improve with the implantation of islet cells in the spleen.¹⁰⁵ One year later, John S. Najarian, head of surgery at the University of Minnesota, used tissue from islet cells isolated from a cadaver in a diabetic patient with chronic pancreatitis.¹⁰⁶

Nevertheless, it was found that only 10% of these patients did not require insulin within five years of the transplant. There are also other limitations, such as the limited number of cells that can be obtained from each donor (2.5 donors are required per recipient), poor reproducibility in terms of the quality and quantity of cells isolated from cadavers and the need for long-term immunosuppressive therapy. As a result, islet cell transplantation can only be offered to a small number of patients.^{107,108}

The future

Robot-assisted surgery has been gradually introduced in state-of-the-art centres over the last few years, but has only recently started to be used in pancreatic surgery. It offers numerous advantages, such as 10× magnified high-definition 3D vision, elimination of hand tremors which improves precision of movement, and the ergonomic design of the console, which reduces surgeons' muscle fatigue. The biggest published series of 250 robotic pancreatectomies shows similar postoperative mortality rates, morbidity and conversion to open surgery as conventional laparoscopic surgery performed at referral centres.¹⁰⁹ Nevertheless, oncological resections (negative resection margins, removal of lymph

nodes) seem to be improved with robotic surgery.¹¹⁰ This will result in more patients with pancreatic malignant tumours who can receive adjuvant therapy. However, given that experience published to date is limited, definitive conclusions can only be drawn once use of the technique has become more widespread.^{111,112}

Conflicts of interest

The author declares that there are no conflicts of interest.

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