

# Current Status and Perspectives of External Versus Internal Pancreatic Duct Drainage during the Learning Curve of Laparoscopic Pancreaticoduodenectomy

Shicheng Gong, Shijia Li, Shuai Wang\*

Department of Pancreatic and Biliary Surgery, Affiliated Jingzhou Hospital of Yangtze University, Jingzhou, China  
Email: \*2070132881@qq.com

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## Abstract

**Objectives:** To summarize the current status and outlook of pancreatic duct drainage in the learning curve period of laparoscopic pancreaticoduodenectomy (LPD). **Methods:** By searching the literature related to the efficacy analysis of internal versus external pancreatic duct drainage in pancreaticoduodenectomy (OPD) and the learning curve period of laparoscopic pancreaticoduodenectomy in recent years at home and abroad and making a review. **Results:** Because of the complexity of the LPD surgical procedure, the high technical requirements and the high complication rate, it is necessary for the operator and his/her team to carry out a certain number of cases to pass through the learning curve in order to have a basic mastery of the procedure. In recent years, more and more pancreatic surgeons have begun to promote and use pancreatic duct drains. However, no consensus conclusion has been reached on whether to choose internal or external drainage for pancreatic duct placement and drainage in LPD. **Conclusions:** Intraoperative application of pancreatic duct drainage reduces the incidence of pancreatic fistula during the learning curve of laparoscopic pancreaticoduodenectomy. However, external pancreatic duct drainage and internal pancreatic duct drainage have both advantages and disadvantages, so when choosing the drainage method, one should choose the appropriate drainage method in conjunction with one's own conditions, so as to reduce the incidence of complications.

## Keywords

Pancreaticoduodenectomy, Laparoscopy, Pancreatic Duct Drainage, Learning Curve Period

\*Corresponding author.

## 1. Introduction

Laparoscopic pancreaticoduodenectomy (LPD) represents one of the most significant and intricate procedures within the domain of laparoscopic abdominal surgery. In 1994, Gagner *et al.* reported the inaugural case of laparoscopic pancreaticoduodenectomy (LPD), and since then, an increasing number of surgeons have begun to attempt it [1]. In 2003, Lu's team successfully completed the first LPD in China, which marked the official advent of the LPD era in China [2]. Following nearly two decades of investigation and advancement, the evolution of LPD in China has reached a point of significant maturation and notable accomplishment [3]-[5]. An increasing body of clinical evidence has demonstrated the safety and feasibility of LPD, as well as its comparable immediate and long-term efficacy to that of open surgery. Some studies have additionally reported that LPD confers advantages in terms of shorter operation time, faster recovery, longer progression-free survival, and a shorter interval before the commencement of adjuvant therapy following surgery.

At present, laparoscopic pancreaticoduodenectomy (LPD) is becoming increasingly prevalent and sophisticated in tertiary hospitals situated in both provincial and municipal regions. Nevertheless, due to the extensive surgical resection, challenging laparoscopic reconstruction, and necessity for the operator to traverse the learning curve before attaining basic proficiency, LPD remains challenging to perform in local and primary hospitals. In particular, the restricted number of cases at local hospitals and primary hospitals prolongs the surgeon's learning curve, necessitating a greater number of surgical cases. Furthermore, studies have demonstrated that the perioperative mortality rate of LPD is higher than that of open pancreaticoduodenectomy (OPD) during the learning period [6] [7]. In light of these considerations, the question of how to safely and efficiently navigate the learning curve has become an urgent clinical issue. Now, by reviewing the literature related to the learning curve period of laparoscopic pancreaticoduodenectomy (LPD) at home and abroad in recent years, as well as the efficacy analysis of intrapancreatic ductal drainage and extrapancreatic ductal drainage in pancreaticoduodenectomy (OPD), we analyze the advantages and disadvantages of intrapancreatic ductal drainage and extrapancreatic ductal drainage, so as to provide certain references for the application of intrapancreatic ductal drainage in the future learning curve period.

## 2. Learning Curve Period

After a certain number of cases of operation practice, laparoscopic surgery of different surgical results than the previous stage significantly improved, complications reduced, and then reached a more stable state of this initial surgical stage is the learning stage of laparoscopists [8]. Current surgical operation measures the intensity of training required to achieve surgical proficiency (generally the number of surgical cases) primarily through the learning curve. The learning curve of experienced laparoscopists is evaluated based on a number of criteria, including

operative time, intraoperative bleeding, intermediate laparotomy rate, number of lymph nodes cleared (in the case of malignant tumors), intraoperative and postoperative complications, and postoperative hospital stay [9]. The findings of the study on the learning curve of various laparoscopic surgical procedures indicated that: 1) The incidence of surgical complications related to ureteral injuries was reduced from 1% to 0.2% after eight surgical procedures by surgeons with expertise in laparoscopic urological surgery [10]. 2) According to related studies, it has been determined that surgeons require 60 to 90 operations to reach the plateau of the learning curve for laparoscopic surgery for gastric cancer [11]-[13]. 3) Lim *et al.*, in performing laparoscopic comprehensive staging surgery for endometrial cancer, arranged in the order of surgery and counted the operation time, found that the average operation time was 183.2 min for the initial 1 - 20 cases, 152.7 min for the 21 - 40 cases, and 148.8 min for the 41 - 56 cases, and it gradually reached a stable plateau period [14]. Laparoscopic pancreaticoduodenectomy necessitates not only the operator's proficiency in laparoscopic surgical techniques but also a substantial background in open pancreaticoduodenectomy. The length of the learning curve for laparoscopic pancreaticoduodenectomy is primarily contingent upon the clinical experience and operating technique of the specialist. The learning curve for laparoscopic or open pancreaticoduodenectomy varies, with those with experience in laparoscopic or open pancreaticoduodenectomy alone requiring a longer period of training.

A substantial corpus of research literature on the laparoscopic pancreaticoduodenectomy learning curve exists, both domestically and internationally. However, a paucity of literature exists that provides a synthesis of this research. The number of surgical cases required for the learning curve to reach the plateau period varies depending on the surgical style in question. Furthermore, the number of surgical cases needed to reach the plateau period differs depending on the criteria used to define the learning curve. This variability makes it challenging to establish a unified standard. In the existing literature comparing the number of cases required for the learning curve period of LPD, the reported values fluctuate considerably, ranging from 20 to 100 cases [15]-[18]. Nagakawa analyzed data on the results of 150 consecutive cases of LPD performed by three senior Japanese surgeons and divided the learning curve into an initial period (1 - 20 cases), a plateau period (21 - 30 cases), and a stabilization period (30 - 50 cases) [18]. Wang [19] *et al.* analyzed single-center data and concluded that at least 40 cases are required to accumulate a certain level of LPD experience. An analysis of LPD data from the U.S. National Cancer Data Bank revealed that the 30-day mortality rate of patients undergoing LPD in low-flow centers was significantly higher than that of patients undergoing open surgery. Furthermore, even in high-volume centers, surgical outcomes remained suboptimal during the initial learning phase of LPD [20] [21]. In conclusion, a low-flow pancreaticoduodenectomy (PD) center with less than 20 cases per year may require 100 cases to complete the learning curve phase of LPD. However, in a high-volume pancreaticoduodenectomy (PD) center, only 20 cases may be

sufficient [22].

From the above literature reports, it is evident that the application of laparoscopic techniques to pancreaticoduodenectomy is worthy of affirmation, but there are many factors affecting the laparoscopic learning curve, and the assessment criteria for individual choice are not the same. Even for the same surgical procedure, different operators can arrive at different surgical curves due to different knowledge of the biliary system, pancreas, and gastrointestinal tract anatomical structures, different experience in open surgery, and different familiarity with the use of laparoscopic instrumentation.

### 3. Pancreatic Fistula

The incidence of postoperative complications associated with laparoscopic pancreaticoduodenectomy (LPD) is estimated to be as high as 20% to 50% [23], with pancreatic fistula representing one of the most prevalent complications, occurring in 10% to 30% of cases [24]. The mortality rate of patients with postoperative pancreatic fistula is 7% to 10% [25], and the probability of death due to pancreatic fistula-related severe complications is as high as 50% [26]. The risk factors of postoperative pancreatic fistula can be broadly classified into three categories: 1) patient-related factors, including age, degree of preoperative jaundice, nutritional status, and the presence or absence of underlying comorbidities; 2) pancreatic local factors, such as pancreatic texture, blood supply, pathological type, the main pancreatic duct diameter of <3 mm, etc.; 3) surgical-related factors, such as surgical operation defects, Retained pancreatic leptomeninges, improperly spaced pancreatico-enteric and biliary-enteric anastomoses, and so on [27] [28]. Therefore, to safely and effectively pass the learning curve, how to effectively prevent and treat postoperative pancreatic fistula becomes the key.

The prevention of pancreatic fistula encompasses the following elements: 1) Preoperative prevention: ① It is imperative to actively enhance the patient's nutritional status, rectify hypoalbuminemia, address impaired liver function, and address anemia prior to surgery [29]. ② Whether the preoperative yellowing should be reduced and the index of yellowing reduction is still controversial [30]. The doctors are not only against "routine reduction of yellow", but also against "no reduction at all". 2) Intraoperative prevention: ① Anastomosis: according to the positional relationship between the pancreatic stump and the jejunum, it can be divided into end-to-end anastomosis and end-to-side anastomosis; according to whether to restore the continuity of the pancreatic duct and the jejunum mucosa, it can be divided into sleeve anastomosis and pancreatic duct-jejunum mucosa anastomosis; according to the number of layers of sutures, it can be divided into single-layer anastomosis, double-layer anastomosis and triple-layer anastomosis [31]. When choosing the anastomosis, the operator should choose the appropriate anastomosis according to the texture and condition of the pancreas, and pay attention to the principle of individualization. ② Technical level: professional surgeons and selection of skilled anastomosis are the keys to reduce pancreatic fistula.

③ Pancreatic duct stenting and drainage: At present, there is no consensus on whether to choose internal or external drainage for pancreatic duct stenting and drainage in OPD surgery. 3) Postoperative prevention: ① Growth inhibitor and its analogs have been demonstrated to effectively inhibit the exocrine function of the pancreas and reduce the secretion of pancreatic juice. Additionally, they have been shown to inhibit the secretion of gastrin, gastric acid, and pepsin, making them an effective means of preventing and treating pancreatic fistula [32] [33]. They are recommended for routine use in postoperative OPD patients, especially in high-risk patients [34]. ② Postoperative monitoring of drainage fluid. Monitoring amylase levels in drainage fluid after OPD is of great value in preventing pancreatic fistulae [35]. The International Pancreatic Surgery Study Group found that monitoring amylase in drainage fluid from the third postoperative day is an effective method for detecting pancreatic fistulae at an early stage [36].

Treatment modalities of pancreatic fistula: 1) non-surgical treatment: ① The basis of the treatment of pancreatic fistula is smooth drainage, and continuous negative pressure drainage with double cannula flushing is the ideal drainage mode [37]. ② When peripancreatic effusion and abscess caused by pancreatic fistula occurs, ultrasound endoscopy-guided or CT-guided percutaneous drainage can be performed. ③ When infection occurs, broad-spectrum antibiotics are used empirically, and drainage fluid is retained for drug sensitivity testing and bacterial culture, and then a targeted treatment plan is selected based on the results. ④ Improvement of nutritional status after surgery will help the healing of pancreatic fistula, and attention should be paid to controlling blood glucose, correcting hypoproteinemia and anemia, and maintaining water and electrolyte balance. 2) Surgical treatment: when the non-surgical treatment is ineffective, surgical treatment can be chosen. Reoperation modalities include pancreatic function preservation surgery and residual pancreatectomy, and function preservation surgery includes external pancreatic drainage, internal drainage (pancreatic-intestinal reanastomosis, salvage pancreatic-gastric anastomosis), subtotal pancreatectomy and abdominal drainage, etc. [38].

#### 4. Status of Pancreatic Duct Drains

In recent years, an increasing number of pancreatic surgeons have begun to advocate for and utilize pancreatic duct drains in LPD procedures [39]. The reasons that motivate an increasing number of clinicians to utilize pancreatic duct support tubes in surgical procedures can be summarized as follows: Firstly, the pancreatic duct support tube can be utilised as a reference for the operator when performing pancreatico-enteric anastomosis, thus assisting in performing pancreatico-intestinal anastomosis laparoscopically and reducing the probability of pancreatic duct tears, stenosis, and mis-sewing [40]. Secondly, the implementation of a compatible pancreatic duct drain in a suitable patient can prevent the accumulation of pancreatic fluid in the pancreatico-enteric anastomosis and subsequent corrosion of the anastomosis. Additionally, the pancreatic duct stent tube can facilitate

the support of the pancreatic duct, thereby preventing the formation of scar stenosis and promoting the growth of pancreatic duct and jejunal mucosa, which in turn facilitates adhesive healing [41].

While the utilization of pancreatic duct stents in LPD offers numerous benefits, there is currently no consensus regarding the optimal choice between internal and external drainage for pancreatic duct drainage in PD. The majority of reports have indicated that external drainage and internal drainage are equally efficacious in preventing near and long-term complications following PD [42]-[44]. However, several studies have proposed that external drainage may be more effective than internal drainage in reducing the risk of pancreatic fistula [45] [46]. It is postulated that complete drainage of pancreatic fluid via the external drain may prevent premature activation of digestive enzymes and bile within the intestine, thereby reducing the corrosiveness of digestive fluids and decreasing the likelihood of contact with the anastomosis, thus better preventing pancreatic fistula [47]. Furthermore, external pancreatic duct drainage has the potential to not only alleviate the intestinal burden, but also serve as an additional observation index for clinical personnel. Following LPD, medical professionals can utilize the abdominal drainage tube to monitor for any postoperative bleeding in the surgical area and analyze the recovery of the biliary-intestinal anastomosis through the bile duct drainage tube. The postoperative changes of pancreatointestinal anastomosis are often analyzed indirectly by vital signs and changes in the amount of drainage and amylase of the abdominal drainage tube. Subsequently, draining pancreatic fluid to the outside of the body and monitoring the changes in the amount of drainage of pancreatic fluid becomes a reference item for analyzing the healing of pancreatointestinal anastomosis [48] [49]. In instances when there is a notable alteration in the amount of pancreatic fluid drained, it can prompt medical professionals to closely monitor the patient's condition and implement necessary adjustments in treatment.

However, external drainage will lead to a large amount of loss of pancreatic fluid, which will increase the difficulty of the recovery of gastrointestinal function, and at the same time, the exposed catheter makes the chances of abdominal infection increase significantly, and also makes the clinical nursing work more cumbersome. Therefore, in response to these shortcomings of external drainage, some scholars believe that internal drainage has more popularization value. Some studies have shown that internal drainage does not increase the risk of postoperative pancreatic fistula compared with external drainage [50] [51]. At the same time, the application of internal pancreatic duct not only can accelerate the reconstruction of gastrointestinal function, thus reducing the incidence of gastroparesis, but also can avoid the early dislodgement of the drain tube and the pain of carrying the catheter for a long period of time due to the improper postoperative care of external drainage tube. Furthermore, following external pancreatic duct drainage, patients are obliged to return to the hospital one to two months after surgery to have the external drain removed [49] [52]. Nevertheless, there are currently no

standardized criteria for the discussion of the timing of removing the pancreatic duct drain. Once the patient returns to the hospital for the removal of the drain, the healing of the pancreatico-enteric anastomosis is not yet complete. This may result in a pancreatic duct tear during removal, followed by stenosis after tissue repair. Additionally, the formation of abdominal wall sinus tracts may be incomplete after the removal of the drain, which can lead to enterocutaneous fistula in severe cases [53] [54]. In contrast, patients with internal pancreatic duct drainage do not experience the aforementioned complications and only require the internal drainage tube to fall off naturally.

## 5. Prospects for Pancreatic Duct Drains

In recent years, with the development and maturity of medical technology, laparoscopic pancreaticoduodenectomy has become a safe and effective surgical treatment for pancreatic head cancer and other digestive tract tumors. However, from open pancreaticoduodenectomy to laparoscopic pancreaticoduodenectomy to robotic pancreaticoduodenectomy, which has emerged in recent years, pancreatic fistula is still a major postoperative complication and even a major factor of death. Most scholars have been devoted to improving the pancreatico-enteric anastomosis technique, exploring many anastomoses such as pancreaticojejunal end-to-end anastomosis, pancreaticojejunal end-to-side anastomosis and pancreatic ductojejunal mucosal end-to-side anastomosis, which makes the safety of the operation improved and the incidence of complications gradually decreased.

However, there are relatively few studies on pancreatic duct drains, and most of the literature does not take into account the learning curve of the operator and the basic conditions of the healthcare organization when comparing pancreatic duct external drains with internal pancreatic duct drains. Compared with low-flow OPD centers, high-flow OPD centers not only have skilled and high-quality PD surgical techniques, but more importantly, standardized postoperative management and timely and correct management of complications, which can effectively avoid the escalation of complications and thus reduce mortality [22]. Moreover, as the surgeon progressively passes through the initial, plateau, and stabilization phases of the learning curve, the time required by the surgeon and his/her team to complete the surgery will be gradually shortened, the amount of intraoperative hemorrhage will be gradually reduced, the surgical technique will become more and more skilled, and the team will become more and more proficient in cooperating with the surgeon.

Considering these factors and the advantages and disadvantages of external pancreatic duct drainage and internal pancreatic duct drainage, when choosing the drainage method, it is necessary to choose the appropriate drainage method according to “place” and “time”, and choose the appropriate drainage method in combination with their own conditions. At the beginning of the learning curve, due to the lack of sophisticated surgical techniques, patient safety should be the first priority and the choice of pancreatic drainage should be based on how to minimize

the incidence of postoperative complications. Once the operator has overcome the learning curve of choosing one type of pancreatic drainage, he or she can attempt to use another type of pancreatic drainage intraoperatively. When the operator is able to maturely perform both drainage methods, he or she can flexibly choose between the two types of pancreatic drainage methods according to the patient's condition to further reduce the incidence of complications and make LPD truly safe and minimally invasive.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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