



Review

Minimally invasive pancreaticoduodenectomy: A comprehensive review



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HIGHLIGHTS

- Minimally invasive pancreaticoduodenectomy (MIPD) is the most challenging abdominal surgery.
- We reviewed 331 published articles, concluding that MIPD is technically feasible and safe in highly selected patients.
- Concerns such as long-term outcomes, cost-effectiveness analysis, and learning curve analysis should be further demonstrated.

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ABSTRACT

Background: While an increasing number of open procedures are now routinely performed laparoscopically or robotically, minimally invasive pancreaticoduodenectomy (MIPD) remains one of the most challenging operations in abdomen. The aim of this study is to evaluate the current status and development of MIPD.

Methods: Embase, Medline, and PubMed databases were searched to identify studies up to and including Feb 2016 using the keywords “laparoscopic”, or “laparoscopy”, or “hand-assisted”, or “minimally invasive”, or “robotic”, or “da vinci” combined with “pancreaticoduodenectomy”, or “duodenopancreatotomy”, “Whipple”, or “pancreatic resection”. Articles written in English with more than 10 cases were included for review.

Results: Thirty-two articles representing 2209 patients were included for review. The weighted average operative time and intraoperative blood loss was 427.3 min and 289.4 mL respectively. A total of 375 patients required conversion to open pancreaticoduodenectomy (OPD), with an overall conversion rate of 17.8%. The postoperative severe complications (the Clavien–Dindo Classification \geq III) occurred in 3.8%–33.0% patients, with an overall severe morbidity of 14.3%. Particularly, the overall incidence of clinically significant postoperative pancreatic fistula (POPF) was 8.0%. There were 26 perioperative death cases in total, with an overall postoperative mortality rate of 2.3%. The weighted average number of collected lymph nodes was 17.9, and R0 resection ranged from 60.0% to 100.0%. Comparisons between MIPD and OPD showed that MIPD increased operative time, decreased intraoperative blood loss and shortened the length of hospital stay, but the overall morbidity and mortality were comparable.

Conclusions: MIPD is technically feasible and safe in highly selected patients and can offer acceptable oncological outcomes. But concerns such as long-term outcomes, cost-effectiveness analysis, and learning curve analysis should be fully demonstrated before the popularization of this challenging procedure.

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1. Introduction

Pancreaticoduodenectomy (PD) has been regarded historically as the most challenging and complicated general surgery.

Minimally invasive techniques are now widely performed and are accepted methods for the treatment of benign, specifically left-sided, pancreatic lesions [1–3]. However, since the first laparoscopic pancreaticoduodenectomy (LPD) was documented in 1994 by Gagner, this procedure has been attempted in a limited number of patients globally, and the acceptance and popularity of this procedure decreased due to the inherent technical limitations of

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laparoscopy and the requirement for advanced laparoscopic skills in the following ten years.

Previous studies described the advantages of minimally invasive pancreaticoduodenectomy (MIPD) including earlier oral intake, less blood loss, shorter post-hospital stay, less pain, and faster recovery. However, most MIPD were performed in selected patients by specialized surgeons, and large-sample size studies of this advanced technique are limited to a few high-volume centers to date. Therefore, the safety and surgical outcomes of MIPD have not yet been definitely determined.

The aim of this study is to provide a comprehensive evaluation of the current status and development of MIPD by reviewing the literature published in English.

2. Materials and methods

2.1. Surgical procedures

Minimally invasive pancreaticoduodenectomy included:

- (1). Total/pure LPD, where both resection and digestive reconstruction were completed laparoscopically;
- (2). Hand-assisted LPD (HALPD), where a hand port or a mini incision was added to facilitate the progress;
- (3). Laparoscopy-assisted LPD (LALPD), in which dissection was performed laparoscopically and reconstruction was completed through a small mini-laparotomy incision;
- (3). Total/pure robotic pancreaticoduodenectomy (RPD), where both resection and digestive reconstruction were completed using da vinci surgical system;
- (4). Robotic-assisted pancreaticoduodenectomy (RAPD), where dissection was performed laparoscopically and reconstruction was completed by da vinci surgical system.

2.2. Literature search strategy

Embase, Medline, and PubMed were electronically searched up to and including Feb 2016 using the keywords “laparoscopic”, or “laparoscopy”, or “hand-assisted”, or “minimally invasive”, or “robotic”, or “da vinci” combined with “pancreaticoduodenectomy”, or “duodenopancreatectomy”, “Whipple”, or “pancreatic resection”.

2.3. Inclusion criteria

Published articles written in English reporting more than 10 cases were included in this study, and the included studies were required to contain patients' characteristics and perioperative outcomes. If a patient's data was repeatedly reported from the same institution, the most informative or recent article was considered for review to avoid data overlap.

2.4. Exclusion criteria

Articles published with only abstract, single case reports, review articles, technique reports, studies referring to animals, and articles written in non-English were excluded from final analysis.

2.5. Data extraction

All the retrieved studies that met the inclusion and exclusion criteria were independently reviewed by two authors. The variables extracted from the included studies were as follows: basic information (first author, publication year, number of patients, country, and number of patients with pancreatic ductal adenocarcinoma

(PDA)), inclusion and exclusion criteria to perform MIPD, surgical techniques (surgical procedures, management of gastroduodenal artery, management of the pancreatic duct, and pylorus preservation or not), intraoperative details and short-term surgical outcomes (operative time, intraoperative blood loss, conversion rate (the conversion is defined as the requirement for laparotomy at any time during the minimally invasive pancreaticoduodenectomy except extraction of the resected specimen and application of a hand-port to facilitate the procedure.), length of postoperative hospital stay, complications and surgical mortality), and oncological outcomes for malignancies (tumor types, number of examined lymph nodes, and rate of margin negative resection). In case of discrepancies between the two reviewers, the data were simultaneously reviewed again by a third reviewer in order to reach a final consensus.

2.6. Statistical analysis

A weighted average (WA) is used to calculate a statistical weighted mean of all the different means collected from the included studies: $WA = (w_1x_1 + w_2x_2 + \dots + w_nx_n) / (w_1 + w_2 + \dots + w_n)$, where w is the number of cases in a publication and x is the mean of a specific variable. Statistical analyses including *chi-square* or *Fisher's exact* test for categorical variables between groups and *Student's unpaired t-test* for continuous variables were performed where appropriate using the SPSS statistical software package (version 19.0, SPSS Inc., Chicago, IL, USA). The level for rejection of the null hypothesis was set at a P value of <0.05 .

3. Results

Thirty-two studies, involving 2209 cases were included in this review (Table 1) [4–35]. The first included study of MIPD was documented in 1997 [35], and it was nine years since the second large series of MIPD ($n = 25$ cases) was published by J. L. Dulucq [34]. USA (9 articles) and China (7 articles) are the countries with more published articles regarding MIPD than other countries. Although PDA is the most common indication for pancreaticoduodenectomy, MIPD was not very popular and was not well accepted to treat patients with PDA globally before Croome reported the promising outcomes of MIPD in patients with PDA [16].

Inclusion and exclusion criteria to perform MIPD extracted from the 32 articles were summarized in (Supplementary Table 1). Only inclusion or only exclusion criteria were detailed in 14 and 20 articles respectively, while both inclusion and exclusion criteria were provided in 13 articles. Patients with small, benign/low-grade periampullary tumors, and low body mass index (BMI) were eligible to receive MIPD, whereas vascular invasion, prior upper abdominal surgery, severe cardiorespiratory disease, and distant metastases were the most reported contraindications for MIPD.

Details on perioperative outcomes regarding MIPD are listed in Table 2. The surgical techniques were heterogeneous, including pure LPD, LAPD, HAPD, RAPD, and pure RPD. Twenty-five authors used one technique, while seven authors reported two surgical methods. The methods regarding the closure of gastroduodenal artery were mentioned in 17 articles. Clips alone, reported in 10 articles, was the most common method, followed by ligature alone (2 articles), and clips plus stapler (2 articles). Stapler alone, Ligasure alone, and ligature plus clips were used in 1 article each. The management of pancreatic duct is the most complicated step during the digestive tract reconstruction. Majority of authors (27 articles, 84.4%) shared their experience on this topic. Pancreaticojejunostomy, reported in 25 articles, was more popular than the other managements of pancreatic stump, including

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