Minimally Invasive Surgery of Pancreatic Cancer: Feasibility and Rationale

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Keywords

Pancreatic cancer · Minimally invasive surgery · Robotic surgery · Laparoscopic surgery

Summary

Minimally invasive pancreatic procedures, in particular minimally invasive pancreaticoduodenectomy, are amongst the most technically challenging procedures in general surgery. Accordingly, a high number of cases is required to master the procedures. Minimally invasive pancreatic surgery is well established for benign and premalignant lesions of the pancreas. Borderline resectable tumors with infiltration of the portal vein are also resected minimally invasively in specialized centers with appropriate expertise. Retrospective and registry studies demonstrate an equivalent long-term survival compared to conventional surgery. Perioperative morbidity and mortality are also equivalent, whereas minimally invasive surgery significantly reduces hospital stay. We expect more widespread use of minimally invasive pancreatic procedures in large centers.

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Introduction

The outcome of pancreatic surgery strongly correlates with the hospital volume and the experience of the individual surgeon [1]. In comparison to other oncologic surgical procedures, the implementation of minimally invasive procedures in oncologic pancre-

atic surgery has been slow. Apart from distal pancreatectomy and enucleation, minimally invasive pancreatic surgery, including robot-assisted surgery, has not yet gained widespread acceptance in the surgical community around the world. It is associated with reduced morbidity, enhanced postoperative recovery, and shorter hospital stay [2–4]; however, recent studies also found that its widespread use can also increase morbidity and mortality [5]. Thus, more widespread use of minimally invasive pancreatoduodenectomy requires structured training programs. Moreover, a minimum of 10 minimally invasive complex pancreatic procedures per year and hospital seem to be necessary to safely implement this new technology [6]. In this article, the feasibility and rationale of minimally invasive surgery for pancreatic cancer will be elucidated.

Parenchyma-Sparing Surgery

Over the last decade, progress has been made regarding the implementation and evaluation of minimally invasive parenchyma-sparing pancreatic surgery. Sauvanet et al. [7] found that parenchyma-sparing resection of intraductal papillary mucinous neoplasms (IPMN), easily performed as a minimally invasive procedure, yields excellent results. The group resected IPMN that fulfilled the Fukuoka criteria (IPMN > 3 cm of size, mural nodules, growth, and/or symptoms) using parenchyma-sparing techniques such as uncinectomy, central pancreatectomy, or enucleation (fig. 1). They found that patients had excellent 1- (100%), 3- (97%), 5- (92%), and 10-year (76%) progression-free survival rates. These procedures might therefore be sufficient for the treatment of this entity if combined with intraoperative fresh frozen section assessment of the specimen to exclude malignancy. The use of these procedures also resulted in excellent endocrine (4% de novo diabetes) and exocrine organ function (exocrine insufficiency 5%).

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Fig. 1. Parenchyma-sparing minimally invasive resection of branch-duct type IPMN. **A** Robotic central pancreatectomy. Lesion before resection (left, arrow). Situs after resection prior to pancreatogastrostomy of the distal pancreas (right). The proximal pancreas was transected using a covered Endo-GIA. **B** Robotic uncinectomy.

Initial Implementation of Minimally Invasive Pancreatic Surgery

The German laparoscopic pancreatic registry group recommends the use of laparoscopic pancreatic surgery for the treatment of smaller tumors, neuroendocrine tumors, and cystic neoplasms as well as duodenal cancers. This reasonable limitation during the initial implementation phase of minimally invasive pancreatic surgery led to a relatively low rate of conversions to open surgery in the almost 600 patients [8]. Low conversion rates are important, since conversion from minimally invasive surgery to open surgery impairs the oncological outcome in many other oncological procedures. In pancreatic surgery, unplanned conversion to open surgery is associated with increased morbidity and 30-day mortality [9].

Pancreatic surgery per se is generally associated with high morbidity in prospective multicenter trials. In cancer patients, this may cause prolonged postoperative rehabilitation, delaying, or even exclusion of postoperative adjuvant oncological therapy. A study from the Mayo Clinic has underlined this correlation and pointed out the value of minimally invasive procedures in this context [10]. Patients treated with minimally invasive surgery for pancreatic cancer had a significantly higher chance to receive adjuvant chemotherapy and to obtain it timely. Additionally, the local recurrence rate was significantly lower in the group treated with minimally invasive surgery, which was attributed to a better visibility, or increased surgical precision and therefore higher R0 resection rates.

Quality of Life

Another important factor, especially in pancreatic cancer, is the postoperative quality of life. We have recently evaluated the quality

of life in patients that underwent minimally invasive resection for pancreatic cancer in comparison to a matched group that received open surgery. We found an increased quality of life in the laparoscopic group in all evaluated dimensions of the SF-36 EORTC questionnaire used.

Distal Pancreatectomy

For distal pancreatectomy, Mehrabi et al. [11] found a significantly reduced operating room time as well as a shorter length of stay in the laparoscopic group of a recent meta-analysis encompassing over 1,000 patients. The Heidelberg group also found a higher rate of R0 resections in the laparoscopic group in this meta-analysis. However, they also identified a selection bias towards smaller tumors in the laparoscopic group. These findings were recently confirmed in an observational registry study using the German StuDoQ quality assurance registry of the German Society for General and Visceral Surgery [5].

Concerning oncologic outcome after resection of pancreatic cancer of the distal pancreas, there is no evidence from randomized controlled trials yet. Large observational studies, however, have demonstrated comparable oncological results after distal pancreatectomy for pancreatic adenocarcinoma [12]. Currently, the European prospective multinational multicentric DIPLOMA trial is recruiting patients to compare laparoscopic with open resection for distal pancreatic cancer [13].

For pancreaticoduodenectomy, our group could show that application of a hybrid approach with laparoscopic pancreatic resection and reconstruction via a small specimen retrieval incision could reduce clinically relevant complications with a comparable or even slightly better long-term oncological outcome [14].

Fig. 2. **A, B** Pancreatic cancer with portal vein infiltration prior (left) and after (right) robotic resection. **A** Subtotal tangential portal vein resection and reconstruction with running suture. **B** Subtotal tangential portal vein resection and reconstruction with a bovine pericardial patch. **C** Robotic distal pancreatectomy with celiac trunk resection (Appleby procedure). Intraoperative flow measurement of the proper hepatic artery (left). Celiac trunk prior to dissection (right).

Complex and Robotic Pancreatic Surgery

The initially limited use of minimally invasive pancreatic surgery now needs to be reevaluated, as several groups have also shown comparable results in complex pancreatic surgery, including vascular resection and reconstruction as well as multivisceral resection [15, 16]. Especially the implementation of robot-assisted surgery added a novel tool for safely expanding the indications for minimally invasive pancreatic surgery to more complex cases. Generally, the use of robotic surgery for all oncologic procedures increased significantly in the USA according to a current trend analysis based on the National Inpatient Sample [17]. In a comparison of laparoscopic and robotic application of minimally invasive surgery for distal pancreatic cancer, both methods seemed equivalent in a recent retrospective evaluation of the National Cancer Database sample of 704 patients [18]. New technologies, how-

ever, also mandate new ways of training. Therefore, minimally invasive techniques in pancreatic surgery should be extensively prepared in off-patient settings. Mastery-based training modules have shown that excellent results can be achieved when applying these new technologies in the proper context [19].

For vascular resection, portal vein infiltration has been a relevant obstacle for many groups trying to expand laparoscopic pancreatic resections to more advanced, borderline resectable tumors or tumors that received neoadjuvant treatment. In our experience, this expansion of indications for minimally invasive techniques can be accomplished best by using robot-assisted surgery. Portal vein resection and replacement can be performed quickly and safely in experienced hands via the implementation of robot-assisted techniques (fig. 2).

Conclusion

The development of minimally invasive techniques will further proceed. The main obstacle of their widespread implementation will be how to safely implement these technologies for a larger number of specialized surgeons. Case numbers needed to safely perform these complex procedures have been estimated at 50 patients for pancreatic head resection and 30 patients for distal pancreatic resection. These numbers per se indicate that robotic and minimally invasive pancreatic surgery require a high-volume infrastructure and high-volume surgeons for safe implementation. Analysis of large databases in the USA has shown that laparoscopic pancreaticoduodenectomy has a significantly increased morbidity and mortality if performed in a low-volume hospital setting compared to open pancreaticoduodenectomy, and even in a recent randomized controlled trial in high-volume centers, an increased morbidity with this technique has been shown [20]. If performed in an adequate setting, perioperative risk factors for prolonged operating room time and hospital length of stay are relatively consistent across open, laparoscopic, and robotic approaches to distal pancreatectomy [21].

Minimally invasive pancreatic surgery is well established in the treatment of pancreatic diseases. Controversies are currently ongoing concerning the safe implementation of the technique, the comparison of laparoscopic and robot-assisted techniques, as well as the learning curve and minimal yearly hospital volume.

Disclosure Statement

Both authors declare that they have no conflict of interest.

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