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Laparoscopic Pancreatic Surgery

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1. Introduction

Pancreatic surgery has higher morbidity and mortality than other forms of gastrointestinal tract surgery, due to associated problems like pancreatic fistula formation and loss of pancreatic function. Until recently laparoscopic surgery of the pancreas was limited to laparoscopic staging or to the evaluation of periampullary cancer for detecting small metastatic nodules or local invasion (Jang et al., 2007; Schachter et al., 2000). Advances in laparoscopic techniques and instrumentation have expanded the role of laparoscopic surgery to a degree that could not have been imagined such as Whipple's procedure (Gagner & Gentileschi, 2001).

Recent reports on laparoscopic surgery of the pancreas are encouraging and support the advantages of laparoscopy. We believe that well selected enucleation and laparoscopic distal pancreatectomy, with or without spleen preservation, are acceptable and recommendable for the treatment of benign or low grade malignant diseases of the pancreas. Moreover, surgeons and laparoscopic industries have developed new techniques and devices that increase convenience, ease, and safety of complicated laparoscopic surgeries, and these efforts will undoubtedly increase the role of laparoscopic or minimal invasive surgery for the treatment of pancreatic disease.

In this chapter, we will discuss the current status of the laparoscopic pancreatic surgery and the role of its associated procedures for the treatment of pancreatic disease.

2. Pancreatic resection

2.1 Distal pancreatectomy

Although laparoscopic pancreatic surgery is considered to be an advanced and demanding procedure, many surgeons have tried laparoscopic distal pancreatectomy due to its technical simplicity and its avoidance of the need for anastomosis as compared with other difficult pancreatectomy (Table 1) (Weber et al., 2009; Mabrut et al., 2005; Melotti et al., 2007; Vijan et al., 2010; Fernandez-Cruz et al., 2007; Røsok et al., 2010; DiNorcia et al., 2010; Jayaraman et al., 2010; Kooby et al., 2008; Song et al., 2011; Velanovich, 2006; Misawa et al., 2007; Teh et al., 2007; Kim et al., 2008; Matsumoto et al., 2008; Eom et al., 2008; Nakamura et al., 2009).

Most of reports demonstrate the feasibility of laparoscopic approach with acceptable morbidity (10~30%) and nearly no mortality.

Study	Cases	Multi-Institutional	Mean Operative Time (min)	Mean Blood Loss (mL)	Length of Stay (day)	Conversion Rate (%)	Splenic Preservation (%)	Overall Morbidity (%)	Pancreatic Fistula Rate (%)	Mortality (%)
Weber, 2009	219	Y	219	245	2.6	10	34	39	23	0
Mabrut, 2005	96	Y	200 ^a 195 ^b	N/A	7	10	71	53	16	0
Melotti, 2007	58	Y	165	N/A	9	0	55	53	27.5	0
Vijan, 2010	100	N	214	171	6.1	4	25	34	17	3
Fernandez-Cruz, 2007	82	N	N/A	N/A	7	7	64	20	9	0
Rosok, 2010	117	N	185.5 ^a 210 ^b	200 ^a 100 ^b	5	7.5	32	16.5	10	N/A
DiNorcia, 2010	95	N	250	150	5	25.3	15.5	28.2	11.3	0
Jayaraman, 2010	107	N	193	150	5	30	21	20	15	0
Kooby, 2008	167	Y	230	357	5.9	13	31	40	11	0
Song, 2011	359	N	195	N/A	8	N/A	49.6	12	7	0

^a With splenic preservation

^b With splenectomy

N/A (Not Available Values)

Table 1. Recently published reports of laparoscopic distal pancreatectomy

Study	Cases		Mean Operative Time (min)		Mean Blood Loss (mL)		Splenic Preservation (%)		Length of Stay (day)		Overall Morbidity (%)		Pancreatic Fistula Rate (%)		Mortality (%)	
	LDP	ODP	LDP	ODP	LDP	ODP	LDP	ODP	LDP	ODP	LDP	ODP	LDP	ODP	LDP	ODP
Velanovich, 2006	15	15	N/A	N/A	N/A	N/A	0	0	5.0	8.0	20	27	13	13	0	0
Misawa, 2007	8	9	255	205	14	307	12.5	0	10.0	16.0	N/A	N/A	0	22	0	0
The, 2007	12	16	278	212	193	609	62	17	6.2	10.6	17	56	8	6	0	0
Kim, 2008	93	35	195	190	110	110	40.8	5.7	10	16	25	29	8.6	14.3	0	0
Matsumoto, 2008	14	19	291	213	247	400	7	N/A	12.9	23.8	N/A	N/A	0	110.5	0	0
Eom, 2008	31	62	218	195	N/A	N/A	42	N/A	11.5	13.5	36	24	9.7	6.5	0	0
Nakamura, 2009	21	16	308	282	249	714	35	31	10.0	25.8	0	19	0	12.5	0	0
Jayaraman, 2010	107	236	163	193	150	350	21	14	5	7	27	40	15	13	0	2
Kooby, 2008	142	200	230	216	357	588	30	12	5.9	9.0	40	57	11	18	0	1

Table 2. Comparisons of laparoscopic and Open distal pancreatectomy

According to several reports comparing the clinical results of laparoscopic surgery with open surgery, no statistical differences were found in terms of operation time, morbidity, or recurrence. However, mean length of hospital stay was shorter in the laparoscopic group than in the open surgery group (Table 2) (Vijan et al., 2010; Kooby et al., 2008; Velanovich, 2006; Misawa et al., 2007; Teh et al., 2007; Kim et al., 2008; Matsumoto et al., 2008; Eom et al., 2008; Nakamura et al., 2009).

We could conclude that laparoscopic distal pancreatectomy is a safe and feasible method equivalent to open distal pancreatectomy in terms of early and late outcome for benign and borderline lesions of pancreas such as pancreas cystic neoplasms and neuroendocrine tumors. Considering superior cosmetic results and early functional recovery, laparoscopic distal pancreatectomy could be treatment of choice in most of non-cancerous diseases located at pancreas body and tail.

The role of laparoscopic distal pancreatectomy for the treatment of pancreatic cancer remains controversial. Many pancreatic surgeons worry about the oncological safety of laparoscopic pancreatectomy in relation to surgical margin, retroperitoneal clearance, and retrieval of peripancreatic lymph node (Kubota, 2011; Kooby & Chu, 2010).

Several reports showed that laparoscopic distal pancreatectomy provided similar short- and long-term oncologic outcomes as compared with open surgery, with potentially shorter hospital stay even in pancreatic cancer. These results suggest that laparoscopic distal pancreatectomy is an acceptable approach for resection of pancreatic ductal adenocarcinoma (PDAC) of the left pancreas in selected patients (Kooby & Chu, 2010; Dulucq et al., 2005; Kooby et al., 2010).

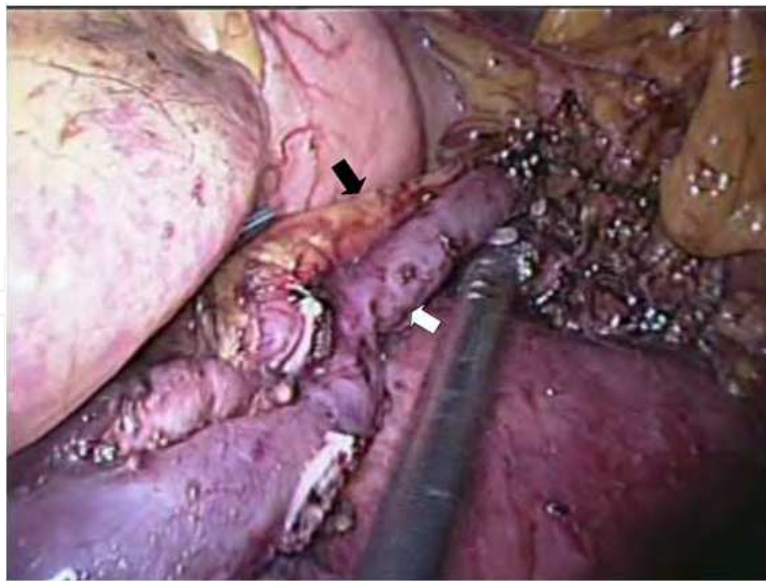
Although the result of laparoscopic distal pancreatectomy for pancreatic cancer seems to be favorable in limited cases, we must wait for more long term results to reach a conclusion on oncological safety of laparoscopic resection for pancreatic cancer.

Spleen preservation and method of preservation are important issues of laparoscopic distal pancreatectomy, and surgeons showed diverse preferences for surgical method (Table 1). Spleen-preserving distal pancreatectomy was introduced by Mallet et al. in 1943 (Mallet & Vachon, 1943), and as knowledge of the immunologic role of spleen increased, efforts to conserve the organ have intensified (Robey et al., 1982; Yamaguchi et al., 2001).

According to the recently published data, 15~70% of distal pancreatectomies were performed preserving spleen (Table 1). Two techniques are employed during spleen-preserving operations. The first involves splenic artery and vein transection such that the left gastroepiploic vessels and short left gastric vessels will supply the spleen (Warshaw's technique) (Warshaw, 1997), whereas in the second the splenic artery and vein are preserved (Figure 1).

This second method demands more advanced instrumentation and skill in terms of dividing the transverse branches of splenic vessels and has a risk of left-sided portal hypertension if the splenic vein becomes occluded after surgery (Yoon et al., 2009).

Whereas Warshaw's technique is technically easy and requires shorter operative time (Kaneko et al., 2004; Mori et al., 2005), it may result in splenic infarction and splenic abscess formation due to insufficient blood flow to the spleen (Warshaw, 1997).



Black arrow: preserved splenic artery

White arrow: preserved splenic vein

Fig. 1. Laparoscopic spleen preserving distal pancreatectomy.

2.2 Pancreatoduodenectomy

Although laparoscopic pancreatoduodenectomy was introduced at 1994 by Dr. Gagner (Gagner & Pomp, 1994), this procedure is still technically challenging.

There have been limited case reports on laparoscopic pancreatoduodenectomy (Table 3) (Gagner & Pomp, 1997; Staudacher et al., 2005; Dulucq et al., 2006; Palanivelu et al., 2007; Pugliese et al., 2008; Cho et al., 2009; Kendrick & Cusati, 2010), and some surgeons advocate its safety and feasibility. However, lack of tactile sensation, difficulties in localizing lesions, and the anatomic complexity of peripancreatic organs to make laparoscopic pancreatoduodenectomy difficult (Cuschieri, 1996).

Even Dr. Gagner, the initiator of laparoscopic pancreatoduodenectomy, concluded that this procedure offers no advantage in terms of patient outcome and may be associated with increased morbidity (Gagner & Pomp, 1997). Nevertheless, laparoscopic experience has allowed some surgeons to claim promising results for laparoscopic pancreatoduodenectomy (Gagner & Pomp, 1997; Staudacher et al., 2005; Dulucq et al., 2006; Palanivelu et al., 2007; Pugliese et al., 2008; Cho et al., 2009; Kendrick & Cusati, 2010; Cuschieri, 1996).

However, laparoscopic pancreatoduodenectomy has many pitfalls. Pancreatoduodenectomy itself requires meticulous anastomosis to reduce morbidities associated with pancreatic leakage, and adequate dissection to remove diseased tissue including lymph nodes and nerve plexus. Small operative windows cannot highlight the merit of minimally invasive surgery in pancreatoduodenectomy because of the long operation time and high morbidity due to pancreato-enteric anastomosis.

On the other hand, it can be expected that technical advances, like robotic surgery (Makary, 2011; Horiguchi et al., 2011), will continue to make pancreatoduodenectomy by minimal invasive surgery more feasible and safe.

Study	Cases	Pathology	Conversion Rate (%)	Hand assist (%)	Operative Time (min)	Blood Loss (mL)	Length of Stay (day)	Overall Morbidity (%)	Pancreatic Fistula Rate (%)
Gagner & Pomp, 1997	10	4 PDAC, 3 AMP, 2 pancreatitis, 1 CC	40	33	510	N/A	22.3	17	50
Staudacher, 2005	7	2 PNET, 1 PDAC, 4 etc	43	100	416	325	12		
Dulucq, 2006	25	11 PDAC, 4 AMP, 2 DA, 1 PNET, 2 pancreatitis, 2 etc	12	41	287	107	16.2		32
Palanivelu, 2007	42	24 AMP, 9 PDAC, 4 MCA, 3 CC, 2 pancreatitis	0	0	370	65	10.2	7.1	N/A
Pugliese, 2008	19	6 PDAC, 4 AMP, 3 etc	32	54	461	180	18	23	37
Cho, 2009	15	6 IPMN,3 IPMC, 2 PNET, 1 AMP, 1 PDAC, 2 etc	0	100	338	445	16.4	13	27

AMP, ampullary adenocarcinoma/ampullary dysplastic adenoma; CC, cholangiocarcinoma; DA, duodenal adenocarcinoma; MCA, mucinous cystadenocarcinoma;; N/A, not reported; PDAC, pancreatic ductal adenocarcinoma; PNET, pancreatic neuroendocrine tumor

Table 3. Published reports of laparoscopic pancreatoduodenectomy

2.3 Other miscellaneous pancreatectomy and palliative procedures

Enucleation is one of commonly conducted procedures of laparoscopic pancreatectomy. According to a review by Tagaya et al (Tagaya et al., 2003), laparoscopic enucleation has been used to treat relatively small benign or low grade malignancies, and tumors located on the surface of the pancreas remote from the pancreatic duct. Tumor location is an important factor for successful laparoscopic enucleation to avoid pancreatic duct injury, and some advocate that enucleation is a safe and simple procedure under laparoscopic ultrasonographic guidance (Matsumoto et al., 1999).

The enucleation offers the possibility of complete tumor removal without loss of pancreatic parenchyma, possible diabetes, and splenectomy in some endocrine tumor or pancreatic cystic neoplasm. However, enucleation seems to be a debatable procedure in patients with pancreas cystic tumors, and does not address the malignant potential of these tumors, and thus, should be used cautiously in selected cases to avoid inadequate safe surgical margins and rupture (Fernandez-Cruz et al., 2005). In addition, the incidence of pancreatic fistula after tumor enucleation has been reported to be 30% to 75%, which is relatively higher than that of conventional pancreatectomy (Pyke et al., 1992; Talamini et al., 1998; Iihara et al., 2001). Moreover, considerations of oncological and operational safety require that surgeons exercise caution when selecting indications for laparoscopic enucleation.

Some surgeons have developed more intricate procedures like laparoscopic central pancreatectomy and ventral pancreatectomy (Orsenigo et al., 2006; Kang et al., 2011; Giulianotti et al., 2010).

Laparoscopy may be used in a palliative context for locally advanced or metastatic pancreatic/periampullary cancers. Many patients with periampullary cancer have symptoms associated with biliary or gastric outlet obstruction, and traditionally these patients have been managed by open bypass surgery. Recently, minimally invasive laparoscopic approaches to gastric and biliary bypass have been successfully applied, and have been shown by non-randomized comparative studies to be safer and to be associated with reduced periods of hospitalization than open surgery (Schwarz & Beger, 2000; Bergamaschi et al., 1998; Rothlin et al., 1999; Rhodes et al., 1995).

Although endoscopic or radiologic procedures for palliative treatment have been enormously developed and have achieved early success rates for endoscopic stent which is comparable to those of surgery with reduced morbidity and hospital stays, the long-term results of endoscopic procedures are not as satisfactory (van den Bosch et al., 1994). Thus, randomized comparisons of laparoscopic biliary bypass and interventional biliary stents in unresectable periampullary cancer are needed.

3. Laparoscopic diagnosis/staging

Laparoscopic diagnosis and staging are controversial in patients with suspected pancreatic cancer. Its main role is to detect occult intra-abdominal metastatic disease, during the procedure any suspicious lesion can be biopsied and peritoneal cytology can also be obtained by instilling normal saline into the peritoneum (Michl et al., 2006; Merchant et al., 1999; Nieveen van Dijkum et al., 1999).

The yield of laparoscopy for the detection of metastatic disease, especially of small peritoneal lesions that have not been detected by imaging modalities, ranges from 15 to 46% (Jimenez et al., 2000; Menack et al., 2001; Minnard et al., 1998; Velasco et al., 1998; Liu & Traverso, 2005). Recent studies have shown lower yields for laparoscopy than for improved non invasive imaging modalities like multi detector CT. The yield of laparoscopy alone is clearly impaired by its inability to detect locally advanced or intra-parenchymal liver disease. To overcome this obvious limitation, laparoscopic ultrasound has been added to laparoscopic staging, and this leads to a marked increase in yield and accuracy (Dulucq et al., 2006). Studies comparing laparoscopy and laparoscopic ultrasound with radiological staging modalities have produced controversial results. However, several studies have found that laparoscopy and laparoscopic ultrasound are more accurate than contrast-enhanced CT at determining T stage (John et al., 1999; Doran et al., 2004).

In contrast, three large studies using contrast-enhanced multi-detector CT imaging as a baseline radiological investigation were unable to confirm this, and found yields as low as 10-15% and accuracies of 35-56% for laparoscopy (Nieveen van Dijkum et al., 2003; Brooks et al., 2002). Despite the use of a pre-operative staging algorithm including laparoscopic ultrasound, up to 20% of patients were still found to be unresectable at the time of laparotomy, mainly because of local invasion (Talamini et al., 1998). Moreover, as diagnostic yields have fallen, due to improvements in non-invasive imaging, the additional costs of laparoscopy have been called into question, particularly since it requires separate anesthesia. Thus, at present, laparoscopy has a limited role in the staging of peri-pancreatic malignancies (Michl et al., 2006).

4. Laparoscopic application to pancreatitis

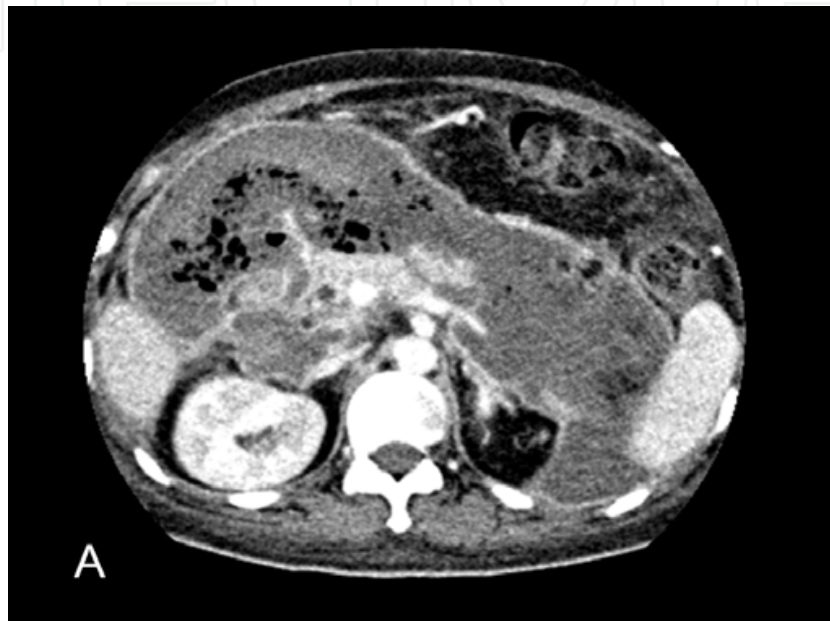
The role of surgery in the management of acute pancreatitis is markedly being reduced because less invasive intervention and intensive medical care are evolving. Although some clinicians advocate a non surgical approach even in cases of infected necrotizing pancreatitis, due to the improved results of medical or interventional treatment (Chang et al., 2006), current indications for surgery in pancreatitis are infected necrotizing pancreatitis, an organizing pseudocyst, or related complications.

The treatment of infected necrosis has changed dramatically during the last few years, and a multimodality approach has emerged, where a combination of several techniques are used in a single patient, and the risks of intervention are weighed against the need for adequate sepsis control (Garden, 2005).

Minimally invasive surgery has consistently been shown to be associated with reduced inflammatory response activation than equivalent open surgery, and some evidence suggests that local sepsis and inflammatory response may also be lessened by minimally invasive surgery. It has been suggested that by minimizing the massive inflammatory injury associated with open pancreatic necrosectomy, a minimally invasive approach to the management of infected pancreatic necrosis may lessen the risk of multiple organ failure, and reduce respiratory and wound morbidity in necrotizing pancreatitis (Garden, 2005; Parekh, 2006).

The laparoscopic approach depends on the localization of pancreatic necrosis. The alternatives are an intraperitoneal approach, direct entry of the retroperitoneal space, and an intraperitoneal transgastric approach. Our group experienced three successful cases of

laparoscopic necrosectomy using a multiple approach technique for necrotizing pancreatitis (Figure 2). The potential benefits of minimal invasive techniques are yet to be proven, because of a rarity of reports that deal with severely ill patients, and thus, the superiority or inferiority of laparoscopic over endoscopic or radiologic intervention must be proven by randomized prospective study.





(A) CT shows severe necrosis around pancreas.

(B) Necrosis was laparoscopically approached and debrided using gauze and forceps.

(C) Postoperative CT shows marked decrease of necrotic area around pancreas.

Fig. 2. A 38 year old man, with severe necrotizing pancreatitis, was successfully managed by laparoscopic approach.

The management of pancreatic pseudocyst, complicated (acute or chronic) pancreatitis represents another important role of laparoscopy in pancreatitis. Pseudocysts complicate 5-10% of acute pancreatitis attacks and often arise as a result of disruption of the pancreatic duct in the presence of gland necrosis. Large (≥ 6 cm diameter), persistent (≥ 6 weeks), and symptomatic pseudocysts are indications for drainage, which is best achieved endoscopically or surgically (Ammori & Baghdadi, 2006).

Endoscopic transmural (transgastric or transduodenal) drainage may be possible in some patients with pancreatic pseudocysts, and is best reserved for pseudocysts that complicate chronic pancreatitis (rather than acute pancreatitis) in the head or body of the pancreas, and those with a wall thickness of less than 1cm (Beckingham et al., 1999). Surgery remains the gold standard for the management of large, persistent and recurrent pseudocysts. Internal drainage is conventionally achieved through a pseudocyst-gastrostomy or pseudocyst-jejunostomy, procedures that are now safely and effectively accomplished laparoscopically (Weber et al., 2009). Transgastric (via anterior gastrostomy) (Smadja et al., 1999), endogastric (Mori et al., 2000; Ammori et al., 2002), a posterior approach through the lesser sac, and Roux-en-Y pseudocyst-jejunostomy have been described (Hagopian et al., 2000). Although reported cases of laparoscopic management of pseudocysts are limited, the data presented are promising, and support the advantages of a relatively short postoperative hospital stay and rapid recovery (Smadja et al., 1999; Mori et al., 2000; Ammori et al., 2002; Hagopian et al., 2000).

Because no randomized controlled trial has compared the laparoscopic, open approaches and endoscopic procedures in terms of the internal drainage of pseudocysts, it is impossible

to clarify which provides the most effective treatment for patients with pseudocysts in different situations.

5. Conclusion

The anatomical complexity of the pancreas and high postoperative morbidity have hindered evaluations of laparoscopic surgery with respect to early functional recovery, and thus, have probably retarded the adoption of laparoscopic surgery for the management of pancreatic diseases. Nevertheless, recent reports on pancreatic laparoscopic surgery are encouraging and maintain consensus option concerning the merits of the technique.

Well selected cases of enucleation and laparoscopic distal pancreatectomy with or without spleen preservation are currently both acceptable and recommendable for the treatment of benign or low grade malignant diseases of pancreas. Most reports on advanced laparoscopic pancreatectomy have concluded that these procedures are feasible and safe when conducted by skilled laparoscopic surgeons. However, technical feasibility does not obviate sound clinical judgment, and caution should be exercised before new technologies are adopted in the absence of well designed clinical trials (Werner et al., 2005).

Nevertheless many surgeons and the laparoscopic industries have developed new techniques and devices that are more convenient and increase the safety of laparoscopic surgery, and their efforts will undoubtedly increase the role of laparoscopic or minimal invasive surgery for the treatment of pancreatic disease.

6. References

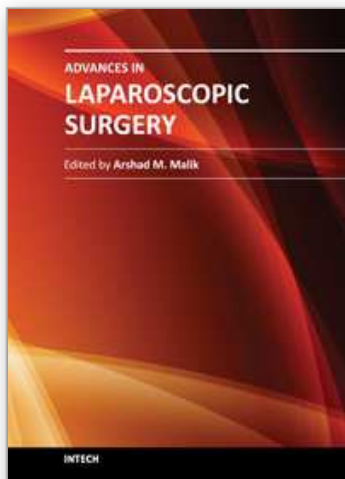
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Laparoscopic surgery, also called minimal access surgery, has revolutionized the field of surgery over the past few years. It has gained worldwide popularity and acceptance by surgeons and patients alike. Minimal scarring, less pain, and shorter hospital stay are the main reasons behind the global appeal of this novel technique. There has been a tremendous improvement in the technique, as well as in the instruments. The technique has passed through the stages of simple laparoscopic surgery to advanced levels, where more complicated procedures are being successfully attempted. The recent introduction of robotic surgery is also gaining popularity, in addition to single port laparoscopic surgery (SILS), which can be scarless surgery. Most of the surgical procedures, which were considered contraindication for the laparoscopic approach, have eventually become the most common and acceptable indications today. This book is intended to provide an overview of the most common procedures performed laparoscopically, as well as some recent advancements in the field.

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