J Hepatobiliary Pancreat Sci (2011) 18:516–524
DOI 10.1007/s00534-011-0398-1

TOPICS

Robotic surgery and emerging endoscopic surgery for hepatobiliary pancreatic sciences

Needlescopic surgery for liver, gallbladder and spleen diseases

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Published online: 17 May 2011

Abstract
Background We propose that needlescopic surgery (NS) should be considered as a way of improving the esthetic result and post-operative quality of life of patients and of reducing costs and stress on surgeons, and we have evaluated the results of NS.
Methods We used NS in 157 patients between May 1998 and December 2010: cholecystectomy in 150 patients, marsupialization of splenic and hepatic cysts in 4 and splenectomy in 3, respectively. Under general anesthesia, one 12-mm and two or three 2- or 3-mm ports were introduced into the operative field. The specimen was retrieved from the 12-mm wound using a plastic bag.
Results The procedures were successfully completed in all patients without conversion to an open procedure. In eight (5.3%) of 150 cholecystectomies a change to 5-mm instruments was required. The mean operation times and postoperative hospital stays for cholecystectomy, splenectomy, and marsupialization of splenic and hepatic cysts were 80.2 min and 3.2 days, 167 min and 5.6 days, 170 min and 7 days, and 120 min and 7 days, respectively. There were a few perioperative complications. The most important factor for reducing operation time and achieving a low conversion rate is the use of at least one 3- or 5-mm port for the grasping instruments in cholecystectomy. We recognized a residual cyst requiring splenectomy 62 months after marsupialization in one case. Technical points for performing safe procedures on solid organs were: no direct organ mobilization to avoid organ injuries, the rotation of the operating table and the utilization of organ gravity to create a better operative field, the minimum use of the needlescope to perform a safe maneuver and the improvement of bi-manual technique.
Conclusions NS is a safe and feasible procedure for achieving minimal invasive surgery. We should consider NS as a first choice to treat operable diseases in this laparoscopic era.

Keywords Needlescopic surgery · Cholecystectomy · Splenectomy · Needlescopic instruments · Needlescope

Introduction

Laparoscopic surgery for benign abdominal diseases has become a standard surgical procedure all over the world. Recently, seeking to further minimise the invasiveness of surgery, several new endoscopic procedures, such as natural orifice translumenal endoscopic surgery (NOTES) [1, 2], single incision laparoscopic surgery [3, 4], needlescopic surgery (NS) [5] and robotic surgery [6, 7], have been introduced as alternatives to conventional laparoscopic surgery. These surgical results have been compared with those of conventional procedures, and their clinical advantages and disadvantages have been discussed. In particular, the recent development and improvement of miniaturized laparoscopic instruments of 3-mm diameter or less has led laparoscopic surgeons to shift towards performing operations using needlescopic instruments. The perceived advantages of the needlescopic technique are wounds that heal leaving imperceptible scars, reduced postoperative analgesic use, potential reduced risk of port site hernias, lower incidence of wound complications, a smaller sheath that makes the introduction smooth and effortless decreasing the risk of intra-abdominal injuries,

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and a high satisfaction rate with possibly a faster recovery. In this article, we report our experience of performing laparoscopic surgery using needlescopic instruments for liver, gallbladder and spleen diseases, and review the literature on NS.

Materials and methods

Between July 1998 and October 2010, 150 patients with gallbladder diseases (stone, polyp, adenomyomatosis, acute and chronic cholecystitis), 6 patients with splenic diseases (idiopathic thrombocytopenic purpura (ITP), cyst, torsion, hereditary spherocytosis, lymphoproliferative disorder) and one patient with hepatic disease (cyst) were enrolled in this clinical study. The patients consisted of 66 men and 84 women with gallbladder diseases, 2 men and 4 women with splenic diseases and one woman with hepatic disease. The age ranges were 27–83 years (mean age 54.6 years), 19–69 years (mean 37.7 years) and 74 years, respectively. The exclusion criteria included high risk for general anesthesia.

Surgical procedure for cholecystectomy

Under general anesthesia, the patient was placed in a supine position with insertion of a nasogastric tube and

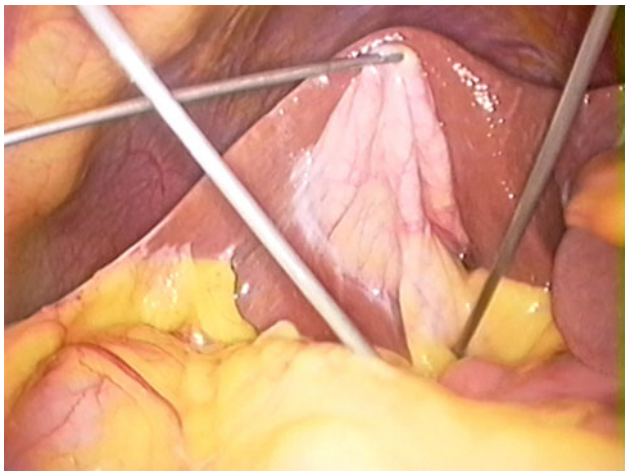

Fig. 1 Operative view from 10-mm laparoscope showing manipulation of the gallbladder using three 2-mm instruments

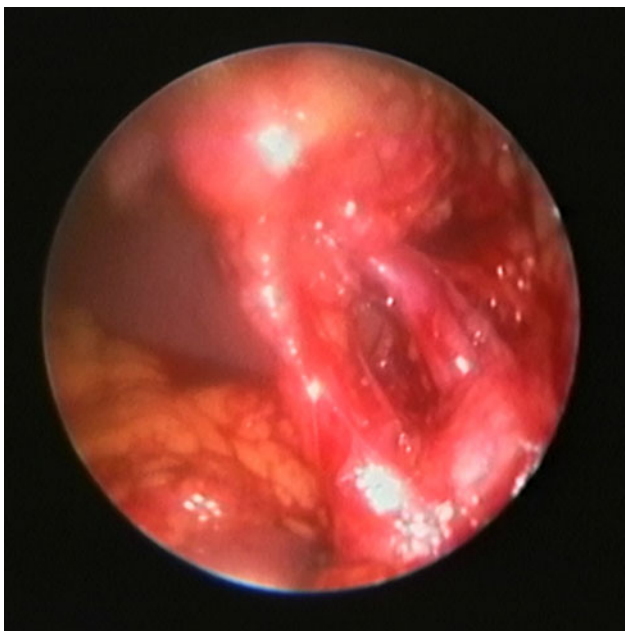

Fig. 2 Critical view when using 2-mm needlescopic instruments

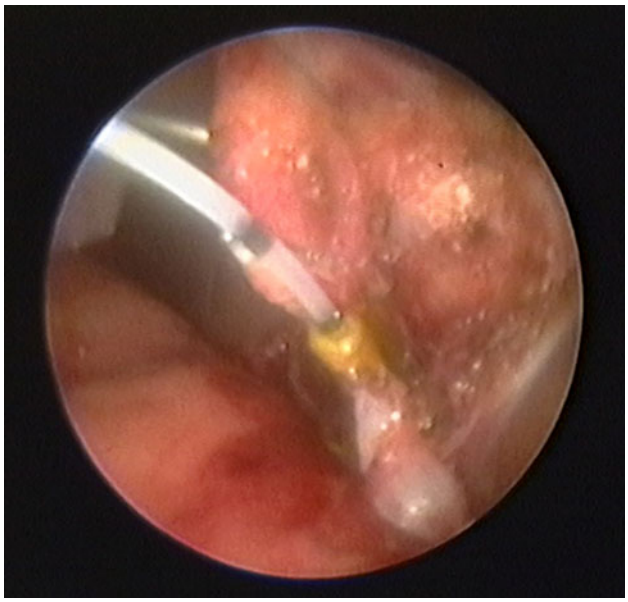

Fig. 3 Cannulation into the cystic duct for intraoperative cholangiography

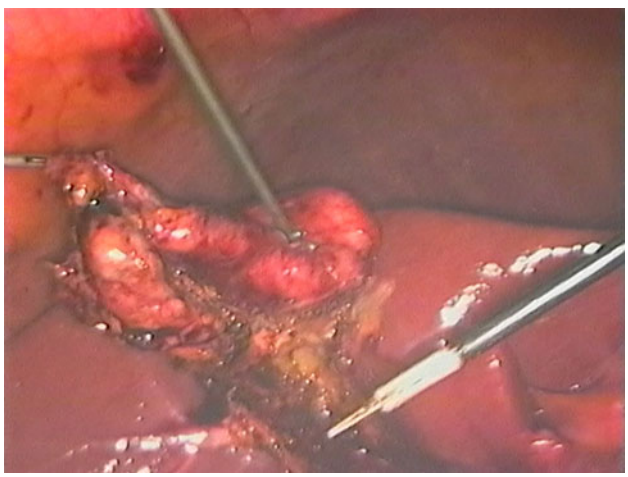

Fig. 4 The gallbladder freed from the liver bed

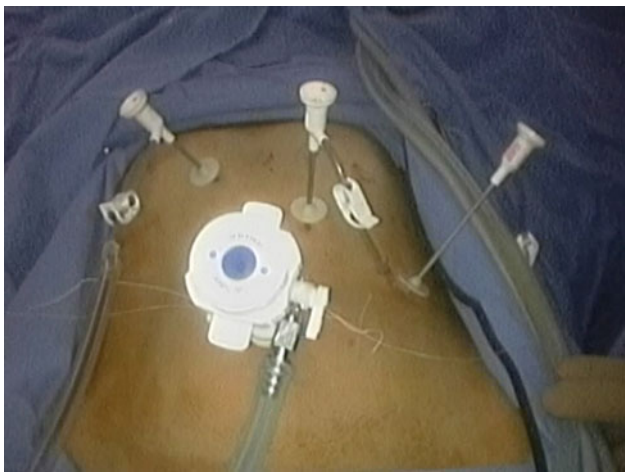

Fig. 5 The external view during splenectomy

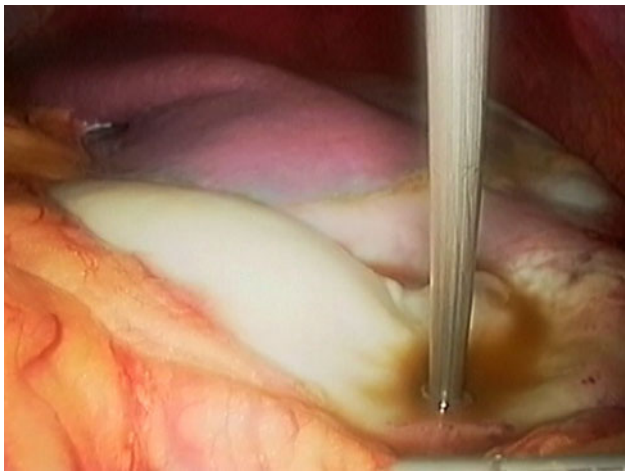

Fig. 6 The clear contents of the cyst being aspirated and evacuated using a suction catheter

Fig. 7 The exposed wall of the cyst being excised near the splenic parenchyma using electrocautery

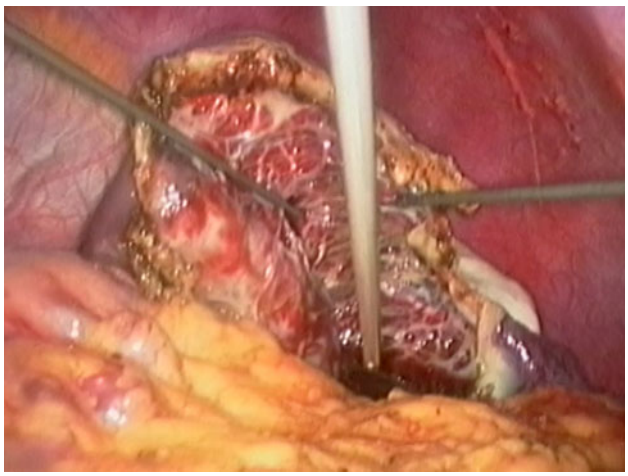

Fig. 8 The inside of the residual cystic wall being cauterized after marsupialization

urinary catheter. The operator stood on the left side of the patient and the assistant on the right. The first 12-mm port was introduced into the peritoneal cavity by an open laparoscopy technique at the umbilicus. After creating the pneumoperitoneum using CO_2 gas with an intraperitoneal pressure of 10 mmHg, three 2-mm ports (MiniSite: Covidien Co. Ltd., Norwalk, CT, USA) were inserted at the right upper quadrant and epigastrium under the guidance of a 10-mm laparoscope through the umbilical port (Fig. 1). Intraperitoneal pressure was changed to 8 mmHg when the procedure was started. The operator manipulated 5-mm dissecting forceps, cutting forceps, electrocautery, laparoscopic coagulating shears (LCS) (SonoSurg: Olympus K.K. Tokyo, Japan) and 10-mm clips in the left hand from the umbilical port and a 2-mm needlescope in the right hand from the epigastric 2-mm port during all procedures. The assistant manipulated two 2-mm ports in the right upper quadrant using both hands. After obtaining the critical view (Fig. 2), intraoperative cholangiography (IOC) was selectively performed. The catheter was inserted into the small orifice of the cystic duct from the umbilical port using a specialized 5-mm instrument (Fig. 3). The cystic duct and artery were divided after confirmation that there was no bile duct injury or common bile duct stones. The gallbladder was freed from the liver bed (Fig. 4) and removed from the abdominal cavity using a plastic bag. The umbilical wound only was closed.

Surgical procedure for splenic diseases

Under general anesthesia, the patient was placed in the right decubitus position. The operator stood on the right side of the patient and the assistant on the left.

In splenectomy, the first 12-mm port was introduced in the lateral margin of the left rectus abdominis muscle at the level of the umbilicus. After creating the pneumoperitoneum using CO_2 gas with an intraperitoneal pressure of 10 mmHg, three 2-mm ports were inserted in the left upper quadrant at the subxiphoid and at the left subcostal margin in the midclavicular and mid-axillary lines using the guidance of a 30° 10-mm laparoscope through the initial periumbilical port (Fig. 5). The intraperitoneal pressure was changed to 8 mmHg when the procedure was started. Initially, we explored for accessory spleens. Subsequently, the splenocolic ligament was divided using LCS under the guidance of a 2-mm laparoscope. The spleen was freed from the splenorenal ligament toward the posterior aspect of the splenic hilus by LCS via the 12-mm port, and an operative field was created by manipulation of the two shafts of the needlescopic grasping forceps under the needlescopic vision. At this time, the spleen was still connected to the splenic hilus and supported by the splenophrenic ligament. Subsequently, the splenic hilar and short gastric vessels were divided simultaneously using an Endo-GIA linear stapler (Covidien Co. Ltd.) via the 12-mm port. The isolated spleen was then placed in an impermeable bag (Endo-Catch II; Covidien Co. Ltd.) and extracted via the 12-mm port after morcellation. No bleeding from the stapled line was observed. A suction drain was placed into the left subphrenic space. The 12-mm port wound only was closed.

In splenic marsupialization, the first 12-mm port was introduced into the peritoneal cavity from the umbilicus using an open laparoscopy method. Pneumoperitoneum was created by insufflation of CO_2 gas with a maintenance pressure of 10 mmHg. Another three ports were inserted into the peritoneal cavity in the right or left upper quadrant, depending on the location of the cyst. Intraperitoneal pressure was changed to 8 mmHg when the procedure was started. Initially we performed intraoperative ultrasonography (Aloka Co. Ltd., Tokyo, Japan) to confirm the location of the cyst and the conditions surrounding it, the extent of cystic wall not covered by the splenic parenchyma and the absence of elevated lesions inside the cyst. The clear contents of the cyst were aspirated and evacuated completely using a suction catheter (Fig. 6). After lifting up the cystic wall using nylon threads from the outside of the peritoneal cavity, the exposed wall of the cyst was excised near the splenic parenchyma using electrocautery (Fig. 7). The excised wall of the cyst was removed through the umbilical port. After cauterizing the inside of the residual cystic wall, a suction drain was placed into the cyst cavity (Fig. 8). The umbilical port only was closed.

Surgical procedure for hepatic cyst

Under general anesthesia, the patient was placed in a supine position with insertion of a nasogastric tube and urinary catheter. The operator stood on the left side of the patient, the assistant on the right and the laparoscopist beside the operator. The first 12-mm port was introduced into the peritoneal cavity by an open laparoscopy technique at the umbilicus. After creating the pneumoperitoneum using CO_2 gas with an intraperitoneal pressure of 10 mmHg, three 2-mm ports were inserted at the right upper quadrant and epigastrium using a 10-mm laparoscope through the umbilical port, depending on the site of the hepatic cysts. Intraperitoneal pressure was changed to 8 mmHg when the procedure was started. The operator manipulated 2-mm dissecting forceps, cutting forceps or electrocautery from the epigastric and right subcostal ports with both hands. The assistant manipulated a 2-mm grasping forceps in the right subcostal port and the laparoscopist a 10-mm laparoscope from the umbilical port. The remainder of the procedure is same as that of splenic marsupialization.

Results

Cholecystectomy

Cholecystectomy was successfully completed using needlescopic instruments in 142 patients. Eight patients (5.3%) required a change from a 2- to a 5-mm port; there was no conversion to open cholecystectomy. The reasons for conversion to larger ports were a thickened wall of the gallbladder due to chronic cholecystitis and dense adhesions around the gallbladder due to acute cholecystitis. No perioperative complications were observed. The mean operation time was 80.2 min (range 49–120 min) and the estimated blood loss was minimal. The mean postoperative hospital stay was 3.2 days (range 2–4 days).

Splenectomy

Splenectomy was successful in all cases. An accessory spleen was also removed in one case. The mean operation time was 167 min (range 125–235 min). The mean blood loss was 70 ml (range 0–120 ml). The mean resected spleen weight was 170 g (range 140–217 g). There were no intraoperative or postoperative complications. None of the patients needed any postoperative analgesia, and recovery was uneventful. On postoperative day 7, the mean platelet count was $183{,}000 \times 10^4/\mu L$ (the mean preoperative platelet count was $24{,}600 \times 10^4/\mu L$). The postoperative

hospital stay ranged from 4 to 7 days, with a mean of 5 days.

Marsupialization

Marsupialization was successfully accomplished in all cases. The operation time ranged from 120–240 min with a mean of 170 min for splenic cyst and 120 min for hepatic cyst, and the mean blood loss was minimal in both diseases. There were no perioperative complications expect for temporary postoperative thrombocytosis in one patient with a splenic cyst. The histopathological diagnosis was pseudocyst in all cases. The postoperative hospital stay ranged from 5 to 7 days, with a mean of 5.6 days for splenic cyst and 7 days for hepatic cyst. A residual splenic cyst requiring splenectomy was detected in one patient.

During the follow-up period, there were no medical episodes associated with the needlescopic procedures in any patients. The 2-mm postoperative scars were virtually invisible 2 weeks after surgery.

Discussion

In general, reducing the size of the laparoscopic ports and instruments is associated with fewer traumas and better esthetic outcome for the patients, but more stress for surgeons when performing laparoscopic procedures and a high incidence of conversion to conventional or open treatment. The stress is caused by a narrow operative field, a reduction of light transmission and image quality [5, 8], a blurring of vision due to the use of electrocautery [9], a reduction in the ability to manipulate the instruments due to their increased flexibility, particularly in the presence of fibrosis or inflammation [5, 8, 10], and the difficulty of learning to use the instruments [8]. Recently, many randomized clinical trials have provided sufficient evidence that needlescopic cholecystectomy (NC) is also a safe procedure [11–16]. However, it has not been satisfactorily demonstrated that needlescopic instruments for NC result in cogent benefits for patients with regard to compulsory length of hospital stay, quantity of analgesia required, and the start of intake of solid food after surgery [17]. We started the program of NS in May 1998, and were encouraged by the intraoperative and short-term postoperative outcomes of 50 initial cases of NC. After gaining surgical skill and improving needlescopic instruments, a comparative clinical trial to recommend the best use of the needlescope in NC was carried out [18]. We consider that NC is a safe and effective procedure for the management of gallbladder disease.

Table 1 shows the operative results with 2-mm instruments for cholecystectomy from 13 institutions [5, 8–11, 14, 15, 18–23]. The mean age of the patients was 49.1 years. Watanabe et al. [9] operated through a 10-mm port in the subxiphoid and a 2-mm port in the umbilicus. Schmidt et al. [20] used 1.7-mm instruments in place of 2-mm instruments. The mean operation time was 75 min (range 42–98 min). Our operation time was in the middle of the range of the reports. IOC was routinely performed in 3 reports (23.1%) [5, 9, 23] and selectively in 2 reports (15.4%) [10, 18]. The mean operation times with routine

Table 1 Needlescopic cholecystectomy (using 2-mm or smaller instruments)

Author	Year	No. of cases	Age (years)	Ports (mm)	Operation time (min)	IOC	Stay (days)	Conversion *n* (%)	Complication *n* (%)
Watanabe [9]	1997	20	45	2-10-2-2	80	+	4.0	0	0
Yuan [8]	1997	14	47	11-2-2-2	79.3	−	1.57	0	0
Gagner [5]	1998	60	NS	10-2-2-2	98	+	1.2	3 (5)	0
Ngoi [19]	1999	36	30–78	10-2-2-2	42	−	NS	0	0
Reardon [10]	1999	100	56	10-2-2-2	88.7	±	1.5	5 (5)	3 (3)
Bisgaard [11]	2000	13	46	10-2-2-2	85	−	NS	5 (38.5)	0
Schmidt [20]	2002	40	52.4	10-1.7-1.7-1.7	51	NS	3.3	0	1 (2.5)
Alponat [14]	2002	17	45.8	10-2-2-2	80.9	−	NS	5 (29.4)	NS
Lai [21]	2003	33	49.8	10-2-2-2	97.4	−	2.05	6 (18.2)	4 (12.1)
Huang [15]	2003	30	49.6	10-2-2-2	64.8	−	3.0	5 (16.6)	3 (10)
Lee [22]	2004	1,011	54.8	10-2-2-2	68.8	−	2.5	2 (0.2)[a]	21 (2.08)
Franklin [23]	2006	303	41.9	10-2-2-2	59.3	+	0.95	1 (0.35)	1 (0.35)
Tagaya [18]	2007	40	51.8	10-2-2-2	79.8	±	3.2	1 (2.5)	0
Present	2010	150	53.7	10-2-2-2	83.9	±	3.3	8 (5.3)	0

NS: Not stated, ±: selective IOC

[a] Conversion to open laparotomy in 1 case (0.1%)

Table 2 Needlescopic cholecystectomy (using 3-mm instruments)

Author	Year	No. of cases	Age (years)	Ports (mm)	Operation time (min)	IOC	Stay (days)	Conversion *n* (%)	Morbidity *n* (%)
Davides [24]	1999	25	52	10-3-3-3	75	+	1.36	0	0
Cheah [13]	2001	37	49	10-3-2-2	50	−	1	3 (8.1)[a]	0
Look [25]	2001	28	53.4	10-3-3-3	72.1	−	NS	4 (14.3)[b]	0
Bisgaard [26]	2002	25	47	10-3.5-3.5-3.5	65	±	0–2	2 (8)	1 (4)
Ainslie [27]	2003	21	58	10-3.3-3.3-3.3	74	+	NS	0	2 (9.5)
Sarli [28]	2003	67	53	3-3-3-12	50	±	1	4 (5.9)	5 (7.5)
Hsieh [29]	2003	38	55.7	10-3-3-3	113.8	NS	4.3	3 (7.9)	4 (10.5)
Lai [21]	2003	64	49.8	10-2.5-2-2	74.0	−	1.78	15 (23.4)	7 (10.9)
Lai [21]	2003	53	49.8	10-3-2-2	57.9	−	1.61	2 (3.8)	3 (5.7)
Cabral [30]	2008	30	45.2	10-2-2-3	44.9	−	1	7 (11.6)[c]	7 (11.6)
Carvalho [31]	2009	1000	45.9	10-3-2-2	43	−	0.67	28 (2.8)	30 (3)

NS: Not stated, ±: selective IOC

[a] Conversion to open laparotomy in 1 case (2.7%)

[b] Conversion to open laparotomy in 3 cases (10.7%)

[c] Conversion to open laparotomy in 1 case (3.3%)

IOC, selective IOC and without IOC were 79.1 min, 82.9 min, and 74.0 min, respectively. IOC did not greatly influence the operation time. Our recent operation time has been a little longer than the mean of the previous reports. The mean postoperative hospital stay was 2.3 days (range 0.95–4.0), the conversion rate ranged from 0 to 38.5%, with a mean of 8.6%, and there was only one conversion to open laparotomy in all reported cases. This result greatly depends on the number of cases performed. In reports of more than 100 cases, the mean conversion rate (2.8%) was very low [10, 22, 23], and the mean morbidity rate (2.4%) was also low. There was one major complication involving a partial accidental laceration of the right hepatic duct, which was repaired by conversion to conventional laparoscopic procedure in one case [23]. We have not experienced any intra- or postoperative complications.

Table 2 shows the operative results with 3-mm instruments in 10 institutions [13, 21, 24–31]. The mean age was 50.8 years. A 12-mm port was introduced in the left upper quadrant on the midclavicular line and a 3-mm port in the umbilicus, subxiphoid and right lower quadrant [28]. The mean operation time was 65.4 min (range 43–113.4). IOC was performed in 4 reports (routinely in 2 [24, 27], selectively in 2 [26, 28]). The mean operation times with routine IOC, selective IOC and without IOC were 74.5 min, 57.5 min and 56.9 min, respectively. The mean postoperative hospital stay was 1.6 days (range 1–4.3). The mean conversion rates to conventional laparoscopic cholecystectomy and open cholecystectomy [13, 25, 30] were 7.8% (range 0–23.4) and 1.5% (range 0–10.7), respectively. However, the conversion rate greatly depends on the exclusion criteria for NC in each institution. The morbidity rate ranged from 0–11.6%, with a mean of 5.7%. There were no major complications such as bile duct injury. These results suggest that the operative results with 3-mm instruments are superior to those with 2-mm instruments.

In fact, the term "needlescopic" is used for any procedure in which the instruments used are 3 mm or less in diameter [5]. Needlescopic instruments are usually either 2 or 3 mm in diameter; however, there are several important differences between these instruments. Three-mm instruments are superior to 2-mm instruments in terms of rigidity, ease of division and dissection by curved-jaw forceps, and capacity of the suction and irrigation device. Thus, we have successfully performed NC with 3-mm instruments in 10 patients with acute cholecystitis. Hsieh [29] also reported that the results of cholecystectomy for acute cholecystitis by minilaparoscopic cholecystectomy using 3-mm instruments are as good as those of conventional laparoscopic cholecystectomy if the operation is performed at an early stage, resulting in smaller incisions and minimal complications. Lai et al. [21] reported that there were significant differences between 2- and 3-mm instruments in the success rate, operation time and length of hospital stay, and the size of the subxiphoid port. From these points of view, 3-mm instruments will play a similar role to that performed previously by 5-mm instruments. However, several limitations still remain with the use of 2-mm instruments, and we therefore have to overcome them to achieve a good surgical outcome. Recently, a new type of 2-mm instruments (BJ Needle: Niti-on K.K., Chiba, Japan) has been introduced. They provide more rigid grasping and less bending than ordinary 2-mm instruments, with a consequent reduction in operation time and stress for surgeons.

Table 3 Needlescopic cholecystectomy (using 5-mm instruments)

Author	Year	No. of cases	Age (years)	Ports (mm)	Operation time (min)	IOC	Stay (days)	Conversion *n* (%)	Morbidity *n* (%)
Tanaka [32]	1998	5	56	12-5-1.8-2.5	74	−	6.2	0	0
Faggioni [33]	1998	60	46.1	10-5-2-2	36	±	2	0	0
Kimura [34]	1998	20	54.3	10-5-3-3	107.2	+	4.9	0	0
Unger [35]	2000	56	51	5-5-2-2	72	+	1.31	9 (16)	3 (5.3)
Schwenk [12]	2000	25	52	5-5-2-2	70	−	3	1 (4)	0
Leggett [36]	2001	159	44.7	10-5-3-3	20.9	−	<1	5 (3.1)	1 (0.6)
Novitsky [16]	2005	34	46.7	10-5-2-2	50.5	±	NS	8 (23.5)	1 (2.9)

±: selective IOC

Table 4 Needlescopic procedure for splenic diseases

Author	Year	No. of cases	Age (years)	Ports (mm)	Operation time (min)	Blood loss (ml)	Stay (days)	Conversion *n* (%)	Complication *n* (%)
Gagner [5] (Torsion, ITP, cyst, hereditary spherocytosis, lymphoproliferative disorder)	1998	5	NS	12-2-2-2	90	NS	1.0	0	0
Seshadri [37] (Cyst)	2000	1	22	12-3-3	60	NS	1	0	0
Mamazza [38] (NS)	2001	10	NS	12-3-3-3	175	NS	2.2	3 (30)	2 (20)
Tagaya [39] (ITP)	2002	3	43.3	12-2-2-2	167	70	5	0	0
Tagaya [40] (Cyst)	2002	3	32	12-2-2(5)-2	170	Minimal	5.6	0	0

NS: not stated, ITP: idiopathic thrombocytopenic purpura

We are continuing the evaluation of the BJ needle in a multi-center trial.

Table 3 shows the operative results with 2- or 3-mm instruments plus 5-mm instruments in 7 institutions [12, 16, 32–36]. The mean age was 50.1 years. The mean operation time was 61.5 min (range 20.9–107.2). IOC was performed in 4 reports (routinely in 2 [34, 35]; selectively in 2 [16, 33]). The mean operation times with routine IOC, selective IOC and without IOC were 89.6, 43.3 and 55.0 min, respectively. The mean postoperative hospital stay was 3.1 days (range 1–6.2). The mean conversion rates to conventional laparoscopic cholecystectomy and open cholecystectomy were 6.6% (range 0–23.5) and 0%, respectively. The morbidity rate ranged from 0–5.3%, with a mean of 1.26%. There were no major complications. The operation time was short compared with that of the 2- or 3-mm instruments procedure. The conversion and morbidity rates were also lower than the results of 2- and 3-mm instruments. The addition of one 5-mm instrument produced a similar outcome to that using the conventional laparoscopic method. The most important factor resulting in reduced operation time and a low conversion rate is the use of at least one 3- or 5-mm port for the grasping instruments.

Table 4 shows the operative results of needlescopic procedures for splenic diseases in 5 reports from 3 institutions [5, 37–40]. The splenic diseases included ITP, cyst, torsion, hereditary spherocytosis and lymphoproliferative disorder. The placement of ports was similar in all reports, at the periumbilical and left subcostal regions. In 3 of the 5 reports, 2-mm instruments were used; in the other 2, 3-mm instruments were used. The mean operation time was 150 min for splenectomy and 142.5 min for marsupialization. The estimated blood loss was minimal. The mean postoperative hospital stay ranged from 1–5.6 days, with a mean of 2.96 days. Mamazza et al. [38] reported conversion to conventional laparoscopic splenectomy in 3 of 10 patients and two complications (urinary retention and postoperative bleeding due to a low platelet count). There was no major morbidity or mortality. From the above findings, although there were few reports regarding needlescopic procedure for splenic diseases,we can conclude that needlescopic procedures for splenic disorders are safe

and effective with low conversion and morbidity rates. Technical points to improve safety during procedures on solid organs, such as spleen or liver, are: no direct organ mobilization to avoid organ injuries, rotation of the operating table and utilization of gravity on the organ to create a better operative field, the minimum use of needlescope to perform a safe maneuver, and the improvement of bimanual technique.

From the above findings, we recommend that the use of the needlescope should be kept to a minimum due to the limitations in manipulating needlescopic instruments, reduced instrument visualization, and demands on the surgeon. Although this procedure is indicated in children or young women to improve the esthetic outcome, ease of use and safety, the feasibility and safety of needlescopic instruments for patients with complications are still unclear, and further clinical studies will be needed for verification [18]. In conclusion, laparoscopic cholecystectomy using a needlescope and needlescopic instruments is a safe and feasible procedure to achieve a minimal invasive surgery, and is not associated with major complications such as bile duct injury or uncontrolled bleeding. Several of the technical obstacles encountered in NS should be resolved in the near future.

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