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Laparoscopic hand-assisted surgery for hepatic and pancreatic disease

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Abstract. Herein I describe my initial experience with the use of a novel device, the Omniport, in 15 patients undergoing hand-assisted laparoscopic surgery (HALS) on the liver and pancreas. The device, which essentially consists of a hand cuff with a spiral inflatable valve, enables withdrawal and reinsertion of the hand without loss of pneumoperitoneum during the operation. The cuff's effective sealing pressure is equal to the pneumoperitoneal pressure; hence, hand comfort is maintained during the intervention. The device was effective in maintaining pneumoperitoneum in all cases. All but one operation was completed with the HALS approach. The one conversion was due to bleeding from the superior mesenteric vein during a 90% pancreaticosplenectomy. Immediate effective control of the bleeding by compression between the thumb and index finger was achieved, and the cuff of the Omniport was deflated as the incision was enlarged. There were no postoperative complications. The HALS approach has distinct advantages in terms of exposure and safety over the total laparoscopic technique for major surgery on the liver and pancreas, and it is recommended for these interventions.

Key words: Laparoscopic hand-assisted surgery — Omniport — Hand port — Liver surgery — Pancreatic surgery

The laparoscopic approach entails a number of restrictions in the execution of major operations. These restrictions concern adequate exposure during complex dissections, delivery of malignant specimens, loss of tactile palpation, and the execution of complex anastomoses necessary to restore the continuity of the gastrointestinal and biliary tracts. These problems ultimately led to the development of laparoscopically assisted surgery (LAS) for the gastrointestinal tract. With this approach, following mobilization, a strategically placed mini-abdominal incision is placed at the appropriate site for the delivery, excision, and hand-sewn or stapled anastomosis. In LAS, the pneumoperitoneum is lost during the open part of the procedure, during which the surgeon uses normal stereoscopic binocular vision. Hand-assisted laparoscopic surgery (HALS) is different because the assisting hand of the surgeon is used for display, exposure, palpation, gentle traction, and blunt finger dissection during the operation; it also provides immediate hemostasis in the event of intraoperative bleeding [6, 13, 18, 20, 25]. With HALS, the pneumoperitoneum is maintained throughout the operations, and the surgeon operates from displayed images of the operative field as in laparoscopic surgery.

There is no doubt that the execution of complex operations is thus facilitated, especially in the presence of omental obesity. Furthermore, the control of the hemorrhage is greatly improved because the fingers of the hand (index and thumb) can be used to grasp the bleeding vessels. This is particularly important during surgery on vascular organs such as the liver, kidneys, and pancreas. The HALS approach should encourage surgeons to develop and engage in more advanced laparoscopic cancer operations while also allowing them to retain many of the advantages of laparoscopic surgery, including the cost benefits [6, 21]. There are now several published reports on the benefits afforded by HALS in the conduct of various operations, including gastrectomy [15, 19], esophagogastrectomy [27], gastric bariatric surgery [23, 26, 28], transhiatal esophagectomy [5], splenectomy [1, 11, 12], disease and donor nephrectomies [17, 22, 24, 29, 30], colorectal surgery [7, 14, 16], hysterectomy [21], pancreatic resections [10, 16], and drainage of intraabdominal abscesses [9].

A variety of hand-access devices have been used. The majority of these devices have one major limitation—they fail to maintain a satisfactory pneumoperitoneum; furthermore, in the majority of cases, the pneumoperitoneum is usually lost once the hand is withdrawn from the peritoneal cavity. In a prospective multicenter study on HALS involving 58 patients for 24 different procedures, 22% of the cases required conversion to an open technique because of failure to maintain pneumoperitoneum or inability to complete the anticipated operation by this method. In this study, the surgeons concluded that the HALS approach with one hand port device shortened the operative time in 58% of cases [18].

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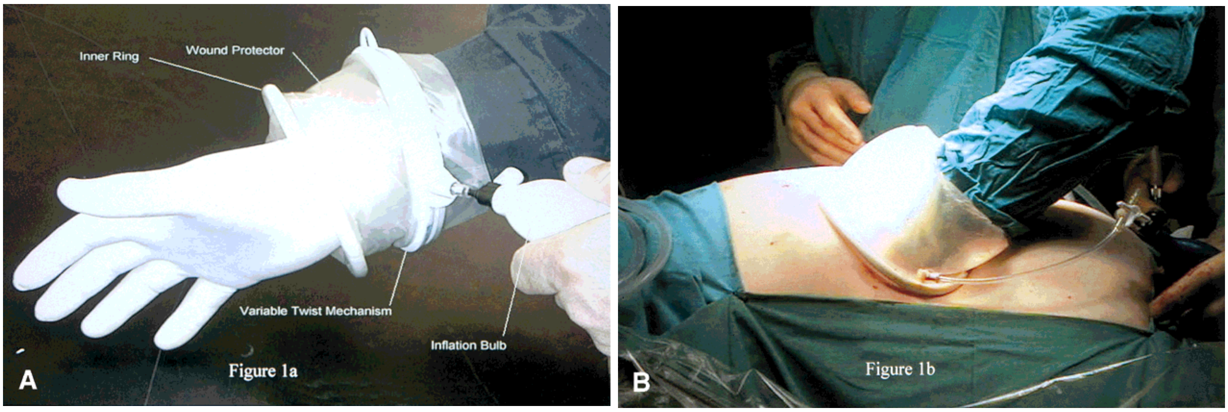


Fig. 1. A Omniport device. Essentially, this device is a wrist cuff with a special inflatable tubular valve between the outer and inner rings. **B** Omniport in use.

The reported experience with HALS liver and pancreatic surgery is limited. This paper reports on the experience of Ninewells Hospital in Dundee, Scotland, with HALS surgery for pancreatic and liver disorders using a novel device (The Omniport; Advanced Surgical Concepts, Dublin, Ireland). The Omniport is essentially a wrist cuff that provides an effective seal and enables maintenance of the pneumoporitoneum when the assisting hand is withdrawn from the peritoneal cavity.

Materials and methods

The Omniport device

The Omniport (Fig. 1) is a new HALS device of unique design—in essence, an inflated, twisted, endless tubular cuff of pliable material. Two semi-rigid rings facilitate attachment of the deflated cuff to the patient and further act to secure the cuff within the incision when the device is inflated. When inflated, the cuff comprises a nominally cylindrical outer sleeve and an hourglass-shaped inner sleeve connected by rounded ends. The lumen of the inner sleeve defines the passageway through which access is gained to the abdominal cavity. The application of a pressurized air to the Omniport causes the outer sleeve to become relatively stiff both torsionally and axially. As a result of the torsional stiffness so induced, all the twist is trasferred to the inner sleeve, which has only axial stiffness. It is the twisting of the inner sleeve that gives it its overall hourglass shape, the diameter of the neck of the hourglass being determined by the degree of twist. The diameter of the outer sleeve is dimensioned to facilitate a range of incision lengths for HALS.

Initially, the portion of the outer sleeve within the incision is constrained by the incision margins. The application of air pressure to the Omniport causes fine outer sleeve to expand outward, retracting the incision and forming a gas-tight seal between the incision margin and the outer sleeve. The presence of natural viscous fluids at the incision margin facilitates the maintenance of the gas-tight seal while at the same time acting as a lubricant, thus facilitating rotation of the Omniport in response to the rotational movement of a surgeon's arm. Although the inner sleeve has an overall hourglass shape, each linear longitudinal element of the inner sleeve is aligned at an angle to the axis of the device. The insertion of a surgeon's arm or an instrument stem into the lumen of the inner sleeve causes the linear elements to bend, forming a spiral around the arm or instrument. The air pressure within the Omniport, acting on the rounded ends, causes axial tension to be applied to the inner sleeve. In this way, the axial tension acts to straighten the linear elements. This straightening will be resisted by the presence of the instrument or arm, resulting in a radially inward pressure being exerted on the instrument or arm. In addition to the pressure exerted on the arm as a result of the pressure acting on the rounded ends, there is also the pressure acting directly on the inner sleeve by the pressurized air within the Omniport. Thus, the pressure acting on the instrument stem or surgeon's arm is greater than the pressure of the pressurizing air within the cuff.

Since the pressure within the cuff must be at least equal to insufflation pressure in order to achieve a seal at the incision margin, the radially inward pressure being exerted by the inner sleeve must always be slightly greater than insufflation pressure. The Omniport's frictionless rolling inversion action facilitates forward and backward movement of the surgeon's arm without placing undue strain on the arm. Similarly, the pliant nature of the Omniport cuff permits a degree of lateral and angular movement of the surgeon's arm within the incision.

Ergonomics

There are important ergonomic considerations underlying the correct placement of the hand-access device and the various ports in HALS. The location of the mini-laparotomy wound (5–7 cm, depending on the surgeon's hand size) is dictated by the anatomical region of the intended operation and the position of the surgeon (i.e., left side of the patient, between the patient's legs, right side of the patient). For liver and pancreatic surgery, the practice at Ninewells Hospital is for the surgeon to operate from the left side, with the patient in the supine head-up position. With this setup, the Omniport is placed through a vertical midline low epigastric region for surgery on the pancreas, stomach, and left liver; it is placed in the right upper quadrant (transverse/oblique) for operations on the right liver.

In laparoscopic surgery, the best location for the optical port (laparoscope) is between the two operating ports with equal azimuth angles [8]. This setup, which enables the best viewing and manipulations, is difficult with the use of any hand-access device and constitutes one of the disadvantages of HALS. In practice, the off-optical axis is used for the placement of the optical port such that the laparoscope is to one side or other of the hand-access device and instrument port. We have found that for right-handed surgeons, the following placement of the optical port gives the optimal viewing and ergonomics:

1. Pancreas, left liver, spleen, and stomach—left upper quadrant along the lateral margin of the rectus abdominis
2. Right liver—left upper quadrant at 2.0 cm to the left of the midline

To maintain an effective fit of the device, it is important that the wound used for the insertion of the Omniport be created after the establishment of a CO_2 pneumoperitoneum. If the wound is made and the device inserted before the establishment of a pneumoperitoneum, the wound will be stretched by $\leq$40% [4]. Hence, the snug fit of the device in the wound is lost and leakage occurs. The best method for insertion of the Omniport is to compress the two rings between the thumb and fingers with the outer ring (which has an attachment to the inflating system) uppermost. This will enable insertion of the device into the peritoneal cavity. The outer ring is then exteriorized in a circular counterclockwise fashion.

Results

The HALS experience with liver and pancreatic surgery is shown in Table 1. The patients (nine men and 6 women; age

Table 1. Hand-assisted laparoscopic surgery (HALS) of liver and pancreas using the Omniport device

Disease	*n*	HALS operation	Conversion[a]
Pancreatic cystadenoma neck and adjacent body	1	90% pancreatiocosplenectomy	Yes
Nonsecreting pancreatic islet cell tumor	1	Distal hemipancreaticosplenectomy	No
Pancreatic pseudocysts	2	Cystogastrostomy ($n = 1$), infracolic cystenterostomy ($n = 1$)	No
Infected pancreatic necrosis	2	Infracolic pancreatic necrosectomy ($n = 2$)	No
Hepatic colorectal secondary deposits	1	Left hepatectomy	No
Hepatic colorectal secondary deposits	1	Left hepatectomy lobectomy (segments ii and iii)	No
Hepatic colorectal secondary deposits	2	Segmentectomy v, vi ($n = 1$), segmentectomy iv, v ($n = 1$)	No
Hepatic colorectal secondary deposits	3	Radiofrequency thermal ablation for bilateral disease ($n = 3$)	No
Focal nodular hyperplasia	1	Cholecystectomy and segment iv resection en block	No
Primary hepatoma in a cirrhotic liver (6 cm)	1	Cryoablation	No
Total	**15**		**1**

[a] Conversion rate = 6%

range, 30–72 years) were all in ASA grade I. One patient with a large proximal pancreatic cystic tumor was morbidly obese (BMI 40). A satisfactory pneumoperitoneum was maintained throughout the operation in all cases. During the operations, the surgeon withdrew his assisting hand to replace it with the dominant hand or the assistant's hand or to insert instruments (staplers, needle drivers) or swabs (to control oozing) in eight cases without loss of the pneumoperitoneum. All operations except the 90% pancreaticosplenectomy were completed using the HALS approach.

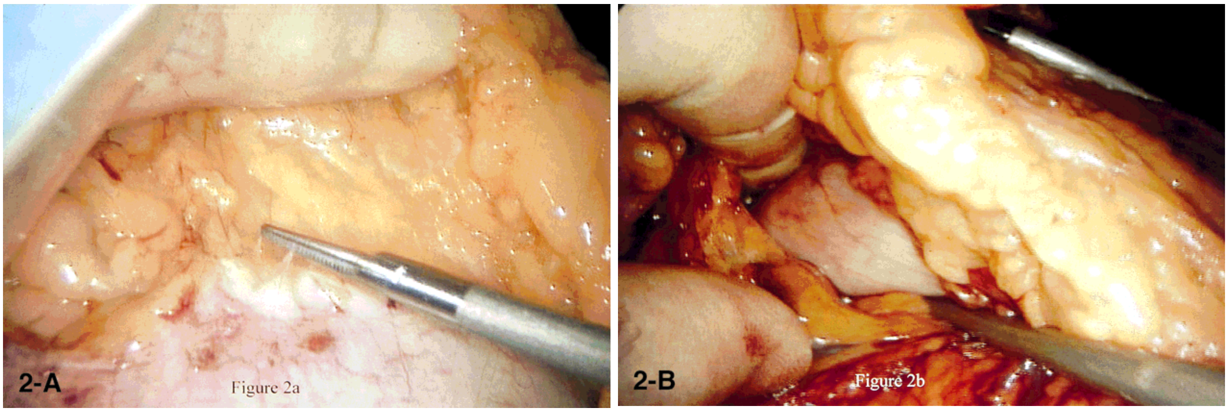
The internal handling by grasping the tissues greatly facilitates the dissection of fascial planes. In particular, the detachment of the greater omentum from the transverse colon and mescolon in pancreatic and gastric surgery is made much easier (Fig. 2). Grasping of the pancreas enables a combined instrumental and thumb dissection (Fig. 3). In segmental liver resections, detachable atraumatic clamps are placed across the hepato-duodenal ligament (portal vein, hepatic artery, and bile duct). This maneuver, together with hand grasping of the segments of the liver to be removed, virtually abolishes bleeding during the liver resection. Control of the parenchymal vessels is obtained by clips and by use of argon spray coagulation. In all of the liver resections, the operative blood loss was <500 ml, and none of the patients required blood transfusion in the perioperative period. Bleeding from one of the hepatic veins to the caudate lobes was encountered during resection of the caudate lobe, but it was totally controlled by finger compression during suture ligation of the small hepatic vein. In two other patients undergoing hepatic resections, bleeding from segmental veins was readily controlled by finger compression, followed by laparoscopic suture ligation or clipping.

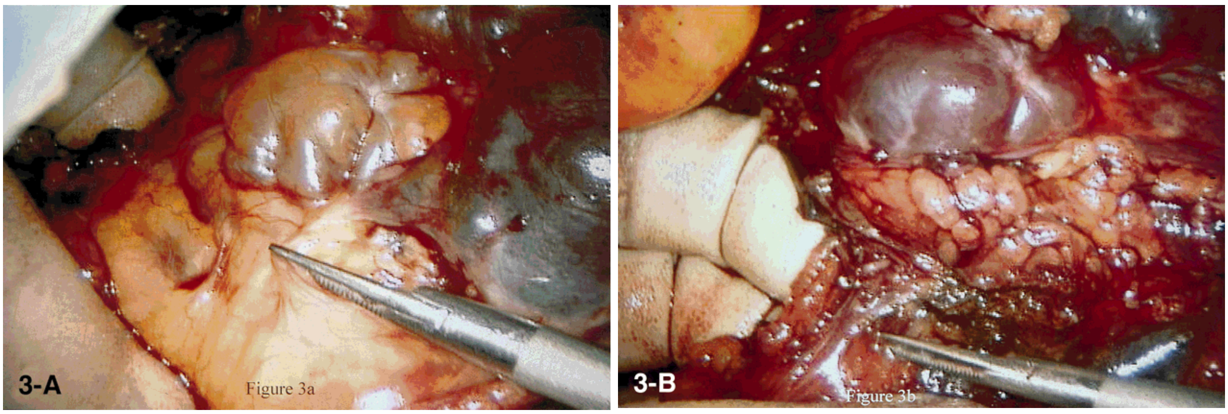
The median duration of the operations was 2 h (range, 1–6) h. There were no deaths or major postoperative complications. For the liver cases ($n = 8$), the median postoperative hospital stay was 4 days (range, 3–6). The two patients who underwent cystogastrostomy (Fig. 4) were discharged on the 3rd postoperative day. Both cases of HALS pancreatic necrosectomy for infected pancreatic necrosis were conducted by the infracolic approach [2, 3], with insertion of drains in the lesser sac for postoperative irrigation with hyperosmolar dialysate solution for 7 days. These two patients were discharged from hospital 3 and 4 weeks later, respectively.

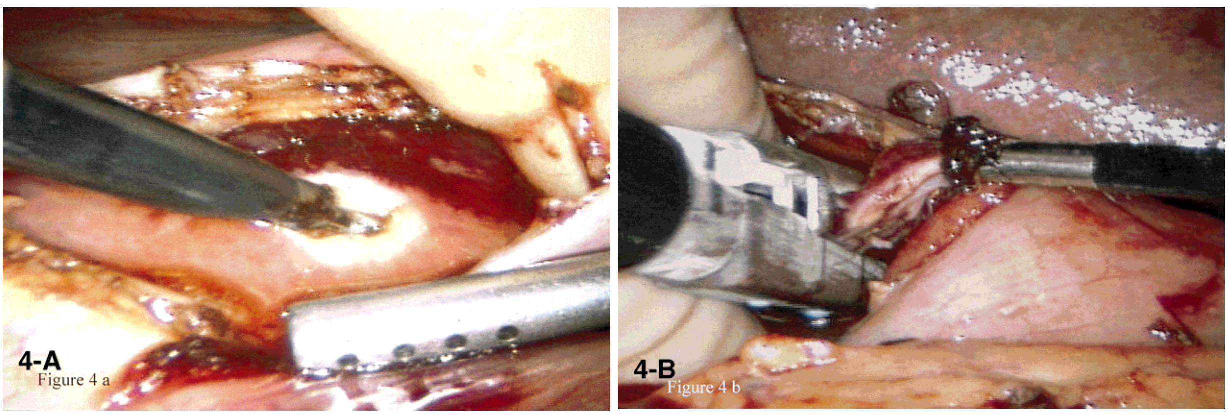
The patient undergoing HALS 90% pancreaticosplenectomy for a large cystic tumor of the neck and body of the pancreas (Fig. 5) required conversion due to major bleeding from the superior mesenteric vein. This intraoperative complication demonstrates the safety afforded by the Omniport HALS device. During dissection of the tumor, part of the lesion was behind the portal/superior mesenteric vein, which was stretched over it. The vein was accidentally damaged during the attempt to free it from the surrounding tumor. Bleeding was stopped immediately by compression of the injured vein between the thumb and index finger of the intraperitoneal assisting hand. The cuff of the Omniport was deflated, the wound was enlarged, and proximal and distal control by vascular clamps was achieved before the compression by the finger and thumb was released. The damaged superior mesenteric vein was repaired by vascular suture. Total operative blood loss was 800 ml. The patient enjoyed a smooth postoperative recovery and was discharged from hospital 10 days later. In the event of major bleeding, the ability of the Omniport to become a simple hand cuff on deflation enables immediate finger control to be maintained during conversion.

Discussion

Our department's experience with the Omniport for hand-assisted laparoscopic surgery of the liver and pancreas has been entirely favorable, and we consider it an advance on other hand-access devices used previously at our institution. The important attributes documented by this initial experience include maintenance of the pneumoperitoneum throughout the operation in all cases, easy withdrawal of the hand and insertion of swabs, ability to use hand-held instru-







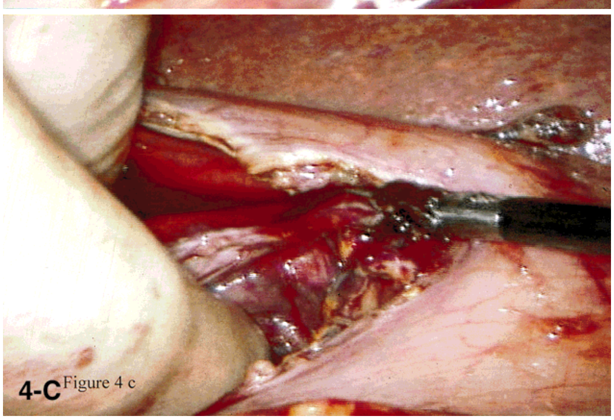


Fig. 2. **A** Detachment of greater omentum from transverse colon and mesocolon. **B** Exposure of lesser sac following complete detachment of the greater omentum.

Fig. 3. Combined finger and scissors dissection. **A** Inferior border of pancreas. **B** tumor.

Fig. 4. Cystogastrostomy. **A** Opening the cyst through posterior wall of stomach (linear cutting stapler enlargement of the cystogastrostomy). **B** Complete posterior cystogastrostomy. The entire procedure took 1 h.

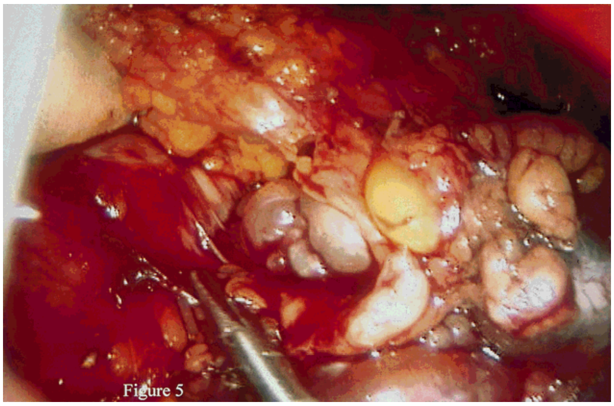


Fig. 5. Large cystic tumor of the proximal pancreas.

ments and staplers without loss of the pneumoperitoneum, and effective and immediate control of major hemorrhage. In addition, the device allows the surgeon to change hands (left with right or assistant's instead of surgeon's hand) as the need arises during the course of the operation. This is a very important consideration and improves the exposure needed, which changes often during the course of a major endoscopic operation.

We have also documented good reach with the intraabdominal hand during the operation. The equilibration between the pressure within the cuff with the intraperitoneal pressure results in an effective but comfortable seal, so that numbness and swelling of the hand are avoided during long operations. The Omniport also provides foolproof protection of the wound during the extraction of malignant specimens. The surgeon simply grasps the specimen in the assisting hand and delivers it through the device as the cuff pressure is reduced sufficiently to allow the hand holding the specimen to negotiate the spiral valve.

The reported experience with hand-access devices [1, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26] indicates that HALS facilitates endoscopic surgery over a wide spectrum of interventions and thereby reduces the operating time. Furthermore, hand-assisted laparoscopic surgery provides an increased measure of safety and shortens the learning curve. For example, in one report on HALS colectomy from a single institution, only one of the four surgeons had had prior experience of laparoscopic colectomy [14]. The hand-assisted technique significantly reduces the warm ischemia time [22, 24, 30] and is likely to become the optimal technique for living-donor nephrectomy. In addition, application of the hand-assisted method to laparoscopic nephrectomy is likely to expand the available expertise to more transplant centers.

The combination of HALS with gasless abdominal wall-lift techniques confers distinct oncological advantages on laparoscopic surgery for intraabdominal cancer and should abolish the current concern about tumor dissemination and port site deposits. We have documented similar advantages for HALS in liver and pancreatic surgery. The particular benefits include vastly improved exposure, better finger blunt dissection, and increased safety due to immediate control of major bleeding from large vessels. These benefits, together with shorter operating times, have led us to choose HALS rather than the total laparoscopic approach for these cases, with the exception of in situ ablation of accessible hepatic deposits in the anterior segments of the right and left liver.

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