

Pearls & Pitfalls of Solid Organ MIS Postgraduate Course



Philadelphia, PA
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The Pennsylvania Convention Center

Program Chair
Course Chair
SAGES President

Adrian Park, MD
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COURSE OUTLINE AND TABLE OF CONTENTS

Title: Pearls & Pitfalls of Solid Organ MIS

Date: Wednesday, April 9, 2008

Time: 7:00 AM – 12:00 PM

Course Chair: George Ferzli, MD

Description:

The minimally invasive approach to solid organs is currently well established and accepted. However there are still a number of critical controversies. The course is intended to familiarize the participant with the current concepts, knowledge and versatility towards these specific situations.

Objectives:

- To know and update the current knowledge in relation to selected controversial topics on MIS for solid organs. The exposition will be directed to expose the details and tricks (pearls) of this topic as well as how to avoid the pitfalls during these operations.

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How and When to choose the Best Position for LS? Anterior, Lateral or Semi-lateral

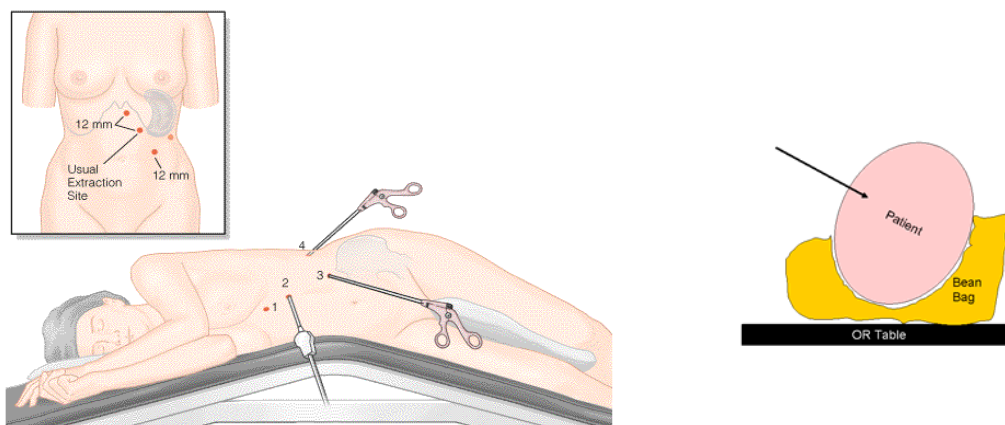
Eric C. Poulin M.D., MSc., FRCSC, FACS
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Choosing the appropriate position for Laparoscopic Splenectomy is just the start. While a good choice of position and set-up does not guarantee success, a bad choice guarantees misery.

There are essentially 2 basic approaches to Laparoscopic Splenectomy: The Lateral Approach and the anterior Approach. There are also “Intermediate” approaches which are modifications of the Basic Approaches.

The Lateral Position

The lateral Position (and its variations) is currently by far the most frequently used approach. The patient is put in a right lateral decubitus position with the operating table flexed and the kidney bolster up. It is also advisable that the patient be slightly angled posteriorly to keep the instruments from hitting the operating table. From time to time during surgery, the patient can be put in a Trendelenburg or Reverse Trendelenburg position as required. The Reverse Trendelenburg position tends to separate the spleen from the diaphragm.



With the patient in the lateral position, a variety of trocar displays can be used: 3 or 4 trocars (mixture of 5mm and 12 mm trocars, Use of an umbilical trocar for better cosmetic results in thinner patients with small spleens (ITP), use of needlescopic trocars (3mm), Three trocar operations, etc.

Advantages of the Lateral Approach

1. Allows dissection in the relatively avascular areolar tissue of the retroperitoneum
2. Almost eliminates inadvertent trauma from instruments
3. Easy access to phrenicocolic ligament (keep 2 cm on spleen side for handling spleen)
4. Easy separation of gastrosplenic (Contains gastroepiploic branches at lower pole and short gastric vessels at upper pole) from lienorenal ligament (Contains tail of pancreas, splenic artery and vein)
5. Easy identification of tail of pancreas (within 3 cm of spleen in 70% of patients)
6. More room for bagging specimen
7. If blood loss occurs, it will flow away from the hilum. In the anterior position, blood will pool in the hilum
8. With bean bag in place, patient can be moved to 45° position
9. The “ideal position” for spleens up to 20 cm+.

The Anterior Approach

The patient is placed on a bean bag in dorsal decubitus and modified lithotomy position. An arrangement of 3 to 5 (5 and 12 mm trocars) trocars is placed in a semi-circular arrangement away from the left costal margin.

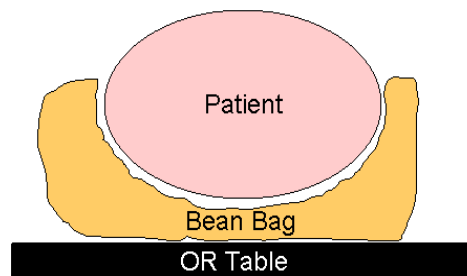
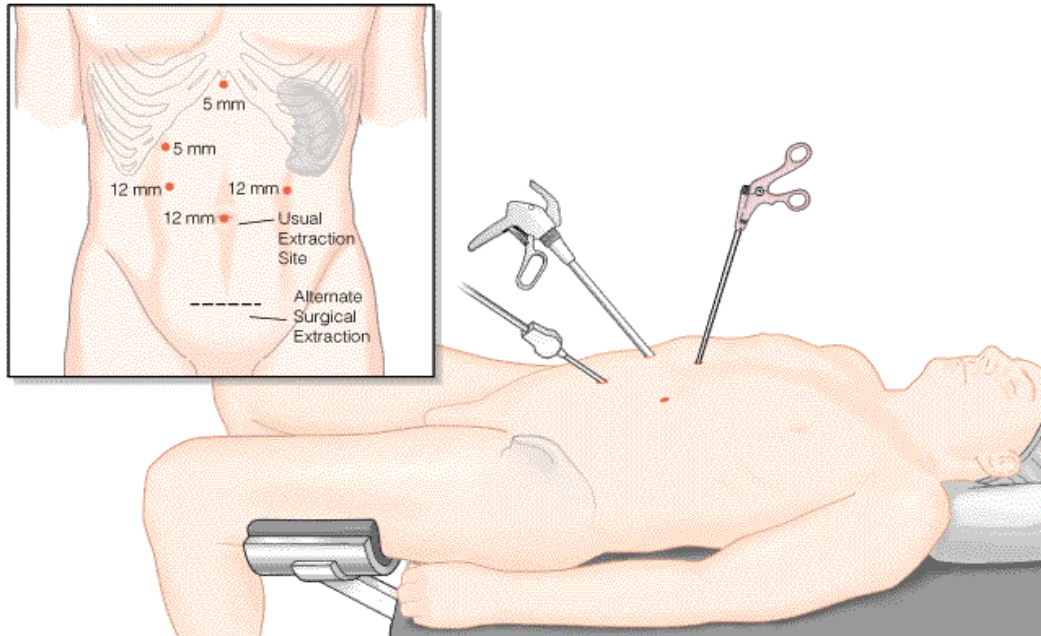
Advantages of the Anterior Approach

Today, there are few advantages to the anterior approach which historically was the first used in laparoscopic splenectomy.

Should a case be made to get early control of the splenic artery in the lesser sac, this approach offers easier access to the lesser sac.

The anterior approach is also used in megaspleens (>30 cm interpole length) in conjunction with a hand port.

A case can be made for its use when concomitant surgery is required (i.e., cholecystectomy especially in pediatric patients. Synchronous cholecystectomy can be done with more difficulty in patients under the lateral approach.



Variations of the Anterior approach

With the patient properly secured in the bean bag, a number of variations of the anterior position can be accomplished bringing the patient in a semi-lateral position.

A 10° to 35° inclination can thus be given to the operating table. It is suggested to keep the bean bag under continuous suction during the procedure. An unrecognized micro perforation of the bag can lead to a slow progressive leak of air leading to a potential catastrophe with the patient falling from the operating table.

Variations of the Lateral Approach

A number of variations of the lateral approach have been described in the literature with various evocative names like the “hanging spleen” approach, the pure lateral approach or the “leaning spleen approach. They basically refer to the flexibility of the lateral approach where inclinations of the operating table can be used to facilitate the procedure and adapt to the patient’s anatomy. The authors who described the “leaning spleen “ approach describe a 70° semi-lateral approach where it is easier to gain access to the lesser sac to get early control of the splenic artery.

Variations of the Lateral Approach



...In Real Life

Reviewing the indications for splenectomy and the major reports in the literature, it appears that a majority of these conditions (85% to 95 %) lend themselves to the lateral approach. This approach is arguably possible for spleens up to 25-26 cm in length and includes the following diagnosis: ITP, HIV-ITP, Evans, AIHA, Spherocytosis, TTP, many lymphomas, Hodgkin’s, CLL,CML, Cysts, Metastases, Trauma.

The remaining patients can be treated with the anterior approach...or open splenectomy as the spleen often exceeds 30 cm in length. They comprise some lymphoma patients, Myelofibrosis, some hairy cell leukemias, Myelofibrosis/polycythemia vera. Today most authors would also use a Hand-Assist devices for this type of surgery.

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HALS & Pre-op Embolization and Splenomegaly: Technique and Indications

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Hand-Assisted Laparoscopic Surgery (HALS) is an evolution of endoscopic technique which has been developed to overcome some mechanical limitations of total laparoscopic surgery (LAP), at the same time attempting to retain most of its benefits. Many years after its introduction into clinical practice and despite the growing number of hand-access devices now available on the market, HALS has not yet gained widespread acceptance among general surgeons and seems to remain an underutilized option. Cost issues are likely to play a role, given that hand-access devices are invariably single-use and usually very expensive. Reluctancy to adopt this approach could also be the reflection of a puristic attitude of general surgeons already familiar with advanced totally laparoscopic surgery, who might regard HALS as a substitute of laparoscopy for beginners.

At the opposite, HALS has been enthusiastically embraced by many urologists and transplant surgeons who appreciate the advantage offered by this technique in terms of ease of dissection and enhanced safety during laparoscopic nephrectomy for kidney diseases and living donation.

It is our view that the crucial question to be addressed is not *if* HALS should ever be adopted, rather *when* this technique does become the most advisable option of treatment.

The laparoscopic management of splenomegaly is still controversial. Many consider a spleen with a transverse diameter longer than 20 cm a relative contraindication to

laparoscopy and those exceeding 30 cm an absolute one. However, it has been demonstrated that the use of HALS in such circumstances makes the minimally invasive splenectomy feasible even when facing a megaspleen. In addition, one should also consider that the size of the spleen is not the only factor to be taken into account when planning a minimally invasive splenectomy. The abdominal compliance also matters (more complex when insufflation does't change its external shape); as well as the underlying disease (the hylum is more difficult to dissect in lymphomas). In all these circumstances HALS provides significant help to the surgeon and enhances the safety of the procedure. The Hand-Access incision is best placed in the right subcostal area, shifting more laterally as the size of the spleen increases. In this way, the assisting left hand of the surgeon does not obscure the endoscopic view and the concept of instrument triangulation (with the optics in the middle on the operating instruments) is retained.



positioning of the Hand Access device and operative setting

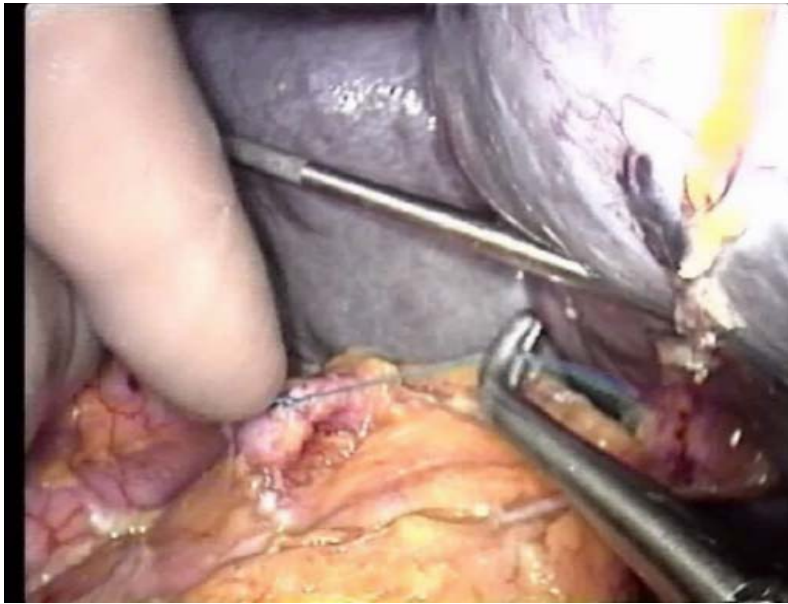
The need for an incision 7 to 8 cm in length is also determined by the necessary extraction wound: anything smaller would not be enough to deliver the very large spleen outside the abdomen. In case of megaspleen, no laparoscopic commercially available

extracting bag can be used, as these are too small. Our preference is to use an ileal bag, such as the ones we routinely adopt to preserve organs for transplantation. Nonetheless, the bagging of a spleen exceeding 20 cm in major length can be extraordinarily difficult and occasionally take more time than the rest of the procedure. Once again the advantage of having an intracorporeal hand plays a significant role in helping bagging of these spleens inside the ileal bag. Morcellation is then accomplished through the HASL access incision with regular scissors.

Preoperative splenic artery embolization is not necessary for spleens shorter than 20 cm. Increased experience and mostly the lateral surgical approach have permitted a shorter operation and a low conversion rate in these cases. The real question is whether there is any need for this procedure before or during a laparoscopic splenectomy for larger spleens. Embolization has inconstantly been reported to be useful for 20- to 30-cm spleens. In these instances the conversion rate is higher (17%), and blood replacement is frequently required (83%). Blocking of the splenic artery may reduce the size of the organ, prolong the survival of transfused platelets, and reduce the surgical complications. When the procedure is done hours or days before surgery, complications are frequently encountered, such as acute pain and fever secondary to spleen infarction. Infection can subsequently appear if the splenectomy is further delayed. For this reason, some have advocated the intraoperative splenic artery embolization, immediately before or even during the laparoscopic splenectomy. Concomitant splenic artery embolization and laparoscopic splenectomy have been shown to reduce operative blood loss when compared with laparoscopic splenectomy procedure alone. Despite embolization, pure laparoscopic splenectomy (not considering HASL) for spleens longer than 30 cm is futile at this time (100% conversion).

The current trend, however, is to avoid preoperative splenic artery embolization and its drawbacks, regardless of the size of the spleen. The operating surgeon should only keep

in mind that the FIRST STEP of the laparoscopic procedure (HALS or not) should be the ligation of the splenic artery along the superior border of the tail of the pancreas.



early tying of the splenic artery during HALS splenectomy

This step must be accomplished as a rule before any attempt to dissect the hylum of the spleen or to mobilize the organ. Observation of this simple technical tip makes useless the preoperative embolization and prevents excessive blood loss during the subsequent operation. Splenic artery embolization can occasionally remain a pre or intraoperative adjunctive procedure that should be considered in patients undergoing laparoscopic splenectomy for hematologic disorders who are Jehovah's Witness or with significant hypersplenism, where early control of the artery cannot be achieved.

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Portal Vein Thrombosis After Laparoscopic Splenectomy: The Size of the Risk

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1.- The problem: Portal vein thrombosis (PVT) is a potentially life-threatening complication that is uncommonly reported after splenectomy. Clinical symptoms may be insidious and progression can lead to intestinal infarction and portal hypertension. First described by Delatour in 1885, PVT after splenectomy has not usually been considered a severe clinical problem as its incidence is reduced to a subset of patients at risk (10% in myeloid malignancies). However, interest in this complication has recently grown, following the observation of its high incidence when prospectively evaluated in the laparoscopic setting. Issues such as the true incidence, its clinical implication and appropriate therapy and prophylaxis have yet to be resolved.

2.- Incidence. Analysis of pooled data from 16 series published from 1993 to 2006 (Tabla I and II) showed that PVT incidence after splenectomy ranged from 0.9 to 52%. This varied significantly depending on whether 1.- the diagnosis was established in a symptomatic or asymptomatic cohort, 2.- the study was prospective or retrospective, 3.- the exploration was performed immediately postoperatively or delayed, 4.- there was malignant splenomegaly or no splenomegaly. Concern arose, however, when up to 55% of PVT was observed after LS.

1.a. Lap vs open The role of the surgical approach (OS or LS) is not yet clear. While some studies show no influence of surgical technique on the

incidence of PVT, others report a significantly higher incidence after LS, from 8 - 52%, as compared to around 10% after open splenectomy. However, results from single-center, comparative LS and OS studies do not agree on these differences (Winslow, 2002, 5 vs 9%), (Ikeda, 2007, 19 vs 55%)

1.b. Benign vs Malignancy: Malignancy has been considered an independent risk factor for PVT, especially when of myeloid origin (CML and myelofibrosis). The reasons are diverse; hematological malignancy is usually associated with splenomegaly - that entails a dilated splenic vein - and a hypercoagulability state. However, PVT may appear after any type of LS for any diagnosis.

1. c. Prospective vs retrospective: PVT localization differs in relation to the type of study. Retrospective analyses report an incidence between 0.87 and 13.5%, (symptoms present in 38-100%), and the prospective studies report between 8.3 and 52%, with symptoms in 25-100% of cases.

3.- Physiopathology: Several physiopathological factors may favour PVT, although there is no definitive evidence about their role: 1.- Disease-related: myeloproliferative disorders, disorders associated to hypercoagulopathy, hemolytic anemia, hypersplenism or hematological malignancy; 2.- Organ-related: splenomegaly. A large organ is associated with a greater diameter of the splenic vein, and once ligated the large splenic vein stump allows formation of thrombi and serves as origin for thromboembolic incidents. The incidence rate of PVT correlates directly with splenic size. 3. - Technical details: PVT incidence may be influenced by numerous other factors such as technical details (early ligation of splenic artery, use of endoscopic vascular stapler, distal or proximal ligation of the splenic vein), although its definitive role is

controversial. 4. - Modification in splanchnic hemodynamics during pneumoperitoneum. Pneumoperitoneum decreases the mesenteric flow during laparoscopy, and PVS has been observed after cholecystectomy, colectomy, funduplication and other laparoscopic procedures. Mesenteric flow may decline due to the reduced splenic outflow. 5.- Hematological changes after splenectomy (postoperative increase in platelet count, hypercoagulability states). Their role in the formation of thrombi, however, remains unknown.

4.- Clinical picture: PVT may appear immediately after surgery or be delayed for up to 3 years. It may be asymptomatic or resolve spontaneously, as confirmed in a number of patients. Obviously, symptoms after splenic vein thrombosis will depend on the extent of the thrombus. Isolated splenic stump vein thrombosis can be asymptomatic, but portal or mesenteric extension will increase the severity of the clinical picture. Symptoms are often only vague and include diffuse abdominal pain, nausea, fever, ileus, diarrhea, jaundice, ascites, decreased appetite, and others that can be confused with postoperative symptoms or other diagnosis (pancreatitis, etc); the index of suspicion should be high. Small bowel venous infarct and peritonitis may follow extended thrombosis. Difficulty in establishing diagnosis often delays adequate treatment for some weeks. Cumulative analysis of over 1500 splenectomized patients shows that the global incidence of PVT is 73/1500 (5%). Symptoms appeared in 25-100 % of the cases diagnosed of PVT, with a need for laparotomy in 4/73 (5%) and death in 4/73 (5%). Resolution of PVT with patency of the portal vein ranged from 40-80%.

5.- Diagnosis: Accurate diagnosis can usually be made by imaging methods: color Doppler ultrasonography, contrast enhanced CT or magnetic resonance tomography (MRI). Whether or not CT imaging is superior to US in this setting is not clear. The detection rate of thrombosis may be low as it is not only highly dependent on operator skill but furthermore, vision may be limited as in cases of morbid obesity or bowel distension in the first days after surgery. CT with intravenous contrast does not establish the diagnosis de PVT, but it can exclude other intrabdominal complications.

The clinical significance of PVT differs in function of the segment thrombosed. PVT (intra- and extra-hepatic) was observed in 110 of 139 cases described in 16 clinical series, but splenic vein thrombosis was observed in 83 and mesenteric thrombosis in 30. Portal and mesenteric occlusion of the main trunk is related to symptoms, and splenic stump thrombosis or partial intrahepatic PVT may be asymptomatic.

6.- Therapy:

Once diagnosed, prompt therapy is lifesaving. Patients with evidence of bowel necrosis should undergo surgical therapy including bowel resection, with or without thrombectomy. Immediate anticoagulant therapy with intravenous heparin should be administered, followed by oral warfarin therapy at hospital discharge. Therapeutic doses of low-molecular-weight heparin provide good results (> 90% recanalization if treated immediately). Local thrombolytic therapy with streptokinase or alteplase is an alternative. Satisfactory thrombolysis and recanalization may last up 3 months.

Selection of patients in need of therapy is not clearly defined. While most authors propagate anticoagulative treatment for any patients with symptomatic PVT, there is some evidence that the need for such treatment depends on the site and extent rather than the mere existence of a thrombus. A thrombus site within the intrahepatic portal vein is considered less severe than a thrombus within the superior mesenteric vein; this latter should be treated immediately. It is not clear whether small, asymptomatic thrombi detected by CT should receive therapeutic doses of heparin.

Patients presenting with one or more of the aforementioned risk factors need very careful surveillance in regard to possible symptoms of PSTV. Especially in patients presenting with myeloproliferative disease or haemolytic anemia and splenomegaly, routine postoperative anticoagulation prophylaxis and routine postoperative imaging is frequently advisable even after hospital discharge. Although the impact of thrombocytosis on the incidence of PSVT is not yet clear, long-term antiplatelet therapy (acetylsalicylic acid) might be advisable in high risk patients.

Prophylactic administration of subcutaneous heparin remains controversial. Some authors have found this prophylaxis is insufficient to prevent PVST in high risk patients and recommend a combination of heparin, antiplatelet agents and oral warfarin after hospital discharge.

7.- Comment: PVT is an infrequent but potentially severe complication after splenectomy. Current studies including laparoscopically-operated patients and prospectively recorded data show a higher incidence of PVT than

retrospective reports from the nineties, suggesting that PVT may have been an under-reported complication in the past. However, the clinical outcome will depend on the extension of the thrombus and the underlying disease. Clear risk factors seem to be myeloproliferative diseases requiring splenectomy and splenomegaly, although it can occur in any clinical situation. The laparoscopy-related responsibility is not clearly defined. Surgeons should know the risk of this complication and it should be suspected when facing any atypical outcome after LS, especially in the presence of the aforementioned risk factors. Once diagnosed, prompt anticoagulation therapy may resolve the thrombotic event.

	A	B	C	D	E	F	G	H
1	Risk factors							
2	autor/año	Pros/Ret	n SPVT	%	splenomegaly	malignancy	thrombocytosis	haemolitic anemia
3	Rattner/93	R	7	ns	5/7	5/7	ns	1/7
4	Petit/94	R	13	11%	ns	7/13	ns	1/13
5	Loring/98	R	12	9,8%	4/12	ns	ns	ns
6	Chafanjon/98	P	4	8,3%	4/4	4/4	0	ns
7	Riet/00	R	9	2%	3/9	2/9	4/9	4/9
8	Hassn/00	P	5	10%	ns	ns	ns	ns
9	Winslow/02	R	101	58OS/35LS	8	5	ns	1
10	Fujita/03	R	6	0.87%	5/6	1/6	3/6	4/6
11	Pietrabissa/04	P	9	22,5%	9/9	ns	ns	ns
12	Harris/05	P	2	14%	ns	ns	ns	ns
13	Ikeda/05	P	12LS/4OS	55%/19%	2/16	2/16	ns	1/16
14	Romano/06	R	12	7,6%	12/12	8/12	ns	4/12
15	Romano/06	P	7	19%	7/7	2/7	ns	0
16	Stamou/06	P	7	4.8%	5/7	4/7	7/7	1/7
17	Ikeda/07	P	17	52%	ns	ns	ns	ns
18	Svenson/07	R	5	13.5%	4/5	5/5	5/5	1/5
19								
20	R: retrospective							
21	P: Prospective							
22	ns: not stated							

	A	B	C	D	E	F	G	H	I	J
1			Incidence							
2	autor/año	Pros/Ret	N	Technique	Nº PVT	%	Symptoms	Bowel infarct	Resolution	Death
3	Rattner/93	R	<1000	OPEN	7	ns	100 %	3	71%	2/7
4	Petit/94	R	119	OPEN	13	11%	38 %	ns	80%	0
5	Loring/98	R	123	OPEN	12	9,8%	75 %	ns	401%	0
6	Chafanjon/98	P	60	OPEN	4	8,3%	25 %	ns	ns	ns
7	Riet/00	R	563	OPEN	9	2%	100 %	ns	45%	0
8	Hassn/00	P	50	ns	5	10%	80 %	ns	40%	0
9	Winslow/02	R	101	58OS/35LS	8	8 % (5% vs 9%)	100 %	1	5	1
10	Fujita/03	R	688	4LS / 2OS	6	0.87%	66 %	1	50%	1
11	Pietrabissa/04	P	40	LS	9	22,5%	ns	ns	33%	0
12	Harris/05	P	14	LS	2	14%	25 %	ns	ns	ns
13	Ikeda/05	P	43	LS/OPEN	12LS/4OS	55%/19%	100 %	ns	ns	ns
14	Romano/06	R	158	LS/OPEN	12	7,6%	55 %	ns	60%	0
15	Romano/06	P	38	LS	7	19%	100 %	ns	40%	0
16	Stamou/06	P	147	ns	7	4.8%	25 %	ns	70%	0
17	Ikeda/07	P	33	LS	17	52%	100 %	ns	80%	0
18	Svenson/07	R	69	39 LS / 30 OS	5	13.5%		ns	80%	0
19										
20	R: retrospective									
21	P: Prospective									
22	ns: not stated				=					

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Laparoscopic Partial Resection of the Spleen¹

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Since the discovery of the spleen's important immunological function as a filter to eliminate pathogens from the body², efforts have been made to preserve the organ at least partially in cases of disease and injury, rather than to remove it in its entirety, as had been the rule before, due to the friable nature of the organ's tissue. Open partial resection with the stapler became established 1980s, and in the 1990s, the first reports of laparoscopic partial splenectomies were published.³ At present, laparoscopic partial resection of the spleen is mainly performed as an elective procedure for a number of indications; these most commonly include benign (nonparasitic) splenic cysts, benign tumors (hamartoma, fibroma, pulpoma), in some selected cases also metastases and infarcts. From 1994 to 2007, 46 patients aged 13 to 72 years underwent laparoscopic partial splenectomy at our department.

In trauma cases, both splenectomy and organ-preserving procedures are preferably done in conventional open technique. The basic requirement for laparoscopic treatment of abdominal trauma is that the patient be hemodynamically stable, without active bleeding. Such cases, however, can be managed conservatively, i.e. without surgery.^{4 5 6} In the following, we will concentrate on elective splenic surgery.

The technique we use for laparoscopic splenic surgery involves seven basic steps:

1. Patient positioning
2. Trocar placement
3. Mobilization of the spleen
4. Vascular dissection
5. Parenchymal dissection
6. Sealing/tamponading of the transected edge
7. Removal of the specimen

These steps are described in detail as follows:

1. Patient positioning

The patient lies on the operating table in a right semilateral decubitus position with his/her back at an angle of 45° to 60° to the surface of the table. The patient's left arm is tucked above the head. We favor this semilateral recumbent position as it allows safe and nonbloody dissection of the hilar vessels. With the patient in this position, the organs adjacent to the spleen slide away, while the spleen itself is held

in position by the ligaments connecting it to the diaphragm. The surgeon so has a good hilar, lateral and dorsal approach.

2. Port placement

As a rule, three ports are used but a fourth port can be added as necessary for very large cysts. The first is a 10mm port for the optic, inserted on the midline above or below the umbilicus, depending on the size of the spleen. A 12mm port is inserted in the epigastrium to the right of the midline, and a 5mm port along the left midclavicular line. The fourth port, when needed for insertion of a retractor, is placed along the left anterior axillary line.

3. Mobilization of the spleen

When these preparations have been made, we proceed to the mobilization of the spleen. Here, there is a major difference to conventional open splenectomy as the spleen is only partially mobilized: only the pole to be resected is mobilized and the other pole remains fixed by its connecting ligaments. In this way, it is easier to apply the laparoscopic stapler to dissect the parenchyma and the risk of postoperative torsion, always a threat with total mobilization, is avoided. When the spleen's lower half is to be removed, we first sever the omental attachments and the branches of the gastroepiploic vessels, using ultrasonic shears or the Ligasure® instrument. For removal of the upper half of the spleen, we begin mobilization at the splenic hilum and sever the omental attachments and the short gastric vessels. The next step is to mobilize the spleen dorsally.

4. Vascular dissection

The branches of the splenic artery and the vein that supply the upper half of the spleen are severed, for example with the 5mm Ligasure® instrument; clips are not applied. The parenchyma becomes visibly cyanotic and is slowly compressed with an atraumatic grasper. Care should be taken not to tear the capsule; this is best accomplished by moving the grasper very slowly forward, with just enough pressure to break up the parenchyma without injuring the capsule. This step takes 5 to 10 minutes, after which there is a distinct anemic line where the anterior and posterior surfaces nearly contact each other.

5. Parenchymal dissection

When the parenchyma is sufficiently compressed, a stapler is inserted through the 12mm epigastric port and applied to the anemic line described above. The transection is performed stepwise, using a 60mm stapler with 3.5mm blue cartridges. When a large cyst extends beyond the resection line, the cystic wall is peeled off the parenchyma that is to be spared. If the entire part of the spleen bearing the lesion cannot be removed, it is of utmost importance to completely remove all parts of the cystic wall to prevent recurrences.

6. Sealing/tamponading of the transected edge

We used to seal the stapled line with heterologous fibrin but later changed to autologous fibrin. We tamponade the cut edge with collagen fleece.

7. Removal of the specimen

The specimen is removed with a waterproof retrieval bag of suitable size. Usually, the specimen can be macerated and removed through a small incision. When rarely necessary, a drain is placed in the subphrenic space and removed on the second postoperative day.

Perioperative care

Patients receive a single perioperative dose of a broad-spectrum antibiotic and thrombosis prophylaxis as per generally accepted guidelines, as well as a prophylactic pneumococcus immunization 1 to 2 weeks before partial resection of the spleen.

As far as aftercare is concerned, the patient is allowed a liquid diet a few hours after surgery and receives normal diet from postoperative day one. Patients are advised to avoid physical exertion for 6 to 12 weeks following surgery.

Conclusions

We have had excellent results with this type of procedure, with no perioperative mortality. In all cases, we were able to preserve the designated part of the spleen. The introduction of ultrasonic shears and the Ligasure® instrument⁷ has proved to be highly advantageous as the entire dissection can be performed with one instrument, obviating the need to change instruments. Several years ago, we were able to reduce the number of ports from five to three, with a fourth port to introduce a retractor only in the case of large and heavy lesions.

The two factors that have contributed to the feasibility of laparoscopic partial splenic resection are increasing experience on the part of surgeons and improvements in laparoscopic instruments. When established guidelines are followed, this procedure can be performed as quickly and safely as open surgery, generally without sacrificing the entire spleen.

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Pancreatic Malignancies: *What is the role of MIS?*

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Introduction

Minimal access surgery techniques have rapidly evolved to include a variety of complex surgical procedures. However, the role of minimal access surgery for resection of malignant neoplasms has been widely debated and remains an area of controversy for surgical oncologists. Since the early years of advanced laparoscopic procedures, concerns about port-site metastases [1-3] and dissemination of tumor cells via CO₂ insufflation [3] prevented laparoscopic surgeons from further developing innovative new approaches for oncologic resections. More recent prospective, randomized trials have nevertheless shown that the laparoscopic approach can be done in a safe manner [4]. The key issue is to ensure safe, complete oncologic resection, and at the same time provide the additional benefits such as decreased pain, shorter hospital stay, fewer incisional hernias and earlier return to work. Added advantages of the minimal access approach over open surgery that are of particular potential benefits to cancer patients are decreased blood loss and possibly a reduced immunosuppressive impact from the surgical intervention [5]. These advantages however are present only when the operator is an experienced laparoscopic surgeon with extensive expertise in open pancreatic surgery and a clear understanding of pancreatic diseases.

Over the past several years, improvement in open surgical techniques have decreased the mortality and morbidity of pancreatic surgery. The overall prognosis of pancreatic cancer however remains quite poor. In this scenario were the development of innovative minimal access procedures may find increased acceptance with surgeons and affected patients by way of providing less traumatic and debilitating surgery when life span is limited and surgery likely non-curative. This however requires a responsible approach to ensure that the results of the laparoscopic technique in regards to morbidity, mortality and oncologic resection match or improve the results obtained in the open technique.

Distal and subtotal distal pancreatectomy

Even though laparoscopic pancreatic surgery is still not universally practiced, distal resections are now proven to be safe and readily feasible. In experienced hands, the procedure has striking advantages over its open counterpart. The minimal access approach suits distal pancreatectomy well because of the advantages in visual magnification, the inherent delicate manipulation of tissues,

the decreased blood loss, the enhanced access to the pancreas and the absence of need for reconstruction.

Indications for the procedure are in general, equal to an open distal pancreatectomy. [6-7]. In selected cases however, there could be a more liberal indication to do the procedure with a palliative intent in patients with malignancies of the body and tail. This is based on the lesser negative impact that the minimal access approach has in the patient's quality of life.

In the presence of a small lesion, the laparoscopic approach is limited by the inability to palpate the lesion and surgeons dealing with the procedure must have experience in the use of intraoperative ultrasound. Even though not commonly needed, the operation can also be performed in a hand-assisted manner. The surgery can be done either with spleen preservation or with a splenectomy. The indications to include or not to include a splenectomy should not be affected by the fact that the procedure is being done using the minimal access method. Robotic assisted laparoscopic distal pancreatectomy has been described and may have a role in the splenic preserving procedure. However, its advantages over the traditional laparoscopic technique done by an experienced surgeon are still to be proven.

The laparoscopic approach is not limited to distal pancreatectomy of the pancreatic tail. When a more proximal resection to include the neck, body and tail of the pancreas can be safely done. In fact, in experienced hands, the laparoscopic approach to the area of the neck of the pancreas may be even safer than its open counterpart.

Conditions that may preclude a laparoscopic approach include: presence of portal hypertension, either generalized, or limited to the splenic circulation as well as prior episodes of pancreatitis

Technique [7]

The patient is placed in a modified right lateral decubitus position that would allow for rotation to the left or right during the procedure. This facilitates the exposure of the operative area by allowing gravity do a significant portion of the retraction of the neighboring organs . The surgeon stands to the right of the operating table.

Dissection is started by performing a wide mobilization of the splenic flexure as well as the descending colon. Given the lateral position of the patient, this dissection allows for displacement of the colon and omentum medially by gravity. The lesser sac is entered from its lateral aspect, and the gastrocolic omentum is divided and ligated from lateral to medial. This maneuver readily exposes the distal pancreas. Once the distal pancreas has been exposed, the dissection is continued in a clockwise manner, starting at the lower edge of the pancreas from

lateral to medial. When in the right plane, this dissection is readily done with ultrasonic or similar energy in a relatively avascular plane. When more medial dissection is needed, the first named vascular structure that is found is the inferior mesenteric vein. Depending on the indications for the procedure, the dissection is stopped here and attention paid to the division of the pancreas or the dissection continued further medially. When needed, the inferior mesenteric vein is ligated. If more of a subtotal pancreatectomy is necessary, the dissection is continued medially along the lower edge of the pancreas. The area of the ligament of Treitz and the fourth portion of the duodenum are exposed and care is taken to avoid injury. Following the lower edge of the pancreas, the next vascular structure that is evident is the superior mesenteric vein heading cephalad to travel under the neck of the pancreas. The posterior aspect of the tail and body of pancreas has been exposed during the dissection of the lower edge of the pancreas and partially separated of its posterior attachments by gentle blunt dissection. This aids in further facilitating the dissection and exposure of the inferior edge when going from lateral to medial. At the chosen site of pancreatic division, additional posterior dissection is performed from caudad to cephalad up to the superior edge of the pancreas. The splenic vein is exposed and if needed isolated. Passing a Penrose drain to encircle the pancreas aids in its retraction when a splenic preserving procedure is planned.

If the pancreatic parenchyma is thin a stapler technique is used. The use of bioabsorbable staple reinforcement could be of benefit. When the pancreatic parenchyma is too thick at the division site, the use of a stapler is not advised. In that situation, our preference is to divide the pancreas with ultrasonic shears in a fish mouth fashion. The proximal divided edge is then sutured with a running non-absorbable monofilament suture. Particular care is taken to suture shut the pancreatic duct opening. This is done in similar manner as in an open procedure.

After the posterior dissection and ligation of the vessels is completed, attention is paid to the dissection of the superior edge of the pancreas that is now done from medial to lateral, continuing in a clockwise manner. Up to this stage, the superior attachments of the body and tail of the pancreas lateral to the division site had been kept intact. The dissection of the superior edge is continued reaching the end of the tail of the pancreas laterally. The pancreatic mobilization is then completed.

If a splenectomy is performed, a small serosal band between the upper pole of the spleen and the diaphragm can be left undivided until the specimen is within the retrieval bag. This facilitates the manipulation and placement of the specimen in the bag by keeping the specimen anchored superiorly. As described by the author, when retrieving the specimen, care should be taken to preserve the pancreatic specimen intact for pathologic examination.

Even though unusual, the procedure can always be converted to an open procedure if felt needed. As in any other advanced laparoscopic procedure, and

experienced operator will not hesitate to do so when he/she feels that the quality or safety of the operation can be compromised by continuing with the minimal access approach.

Laparoscopic Pancreaticoduodenectomy

When dealing with proximal resections, the need for reconstruction significantly prolongs its learning curve and questions the advantages over its open counterpart. Visual magnification, delicate manipulation of tissues, decreased blood loss are still an advantage but the magnitude of the operation is such that operative times are usually longer and patients hospital stay and recovery are not as shorten as for distal resections. Over recent years however, several authors have acquired the surgical skills and the procedure is being performed safely for selected patients. The operator embarking in this procedure does not only need to have mastered advanced laparoscopic skills, but also have extensive expertise in open pancreatic surgery and a clear understanding of pancreatic diseases.

The surgical technique follows the same general principles of its open counterpart . As mentioned above, the laparoscopic approach is limited by the inability to palpate the lesion. Surgeons embarking in this procedure must have experience in intraoperative ultrasound. The hand-assisted approach is strongly considered for patients with lesions in close proximity to the portal/SMV confluence in which pa. Robotic assisted laparoscopic pancreaticoduodenectomy has also been described and may have a role in facilitating the reconstruction. However, its advantages over the traditional laparoscopic technique done by an experienced surgeon may not justify its cost.

In despite of the above-mentioned limitations of the technique, recent series of laparoscopic pancreaticoduodenectomy appear to show significant advantages over the open counterpart and the oncologic principles of resection practiced on the open procedure are preserved. [8]

Since these series contain only a limited number of patients, further studies are needed to assess if laparoscopic pancreaticoduodenectomy will become a standard procedure.

Nonetheless, as more expertise is being gained, the advantages over its open counterpart appear more evident. Given the poor prognosis of patients with adenocarcinoma of the head of the pancreas and based on the lesser negative impact that the minimal access approach has in the patient's quality of life; the laparoscopic approach could become the procedure of choice once becomes more established as a safe and feasible procedure.

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Cystic Tumors: How to select the approach

Course: Pearls & Pitfalls on Solid Organ MIS

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Introduction:

Current indications for laparoscopic pancreatic surgery are: staging in pancreatic adenocarcinoma in which resectability cannot be defined with imaging studies, treatment of complications of acute pancreatitis (pseudo cysts, necrosectomy and drainage of fluid collections), resections of neuroendocrine tumors, and more recently pancreatic resection for benign and malignant tumors.

The following factors have slow down the widespread of laparoscopic approach in pancreatic surgery 1) the limited number of patients with pancreatic lesions with indication for resection that are suitable for laparoscopic approach, 2) the complexity and technical difficulty of pancreatic resection due to the retroperitoneal location of the gland, and the vascular structures nearby, 3) the need to expose the whole gland and either to palpate it or to perform a translaparoscopic ultrasound, to better define the extent of the disease, 4) an increased incidence of pancreatic stump fistulae reported in large series, and finally 5) the concern of the ability to achieve an oncologically correct resection with negative margins for malignant tumors.

Regardless the approach, indications for cystic tumors have been a matter of debate. Most cystic lesions of the pancreas are benign; however it is important to characterize such lesions and to distinguish true cystic tumors from pancreatic pseudo cysts. Pure cystic asymptomatic lesions are commonly benign and can be safely followed; on the other hand mucin-producing lesions are potentially malignant and warrant surgical resection. Serous cystadenomas, mucinous cystic lesions, and intraductal papillary mucinous neoplasms account for more than 90% of primary cystic pancreatic tumors.

Cystic pancreatic lesions are frequently found incidentally on imaging studies performed for other pathologies; about 35% of patients are asymptomatic at the time of discovery. In symptomatic patients abdominal pain is usually the cardinal symptom. Jaundice is infrequent and it is usually associated with large lesions

obstructing the common bile duct. Four different types of cystic lesions are recognized: 1) Unilocular cysts; 2) Microcystic lesions; 3) Macrocystic lesions; and 4) Mixed lesions or cysts with a solid component. This classification has both diagnostic and therapeutic implications, which are described in table 1. Asymptomatic incidentally discovered cystic lesions <2 cm in size, in patients with non mucinous lesions with normal CEA levels on fluid analysis should be observed (3% incidence rate of malignancy). A solid component in a mucinous cyst and growth of a cystic tumor are both important predictive factors for malignancy.

Table 1. Image patterns for cystic pancreatic tumors with clinical association

Lesion	Morphology	Associated Lesion	Management
Unilocular cysts	<ul style="list-style-type: none"> ▪ No septa ▪ Solid component ▪ Central-cyst wall calcification 	<ul style="list-style-type: none"> ▪ Pseudo cyst ▪ IPMNs ▪ Unilocular serous cystadenomas ▪ Lymphoepithelial cysts 	<ul style="list-style-type: none"> ▪ Observation if <3 cm ▪ EUS Cyst content analysis of suspicious lesions
Microcystic	<ul style="list-style-type: none"> ▪ Polycystic or microcystic pattern (>6 compartments) ▪ Stellate pattern calcification 	<ul style="list-style-type: none"> ▪ Serous cystadenoma 	<ul style="list-style-type: none"> ▪ Observation
Macrocystic	<ul style="list-style-type: none"> ▪ Multilocular (<6 compartments) ▪ Larger compartments 	<ul style="list-style-type: none"> ▪ Mucinous cystadenomas ▪ IPMNs 	<ul style="list-style-type: none"> ▪ Surgery
Solid component	<ul style="list-style-type: none"> ▪ Uni or multilocular with solid component 	<ul style="list-style-type: none"> ▪ Mucinous cystadenomas ▪ IPMNs 	<ul style="list-style-type: none"> ▪ Surgery

Procedures that can be performed for tumors in the body and tail of the pancreas are enucleation, distal pancreatectomy with splenic preservation; this can be accomplished by preserving the splenic vessels or with the Warshaw technique (preservation of the short gastric vessels), distal pancreatectomy and splenectomy and RAMPS. Strasberg and colleagues described a more radical approach to malignant tumors in the body and tail of the pancreas called Radical Antegrade Modular PancreatoSplenectomy (RAMPS), achieving negative margins in 91% of the cases, 63% had adjacent structures or organs resected, 17% needed transfusion, complications occurred in 52% of the patients, there was no operative mortality and mean survival was 21 months.

Results on open and laparoscopic distal pancreatectomy are described in table 3.

Table 3a. Laparoscopic distal pancreatectomy

Author	No	OT (min)	Blood loss (ml)	SP (%)	S Comp (%)	Fistulae (%)	LOS (days)	Conversion (%)
Patterson	15	264	200	20	Na	15.8	6	13.3
Fernandez-	29	198	370	37	Na	10.3	5.7	0

Cruz								
Edwin	17	235	300	29	0	5.8	5.5	23.5
Melotti	58	165	Na	84.4	13.7	27.5	9	0
Mabrut	98	190	Na	62.2	1.7	16.3	7	17.3
Dulucq	21	154	135	72	2	4.7	10.8	0
Palanivelu	22	215	185	31.8	0	4.6	4	0
Pierce	18	233	244	44	0	27	4.5	5.5
D'Angelica	17	196	125	0	Na	19	5.5	11.7

OT= Operative Time, SP= Splenic preservation, SComp=splenic complications, T= Tumor, LOS=Length of stay, Na= no data available

Table 3b. Open distal pancreatectomy

Author	No	OT (min)	Blood loss (ml)	SP (%)	SComp (%)	Fistulae (%)	LOS (days)
Lillemoe	235	282	879	16	0	5	15
Shoup	125	186	600	36.8	Na	7.6	9
Balcom	190	Na	Na	21	Na	14	9

OT= Operative Time, SP= Splenic preservation, SComp=splenic complications, T= Tumor, LOS= Length of stay, Na= no data available

There is one study that compares laparoscopic versus open distal pancreatectomy, operative time (min) was 217.7 ± 55.8 for laparoscopic procedures and 194.8 ± 63.7 for open ($p=0.093$), percentage of patients with the need of transfusion was 3.2 and 11.3 respectively ($p= 0.261$), Length of stay (days) was 11.5 ± 4.1 and 13.5 ± 4.9 respectively ($p= 0.049$). Pancreatic fistulae occurred in 9.7% of the laparoscopic procedures and in 6.5% of the open ones ($p=0.585$).

Laparoscopic approach results in an important reduction of operative blood loss and need of transfusion, and in a shorter length of stay, however it seems that pancreatic fistulae is more frequent in this group of patients.

Laparoscopic enucleation of cystic tumors has been seldom performed, and in most series incidence of pancreatic fistula is more frequent in this procedure than in formal resection.

For tumors in the head of the pancreas pancreaticoduodenectomy (PD) is the procedure of choice, there are two large series of laparoscopic PD, results are summarized in table 4.

Table 4. Results of Laparoscopic Pancreatoduodenectomy

Author	No	OT (min)	Blood loss (%)	Complications (%)	Fistulae (%)	Mortality (%)	Lymph nodes	5 year Survival (%)
Dulucq	22	287	107	32	4.54	4.54	19	Na
Palanivelu	42	370	65	30	7.14	2.38	13	32

OT= Operative Time

Finally laparoscopic central pancreatectomy has been described for tumors in the neck of the pancreas with promising results.

Fernandez-Cruz et al. published the largest series of laparoscopic resection of cystic tumors in 29 patients (27 women), abdominal and back pain were the most common symptoms. Mean size was 5.2 cm; they were all located in the body or tail of the gland. On CT scan 4 lesions were serous and 25 were mucinous. Laparoscopic distal pancreatectomy was performed in 29 patients, in 11 cases splenic vessel-preservation was attempted and accomplished in 7, in 5 cases the

spleen was preserved with the short gastric vessels. Laparoscopic RAMPS resection was performed in 3 patients for suspicion of malignancy. Mean operative time was 198±26 and mean blood loss was 370±50 ml, one patient required transfusion. Asymptomatic pancreatic fistula occurred in three patients. Splenic complications occurred in four patients with preservation of the spleen with the short gastric vessels, in 3 patients Doppler - US showed splenic infarct (3 to 4 cm); splenectomy was needed in one patient with massive splenic necrosis and sepsis. Final pathology showed serous cystadenoma in three patients, mucinous cystadenoma in 22 patients, borderline mucinous cystic tumor in a patient, and mucinous cystadenocarcinoma in three patients. No tumor recurrence was observed in a mean follow-up of 38 months.

Conclusions:

Laparoscopic distal pancreatectomy for cystic pancreatic tumors is feasible and safe, complications do not exceed those of open procedures, however careful management of the pancreatic stump is recommended to diminish the incidence of fistula. Patients with large tumors, with borderline resectability or potential vascular involvement, may be best approach with open resection. Enucleation does not appear to have a role in this group of patients. Whenever is possible splenic preservation is recommended and an effort to preserve the splenic vessels may help to avoid splenic infarction and super-infection. A more aggressive approach can be performed and laparoscopic RAMPS is suggested when suspicion of malignancy is high or when it is proven preoperatively. Laparoscopic PD has been performed in a limited number of centers, and there is no evidence to date to support a more liberal use of this approach. Long term survival in patients with cystic malignant tumors is still dismal.

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Pearls and Pitfalls of Solid Organ MIS PG Course

Pseudocyst: Open, Laparoscopic or NOTES

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Introduction:

Pancreatic pseudocysts have long been treated by surgeons. As minimally invasive techniques and imaging improve, movement from traditional “open” drainage procedures to laparoscopic, endoscopic and percutaneous techniques offers the surgeon a variety of options. Each possesses unique advantages and disadvantages with known pitfalls that must be taken into account when treating this population. Patient selection is vital to successful drainage and selection of the most appropriate technique.

For years, open cyst-enterostomy as either a cyst-gastrostomy or roux-en-y cyst-jejunostomy has been effective with excellent results. It provides the surgeon with the ability to biopsy the cyst wall, create a patulous cyst-enterostomy and debride necrotic material while simultaneously breaking up loculations to ensure adequate drainage.

The advantages of minimally invasive techniques (laparoscopy and endoscopy) were quickly brought to the problem of pseudocysts in attempts to shorten hospital stay and recovery time. The laparoscopic era brought us minimally invasive cyst-gastrostomy as well as roux-en-y cyst-jejunostomy performed using a stapled technique or as a “hand sewn” anastomosis. Similarly, combined transgastric laparoendoscopic techniques have been described for cyst-gastrostomy drainage. These techniques offer the advantages of minimal access while allowing for cyst wall biopsy, debridement and breaking up of loculations. Although it requires advanced laparoscopic and endoscopic skills and may not be an option for all surgeons, morbidity and mortality rivals open techniques in the published literature.

The most recent advancement in drainage of pancreatic pseudocysts is Natural Orifice Transluminal Endoscopic Surgery (NOTES). Although the NOTES acronym is new, trans-gastric or trans-duodenal/papillary endoscopic drainage has been around for years. Use of endoscopic ultrasound for visualization/localization is well described and

adds to the success of this technique. It requires advanced endoscopic skills and may not be an option for many surgeons although advance therapeutic gastroenterologists facile in ERCP access and stenting have been performing this technique. Recovery is very short often necessitating nothing more than an overnight stay in the hospital. Although successful in 70-80% of patients, transmural endoscopic drainage is not for all patients and has significant limitations. Patient selection is vital to the success of this technique. The pseudocyst must be mature and juxtaposed to a site easily accessible to a gastroscope or side-viewing duodenoscope. The wall must be adherent to the wall of the stomach or duodenum with a homogeneous appearance. The presence of loculations or necrotic debris limits the success of this technique due to failure of endoscopically placed stents. Placement of multiple stents may improve outcomes but the ability to debride or break-up loculations is limited. Recurrence rates are higher with this technique presumably due to stent failure and inability to maintain drainage in the face of debris. The ability to biopsy the cyst wall is limited and if there is question as to the diagnosis (i.e. cystic neoplasm), endoscopic transmural cyst-enterostomy is not the technique of choice.

Percutaneous techniques often performed by interventional radiologists are an alternative to open, laparoscopic or endoscopic techniques but do not offer the benefits of enteral drainage as is without the ability to debride collections or biopsy the cyst wall. External drainage has high recurrence rates, are prone to infection and may maintain a pancreatic fistula requiring operative debridement and closure.

Objectives:

1. Outline indications/contraindications for open, laparoscopic and endoscopic pseudocyst drainage
2. Review the results of each technique
3. Review the complications/pitfalls associated with each technique

Overview:

1. Historical "Gold Standard"
 - a. Open cyst-gastrostomy results/pearls
 - b. Open roux-en-y cyst-enterostomy results/pearls
2. Laparoscopic cyst-gastrostomy and roux-en-y cyst-enterostomy results/pearls
3. Endoscopic cyst-enterostomy results/pearls
4. Advantages and Disadvantages/Complications/Pitfalls
5. Where is it all going and what to expect in the future

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**LAPAROSCOPIC MANAGEMENT OF BENIGN
LIVER DISEASE**
**with special reference on the positioning of the trocars and the
patient**

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Despite recent advances in laparoscopic techniques and instrumentation, laparoscopic liver surgery has remained uncharted territory. Laparoscopic fenestration of solitary giant liver cysts has been reported^{4, 6, 8, 10, 18}, but few studies have included management of larger numbers of patients with polycystic liver disease (PLD)^{8, 12, 24} or benign solid tumors^{3, 7, 13, 26}. The feasibility of effective laparoscopic management of echinococcal liver disease is still unclear⁵. Liver cases are traditionally sent to academic liver centers that focus on transplantation and resection of liver cancer, but lack sometimes advanced laparoscopic expertise. The complexity of the laparoscopic techniques and undefined inclusion criteria are additional contributing factors. The aim of this review is to analyze the technical feasibility and safety of laparoscopic liver surgery, and to evaluate its role in the management of two types of benign lesions: hepatic cysts and solid tumors.

INDICATIONS

Benign liver tumors and cysts are relatively rare lesions, but because of improvements in imaging modalities and the wide spread use of ultrasound as a screening tool in patients with abdominal symptoms, they are diagnosed more frequently today. Surgery is indicated when they become symptomatic or complicated or demonstrate rapid growth^{23, 27}.

In order to embark upon safe laparoscopic liver surgery, a combined extensive experience in advanced laparoscopic and hepatobiliary surgery are mandatory. For optimal results, the following rules must be strictly adhered to: laparoscopic operations must conform to standards employed in open surgery; only lesions favorably located should be approached; and, appropriate laparoscopic skills and technology should be available.

For patients with benign solid tumors and hydatid cysts, only lesions located in anterolateral segments 2 through 6 (Couinaud classification) should be considered for laparoscopic treatment. All solitary liver cysts, regardless of their size and anatomic location, are suitable for laparoscopic management. In patients with polycystic liver disease, only dominant cysts located in anterior segments should be approached laparoscopically. Cholangitis resulting from communication of a hydatid cyst with the intrahepatic biliary tree, cirrhosis and poor cardiac function are contraindications to laparoscopy.

Despite isolated reports of laparoscopic resection of malignant hepatic lesions^{9, 26}, laparoscopic management of intraabdominal cancer is controversial¹¹. It is not inconceivable that wedge resection of limited liver metastases could be an acceptable alternative to an open metastasectomy,

pending trials assessing the safety and efficacy of laparoscopic management of intraabdominal malignancy.

TECHNIQUE

The patient is positioned in the inverted-Y position with the surgeon standing between the legs and the assistants at the sides. A 30° videolaparoscope (Karl Storz, Tutlingen, Germany) is introduced at the umbilicus via a 10- to 12-mm trocar (Ethicon Endo Surgery Inc., Cincinnati, OH). Two 10-mm ports surround the umbilicus in a 90° triangulated fashion, and a subxiphoid trocar is used for a fan retractor or the irrigation/suction device. For resection of solid tumors, this basic technique can be modified to a “four-hand” approach, where two additional trocars allow two surgeons to work simultaneously. The first surgeon performs with the laparoscopic ultrasonic dissector an instrumental fracture of the liver parenchyma, exposing all bile ducts and vessels, while the second surgeon controls all the vasculobiliary pedicles with clips or other hemostatic tools. This speeds up the operation and reduces the risk of hemorrhage and carbon dioxide gas embolism.

The “four-hand” technique is used to resect benign solid tumors such as adenomas and focal nodular hyperplasia. The resection begins with division of the round ligament and the right or left triangular ligament for lesions located in the corresponding lobe. Glisson’s capsule is scored 2 cm away from the lesion using electrocautery. The Harmonic shears (LCS, Ethicon Endosurgery, Cincinnati, OH) is one of the key instrument in laparoscopic liver

surgery. It can be used to mimick a “Kelly fracture technique” while achieving hemostasis and biliostasis of all small radicles .Its action is based on the denaturation of proteins through a heat induced coagulation process by the oscillations of the blades at 55,000 cycles /sec. Those shears are used by the first surgeon to dissect the parenchyma, while the left hand retracts the exposed liver surface. Simultaneously, the second surgeon divides all exposed larger vascular and biliary pedicles between large hemostatic clips. Hemostasis and control of bile leak from raw liver surface are achieved by wide application of fibrin sealant. Fibrin Sealant (Tisseel™, Hyland/Immuno Div., Baxter Corp., Deerfield, IL) has been approved for clinical use in the US in 1998 and is currently commercially available. It is achieved by a combination of 2 main products: human derived fibrinogen mixed with an antifibrinolytic agent (aprotinin) and thrombin activated by calcium chloride. The vials are heated at 37°C on a specially designed plate (Fibrinotherm, Baxter Corp., Deerfield, IL) and agitated. The end product (fibrin glue) duplicates natural human polymerized fibrin chains.

It is reconstituted in the clinical setting by combining the two seringes containing fibrinogen on one hand and activated Calcium chloride on the other hand via a laparoscopic applicator (Duplocath *, Baxter healthcare, Inc).

Fibrin sealant has several interesting properties that makes it appealing in laparoscopic liver surgery.

First, it is a powerful hemostatic agent .Reproducing the last step of the coagulation cascade, it will stop venous oozing from the liver surface. It is best applied in a thin layer using the Tissumat * device .It is recommended during

application to monitor the intraabdominal pressure to avoid a surge that could lead to a state of mechanical hyperinflation .The excess CO₂ should be released through the opening of the trocar valve.

It is obvious that the use of Tisseel will not replace excellent surgical technique.

Argon beam coagulation is an alternative hemostatic option but our preference goes to the use of fibrin sealant as it will avoid the charring effect that accompanies the use of the argon technology.

Second, fibrin sealant will occlude exposed small biliary radicles thus minimizing the risk of postoperative biliary fistulas.

Clips are used for hemostasis of large structures, and linear endovascular cutters are reserved for the hepatic veins. A flexible laparoscopic ultrasound probe is useful in locating anatomic landmarks or vasculobiliary structures.

If left lateral segmentectomy is indicated, it is commenced by dividing the falciform and left triangular ligaments until the inferior vena cava is identified. The liver is displaced inferiorly using a fan retractor, and the junction between the left hepatic vein and the inferior vena cava is carefully exposed using the right-angled and peanut dissectors to gain extrahepatic control of the vein. This maneuver should not be attempted if the retrohepatic course of the hepatic vein is too short. The hepatoduodenal ligament is dissected and a rubber tourniquet is passed around the porta hepatis to prepare for a Pringle maneuver in the event of massive hemorrhage. An 0 silk tie is placed around the hepatic vein and the vein is ligated using intracorporeal knot-tying technique but is not divided. The liver capsule is then scored on the anterior and inferior surface 1 cm to the left of the falciform ligament. Using the “four

hand” approach, the liver parenchyma is fractured with long atraumatic forceps or the ultrasonic dissector in a technique similar to the open finger-fracture method. The vasculobiliary pedicles of segments 2 and 3 are identified and serially ligated using hemostatic clips, and divided. The pretied left hepatic vein is divided within the liver parenchyma using a vascular endolinear cutter. Drains are placed in the residual space. The specimen is placed in a puncture-resistant bag (Cook Surgical, Bloomington, IN), sliced into two or three fragments and brought out through the enlarged umbilical port.

Constant monitoring of hemodynamic status and end tidal CO₂ and O₂ saturation are essential for early diagnosis and correction of CO₂ embolism, which may pose at least a theoretical risk during surgery, particularly in the presence of divided parenchyma or hepatic venotomies.

Solitary nonparasitic liver cysts are fenestrated. The blue dome of the cyst is opened using scissors, and the cyst content is aspirated. The cavity is thoroughly examined for the presence of indentations indicating neoplastic changes that would prompt an open resection of the lesion. The wall of the cyst is excised to within 3 mm of the liver parenchyma and is sent for pathology. Careful hemostasis of the cyst edge is performed with electrocautery. The presence of bile at the cystic edge, indicating an injury to septal bile ducts, is assessed, and a hemostatic clip or a tie is applied when needed.

The application of fibrin sealant will alleviate the need of placement of a drain thus reducing the risk of postoperative serous leaks by exudation of the remaining cyst wall.

In inferiorly located cysts, no marsupialisation with omentum is needed .

In cysts located on the dome of the liver, Way advocated stuffing the unroofed cyst with omentum to prevent a recurrence by reformation of the wall .the use of Fibrin sealant alliviates the need for this maneuver.

In PLD, deeper cysts which appear blue must be distinguished from portal or hepatic veins before transcystic fenestration. Laparoscopic ultrasound with color Doppler is helpful to delineate cysts from vascular structures. No drains are placed. Fascia of all wounds must be carefully closed to prevent leakage of cystic fluid.

Small, partially calcified hydatid cysts favorably located in an anterior hepatic segment can be managed by total pericystectomy. It consists of sequential vascular control of all the pedicles, using the pericystic layer as the plane of dissection.

Management of larger hydatid cysts proceeds in three stages. First, cholecystectomy is performed and transcystic cholangiography is done to identify possible intrahepatic biliary fistula or the presence of parasitic debris in the common duct (despite the absence of cholangitis). Next, the parasitic content is sterilized with 10 to 20 cc of hypertonic saline instilled for 10 minutes via a percutaneous spinal needle. The sterilized parasitic debris is aspirated with a large-bore trocar. Care is taken to prevent the spillage of parasitic material to avoid secondary echinococcal infestation or anaphylactic shock. Two 4x4" pieces of gauze marked with a radiopaque strip and Prolene suture for easy retrieval are soaked with hypertonic saline and placed around the cyst, and the cyst is opened and inspected for biliary leaks. These can be further demonstrated by the injection of methylene blue through the

transcystic catheter, and closed laparoscopically. Finally, the residual cavity is filled with omentum.

Fibrin sealant is applied when the cyst has been removed totally (pericystectomy).

Collagen fleeces can also be used as an add-on to the sealant.

All patients are given perioperative albendazole to help prevent recurrence of echinococcal disease in the event of an unrecognized spillage of hydatid debris.

RESULTS

We have recently reported our results of laparoscopic management of benign liver disease in 43 patients operated upon between September 1990 and October 1997¹⁵. There were 11 men and 32 women with a median age of 47 years (range, 22 to 88 years). Of patients with cystic disease of the liver, pathology included solitary giant liver cyst in 16 patients, PLD in 9 and hydatid cysts in 6 patients (Table 1.). Solid tumors consisted of adenoma in 9 patients and focal nodular hyperplasia (FNH) in 3 patients.

Median size was 4 cm for solid nodules (range, 2 to 7 cm) and 14 cm for solitary liver cysts (range, 7 to 22 cm). Patients with PLD had a median of 8 cysts (range, 6 to 12 cysts) with a median diameter, as measured on CT scan, of 8 cm (range, 4 to 16 cm).

41 patients were symptomatic. 2 asymptomatic patients had 6 and 7 cm solid masses excised and shown on pathology to be adenoma and FNH. Presenting complaints included right upper quadrant pain (68%), symptoms related to compression of adjacent organs (22%), sepsis (6%) and refractory pleural effusion (4%).

The operative procedures are shown in Table 1. In three patients (7.1%), the operation was converted to laparotomy. In two patients, conversion was to control bleeding, during fenestration of a polycystic liver, and during total pericystectomy of a hydatid cyst. Both hemorrhagic events resulted from injury to hepatic venous branches. A left lateral segmentectomy for adenoma was converted electively after intraoperative ultrasound showed the mass to be impinging on the inferior vena cava.

Median operative time was 179 minutes (range, 45 to 325 minutes). All solitary liver cysts were fenestrated in less than 1 hour.

There were no deaths. Three patients received blood transfusions. Complications occurred in 6 cases (14%): pleural effusion in two patients with PLD, one empyema after total pericystectomy for hydatid disease which required drainage, recurrent ascites in a patient with PLD that was managed conservatively, and 2 abscesses, which were drained under CT scan guidance. No complications occurred after completed laparoscopic resection of 11 solid tumors. Diet was resumed on the first postoperative day. The median length of stay was 4.7 days (range, 1 to 17 days).

Median follow-up was 30 months (range, 3 to 78 months). All patients underwent a routine CT scan 6 months after surgery. CT scan of patients with solid tumors showed no residual lesions, and they remained

asymptomatic on follow-up. One patient with PLD had recurrent right upper quadrant pain; CT scan showed an increased size of preexisting posterior cysts. He subsequently underwent an uneventful open cyst fenestration. Four patients with hydatid disease remained symptom-free on the last follow-up. The other two returned to their country of origin and were lost to follow-up.

Solitary Giant Liver Cyst

Non-parasitic hepatic cysts are usually asymptomatic and are not associated with hepatic function abnormalities. However, as they expand, they may become symptomatic. Complications such as rupture, infection or intracystic hemorrhage can occur²⁷.

Simple aspiration results in 100% recurrence and has been abandoned²⁵. The goal of surgical treatment of giant solitary cysts is to decompress the cyst and avoid recurrence. The current management involves cyst fenestration, a technique introduced by Lin et al in 1968 for treatment of PLD^{21, 22} and now performed laparoscopically^{6, 8, 18}. The cystic wall should always be examined intraoperatively for possible septations or irregularities that might indicate neoplastic changes (e.g., cystadenoma). An open total cyst excision would be indicated in this situation. Our results show minimal morbidity and no recurrence and concur with published results^{8, 20, 24}. Laparoscopic approach should become the treatment of choice for this indication.

PLD

Surgical management of polycystic liver disease is more complex because proliferating cysts can affect a significant portion of the hepatic parenchyma. The surgical approach is determined by the stage of the disease. PLD may be classified into two groups according to the number, distribution and location of cysts as defined by Morino et al²⁴. Type 1 is characterized by a limited number of large cysts predominantly located in the anterior segments of the liver. Type 2 is characterized by multiple small cysts which are distributed throughout the liver, including posterior segments (“Swiss cheese”). Patients with type 1 disease are amenable to laparoscopic management. Deep cysts that communicate with superficial cysts through a thin parenchymal wall are difficult to reach laparoscopically and moreover are difficult to differentiate from hepatic venous structures.

The rate of recurrence depends on patient selection. In Morino’s series²⁴, recurrence rate was 60% at 6 months, but included predominantly type 2 lesions. Our low recurrence rate of 11% may reflect the inclusion of patients with only type 1 cysts. We believe that laparoscopic fenestration in this instance is the preferred method of treatment. Open fenestration with liver resection should be reserved for type 2 lesions.

Hydatid Cysts

The management of hydatid cysts is challenging even for surgeons with extensive open surgical experience and laparoscopic expertise^{2, 14, 16}. Two surgical techniques are advocated for treatment of hydatid cysts: unroofing the sterilized cyst and omentoplasty, which is reserved for large cysts or

cysts in contact with venous branches of the inferior vena cava; or total pericystectomy, which is indicated for anterior cysts¹⁹. Dissection may prove quite difficult due to the inflammatory response of the liver parenchyma to the parasitic cyst, the increased risk of intraabdominal complications by spilled parasitic debris, the possibility of anaphylactic shock and the complex anatomy of biliary fistulas.

Our series of six laparoscopically treated hydatid cysts resulted in two hemorrhagic and two infectious complications. Anaphylactic shock after laparoscopic fenestration of a hydatid cyst has been reported recently¹⁷. Despite the small number of cases included in our study, we cannot advocate routine laparoscopic management of echinococcal disease.

Benign Solid Tumors

The coordinated dissection offered by the “four hand” approach that we have described for resection of solid liver tumors increases the visibility, safety, and expediency of the procedure⁷. The goal of the operative technique is to reproduce the open surgery finger-fracture technique, which bluntly exposes vascular and biliary structures. For each liver resection, we used an ultrasonic dissector, which is precise but has an unwieldy handpiece. Experience with division of the short gastric vessels during laparoscopic fundoplication and splenectomy, as well as laboratory work in the liver parenchyma, has proven the efficacy of the harmonic shears. It achieved satisfactory vascular control and biliostasis during left lateral segmentectomy.

Following the proven efficacy of fibrin sealant in controlling bleeding in hepatic and splenic trauma²⁸, we used it liberally to control raw surface oozing and for sealing of biliary leaks. In addition to its hemostatic effect, it has the properties of enhancing tissue healing by serving as a network for fibroblast proliferation and by the creation of soft adhesions, thus promoting closure of dead spaces.

Our data support the literature^{1, 7, 13, 26} and suggest that laparoscopic resection of small benign tumors in selected patients is safe, provided the lesions are located in the left lobe (segments 2, 3 and 4) or in the anterior segments of the right lobe (segments 5 and 6). We attempted three laparoscopic left lateral segmentectomies for benign tumors, converting one deliberately because of the proximity of the lesion to the inferior vena cava. The two other cases were completed laparoscopically without complications.

CONCLUSION

Minimally invasive techniques may be used for treating a variety of benign hepatic lesions in selected patients. The size of the lesions is less important than the anatomic location in safe anterolateral regions. Laparoscopic unroofing of solitary liver cysts is the procedure of choice for this indication. The laparoscopic management of polycystic liver disease should be reserved for patients with a limited number of large, anteriorly located symptomatic cysts. Active hydatid cysts present technical difficulties due to their complex biliovascular connections and the inherent nature of the parasite. Our results do not support widespread use of laparoscopy in these cases. Uncomplicated benign liver tumors located in the left lobe or in the

anterior segments of the right lobe can be resected safely using a “four hand” technique. Open surgery should remain the treatment of choice when tumors are malignant, are located posteriorly, or are in proximity to major hepatic vasculature.

The use of fibrin sealant now routinely available has proven to be a useful adjunct in laparoscopic liver surgery minimizing the need for omental patching, improving hemostasis and finally and most importantly, allowing for a very low morbidity provided the indication is appropriate and the technique flawless.

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Synopsis

Laparoscopic liver surgery can be accomplished safely in selected patients with benign liver lesions, provided appropriate laparoscopic skills and technology are available. The size of the lesions is less important than the anatomic location in anterolateral regions. Small benign solid tumors located in the anterior liver segments and giant solitary cysts can be managed safely and effectively using the laparoscopic approach. The laparoscopic management of polycystic liver disease should be reserved for patients with a limited number of large, anteriorly located cysts. Because of the complex nature of hydatid disease of the liver, it is best treated through an open approach.

MIS and Cirrhosis: good or bad friends?

Andrew A. Gumbs, M.D.

INTRODUCTION

Interest in minimally invasive techniques for hepatic surgery has risen over the years mainly because of the successes seen with other types of major laparoscopic surgery, i.e. laparoscopic surgery for colorectal cancer. The hepatopancreato and biliary (HPB) system has been considered the last bastion of laparoscopic surgery due to a combination of anatomical complexity of this system and the lack of surgeons with experience in both laparoscopy and HPB surgery^{1, 2}. Many authors insist on the existence of laparoscopically accessible hepatic segments in the peripheral segments of the liver (segments II, III, IVb and V) and non-laparoscopic segments that are the high and deep segments in the right side of the liver (segments VIa, VII and VIII)³. As a result, laparoscopic and hand-assisted resection of lateral and peripheral liver segments has become more common in the management of benign and malignant tumors⁴⁻⁶. In our experience, however, all segments of the liver can be approached with totally laparoscopic techniques¹.

We currently favor surgical resection to ablative procedures in the treatment of primary and secondary hepatic malignancy¹. Guiding principles of hepatic resection are the need to leave the patient with at least 30% of functional hepatic reserve and at least 1cm of tumor free resection margin for malignant tumors^{3, 7, 8}. Laparoscopy is particularly useful in cases when resectability is uncertain prior to surgery. According to the Clinical Risk Score advocated by Fong et al., evaluation of 5 factors can predict the presence of occult intrahepatic or extrahepatic disease that may make patients unresectable⁹. These factors include: presence of more than one liver tumor, positive node status of primary tumor, disease-free interval of < 1 year, presence of liver tumor > 5cm and CEA level > 200 ng/mL. If any patient has > than 2 of these factors, occult disease rendering patients unresectable will be found in 42% of cases. Because of this, the routine use of laparoscopy with concomitant laparoscopic ultrasound can save patients from unnecessary laparotomy⁹.

Because of concerns for massive hemorrhage, risk of gas embolism and port site recurrences and adequacy of resection margins for malignancies via the laparoscopic approach, major hepatectomies are currently being performed in only a few highly specialized centers^{1, 3, 7, 8, 10-16}. Although an increasing number of centers have started using the hand-assisted technique for hepatic resections, we prefer totally laparoscopic techniques because of reports of decreased length of stay (LOS) when compared to lap-assisted or open resections^{6, 16, 17}. The great disparity in laparoscopic experience and ability has revealed that aside from anesthetic considerations and contraindications to the pneumoperitoneum itself, the only absolute contraindication to a laparoscopic procedure from a surgical point of view is operator ability and not the patient's pathology. Need for complex vascular and biliary reconstruction remain relative contraindications¹. Some

reports have shown benefits in terms of operative time, estimated blood loss (EBL) and length of stay (LOS) after peripherally located hepatic resections performed laparoscopically as compared to traditional techniques¹⁶.

RESULTS

Over a 12-year period from January 1995 until June 2007, a total of 357 liver procedures were performed. Of these a total of 200 laparoscopic liver resections were performed. A total of 46 procedures (23%) were for benign disease compared to 154 (77%) for malignant disease. A total of 136 patients (68%) underwent minor laparoscopic resections and an additional 64 patients (32%) underwent major hepatic resections. Notably, a total of 34% of cases had an associated procedure performed at the same time. Nonetheless, all complications whether associated with the hepatic surgery or associated surgery were considered for the statistical analysis. Major associated procedures were defined as procedures that involved gastrointestinal anastomoses or resection of partial or entire solid organs. The average OR time, estimated blood loss and length of stay was 192 minutes (+/- 106), 324 mL (+/-365) and 10 days (+/- 9). Resection margins averaged 6mm, 11mm in for malignant disease and 4mm in cases for benign disease. Conversions occurred in 13 patients (7%).

In an effort to ascertain the effectiveness of the minimally invasive approach for hepatic resection, we decided to compare our results to 5 National and European referral centers for hepatic pathology. A total of 605 cases (90%) of hepatocellular carcinoma and 59 cases (10%) of cholangiocarcinoma from the literature were compared to our experience of 29 (88%) and 4 (12%), respectively²²⁻²⁶. Although, 39% of procedures were minor resections and 61 % major resections in the literature compared to 52% and 48% in our experience, respectively; more patients in the laparoscopic group suffered from cirrhosis preoperatively (43% vs. 27%). Morbidity was similar at 26% in the open series and 23% in our series, however, the open patients were found more commonly to suffer from hepatic insufficiency. Thirty-day mortality tended to be lower in our group compared to historical open controls (1% vs. 5%). Furthermore, disease free and overall 5-year survival seems to be similar to the laparoscopic approach compared to recent reports in the published literature, 53% and 66% versus 27% and 36%, respectively.

Among the patients from our series with metastatic disease, 86 (75%) patients were found to have disease from colorectal carcinoma and 29 (25%) from other non-colorectal, non-neuroendocrine tumors. These were compared to a total of 1891 non-neuroendocrine cases of metastases to the liver (21% colorectal, 89% non-neuroendocrine) from the published literature²⁷⁻³¹. As in the cases with primary liver cancer, a slightly higher percentage of cases in the open literature underwent major resections when compared to our laparoscopic group, 43% vs. 31%. Other patient characteristics such as age, male-female ratio and number of nodules were more homogenous. Overall morbidity and mortality rates were also similar at 25% and 1% in the open literature compared to the

laparoscopic group 28% and 1.6%, respectively. Notably, the laparoscopic patients tended to suffer significantly fewer pulmonary complications and biliary leaks. The increased incidence of intra-abdominal collections is due to the large percentage of laparoscopic patients undergoing simultaneous associated procedures (i.e. colo-rectal resections). As noted in patients with primary liver cancer, disease-free and overall 5-year survival are similar after minimally invasive resection, 45% and 55% vs. 22% and 32%, respectively.

DISCUSSION

No prospective randomized controlled trials have been published comparing open to laparoscopic hepatic resections. One case-controlled study exists comparing laparoscopic left lateral segmentectomy to open historical controls. In this study 18 patients were identified that underwent laparoscopic bisegmentectomies of segments II and III. The study found longer operative and portal clamping times for the laparoscopic approach, but noted significantly less intra-operative blood loss. Neither group had any mortalities and the complication rate was 11% in the minimally invasive group and rose to 15% in the open group. Complications relating specifically to the surgery were only noted in the open group and consisted of hemorrhage, sub-phrenic abscess and biliary leak⁴.

In our study 89 laparoscopic liver resections over a 10-year period were reported. The majority of cases were performed for malignant disease (73%). Major hepatectomy was performed in 43%, and conversion to open was necessary in 13% of all cases. Mortality was reported in 1 patient (1.1%) secondary to a bile leak; and complications occurred in 16% of patients that underwent minor hepatectomies and increased to 29% after major hepatectomy. We concluded that totally laparoscopic hepatectomy was feasible and safe for even major hepatic resections with similar long-term survival, but acknowledged the considerable learning curve associated with these procedures¹.

During the initial phase of our experience, minimally invasive resection was considered contraindicated if venous or biliary reconstruction was required, however, over the last 5 years even tumors located near the hepatic vein confluences with the vena cava have been considered eligible for laparoscopic resection¹. Since then, our conversion rate has dropped to 6% while morbidity and mortality rate have stayed constant. We attribute the plateau in our morbidity rate to our tendency to attempt and perform increasingly complex cases that we would have done via open techniques during the beginning of our experience. Right hepatectomy remains a challenging procedure, with the majority of our major complications occurring after this procedure¹.

As experience has grown world-wide, other centers have noted increased short term benefits for patients undergoing laparoscopic minor hepatic resections of decreased analgesic requirements and shorter hospital stays when compared to historical open controls: average hospital stay of 3.5 days and 1 day of analgesic use¹⁹. Furthermore, indications to perform laparoscopic resection of

liver tumors have also been found to be safe in patients with hepatocellular carcinoma and Child's A cirrhosis¹⁴. Some Authors have appropriately concluded that laparoscopic resections of simpler hepatic segments such as a bisegmentectomy of segments II and III, should probably be considered the standard of care²⁰.

Other reports of laparoscopic liver resections reiterate the feasibility of major hepatic resection with laparoscopic techniques; however, they also stress the difficulty in performing the dissection around the more posterior segments^{4, 21}. In our series we attempted to isolate patients who had exclusively or principally resections of these posterior segments and excluded patients that had complications that could be directly attributed to an associated procedure. When this was done mortality was nil and morbidity was low in the laparoscopic group 5%. As a result, laparoscopic resection of posterior segments seems to be as safe as via open approaches.

Because of these findings confirming the feasibility of a minimally invasive approach to resections of both benign and malignant lesions of the entire liver, it was decided that a comparison with results from other European centers of excellence who utilize open approaches was appropriate. Because of the vast differences in data reports it was felt that 2 separate comparisons of 5 different reports of short and long-term outcomes of open hepatic resections of primary and secondary liver tumors would be most useful.

When our results were compared with the literature regarding primary liver tumors, our patient population was quite similar to that of the averaged open reports²²⁻²⁶. Notable exceptions were the decreased in-hospital mortality rates and the increased 5-year survival rates. These findings can be partially explained by our decreased morbidity rates.

Because of the many different tumors that metastasize to the liver, a less homogenous patient population was found in the open literature when compared to our series²⁷⁻³¹. Specifically, a higher percentage of colorectal metastases was noted in our series. Nonetheless, because of the similar natural history of non-neuroendocrine metastases to the liver, it was felt that a comparison of our results with these patients in the open literature would be useful. As with the primary tumor population, increased survival was noted in the laparoscopic series when compared to the historical controls. When morbidity was analyzed it was noted that fewer patients suffered pulmonary or biliary complications. As a result, the increased visibility and decreased invasiveness of the minimally invasive approach may confer some short and ultimately long-term advantages.

CONCLUSIONS

Resections in the right lobe of the liver remain challenging procedures. Additionally, some centers believe that the posterior segments of the right lobe of the liver should not be approached laparoscopically, however, at our institution

outcomes after minor laparoscopic resection of the posterior segments of the right lobe of the liver also seem to have similar outcomes. Contrary to some reports, the laparoscopic approach should be considered in the treatment of primary and secondary liver cancer.

Limitations of this study include the fact that the data was not collected prospectively and the difficulty in comparing multiple reports from different institutions. Ultimately, larger randomized controlled trials with longer follow-up will be necessary to see if any true benefits exist to the minimally invasive approach. In the meantime, as more and more surgeons gain expertise in both HPB surgery and minimally invasive techniques, these procedures are becoming more frequent because laparoscopic resections of the entire liver have short and long-term outcomes that are, at least, as good as open controls in the short-term and perhaps superior in the long-term. Post-operative ascites is a rare problem after laparoscopic hepatectomy (<5%), even in cirrhotics, however, larger randomized controlled trials are needed to see if there is any true benefit over traditional procedures.

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MIS Liver Surgical Techniques

**David A. Geller, M.D.
Richard L. Simmons Professor of Surgery
Co-Director, UPMC Liver Cancer Center
Starzl Transplant Institute
University of Pittsburgh**

**Pearls & Pitfalls of Solid Organ MIS PG Course:
MIS Liver Surgical Techniques**



David A. Geller, M.D.

Richard L. Simmons Professor of Surgery
Co-Director, UPMC Liver Cancer Center
Starzl Transplant Institute
University of Pittsburgh

Relevance to Solid Organ MIS Surgery

- Innovations in technology have paved the way for “Minimally Invasive Hepatic Surgery”
- Laparoscopic liver resections for primary and metastatic cancers
- Surgical techniques are constantly evolving

Indications for Lap. Liver Surgery

(Laparoscopic Liver resections and hand-assisted Lap. liver resections)

- Benign liver lesions (Adenoma, FNH, hemangioma)
- Giant hepatic cysts
- Tumors
- Living donor left lateral segmentectomy & R. hepatectomy

Advantages of lap. liver surgery:

- Band-aid sized incisions
- Less pain
- Shorter LOS
- No blood transfusions
- No ICU admissions
- No oncological disadvantages

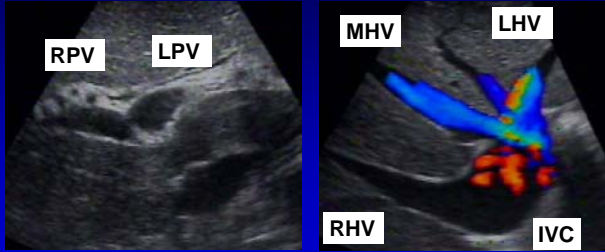
Laparoscopic liver resection requires:

1. Expertise in hepatic resection
2. Expertise in laparoscopic surgery
3. Dedicated Laparoscopic U/S
4. Appropriate equipment/instruments
5. Adequate training/proctoring

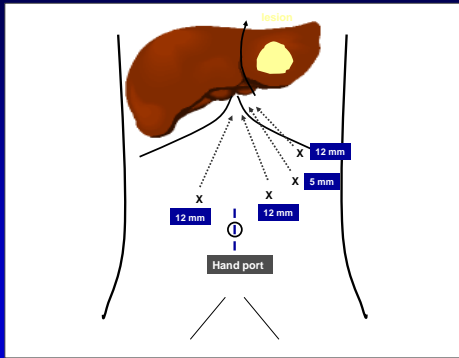
**Techniques for Dividing Liver
Parenchyma/Achieving Hemostasis**

- Blunt fracture/clips
- Monopolar cautery (bovie)
- Bipolar cautery
- Argon Beam Coagulator
- Ultrasonic dissector (CUSA)
- Erbe Hydrojet
- Harmonic scalpel
- Ligasure
- Endovascular stapler
- TissueLink Floating Ball/hook/ DS3.5/3.5c
- Habib 4x Sealer
- SurgRx
- Gyrus PK Cutting forceps

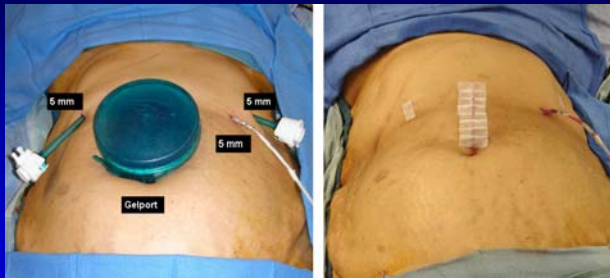
Intra-op Liver U/S of PV, hepatic veins, & IVC



Port Placement for Lap. hand-assisted Left lateral segmentectomy



Hand-Access Lap. Liver Resection
Minimal post-op pain, d/c'd home on POD #2



Outcomes of lap. liver resection for cancer:

From hundreds of laparoscopic liver resection cases, there are no reported cases of trocar site or peritoneal seeding of cancer.

Koffron et al, Hepatology, Dec. 2006



Combined Northwestern University & UPMC laparoscopic liver resection series in 335 pts

<u>Northwestern</u>	<u>UPMC</u>
- 197 cases	- 138 cases
- 58 cancer cases	- 47 cancer cases
No mortality; No tumor seeding	

Simmillis et al, Surgery, 2007

- Meta-analysis of 8 non-randomized studies 1998-2005 comparing laparoscopic to open liver resection
- 165 (40%) Lap; 244 (60%) Open resection
- Lap. cases had significantly less blood loss and LOS (matched for presence of CA and extent of resection)
- No difference in oncologic clearance (margins)
- No difference in 5 yr survival (61% lap. vs. 62% open)
- No difference in 5 yr DFS (31% lap. vs. 29% open)

UPMC Lap. Liver resections:

- 200 patients underwent laparoscopic liver resection at UPMC from 8/01-12/07
- 34% Male / 66% Female
- 96 cases hand-assisted (48%); 104 pure lap. (52%)
- 130 solid lesions (65%); 70 giant hepatic cysts (35%)
- Of solid lesions, 48% benign/ 52% malignant
- **Conversion rate:** 5/200 (2.5%)
(2 size, 1 additional tumor, 1 splenic capsule bleed, 1 MHV back-bleeding)
- **Blood transfusion rate:** 7/200 (3.5%) (1,1,1,1,2,2,2,2 units)
- **ICU admission:** 3/200 (1.5%)
- **Mean LOS:** 2.3 days

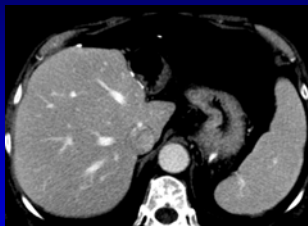
UPMC Lap. Hepatic Resection for Cancer:

<u>Cancer</u>	<u># cases</u>
HCC	28
CRC mets	21
Breast CA	5
Neuroendocrine CA	3
CholangioCA	2
Esophageal CA	2
Sarcoma	2
Gallbladder CA	1
Lung CA	1
Prostate	1
Bladder	1
	<hr/>
	67

Patient - 73 yo F, 2.5 cm LLS colon CA metastasis
OR procedure: Lap. resection left lateral segment

Pre-Op CT 9/04

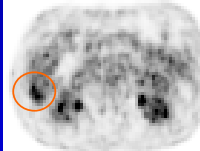
3 yr post-op 9/07



Cancer-free

64 yo WM, Solitary CRC metastasis (2 cm)
OR procedure: Lap. R. posterior hepatectomy

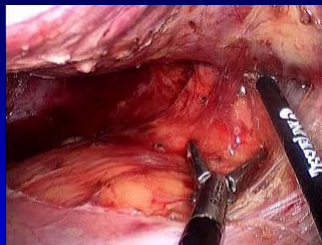
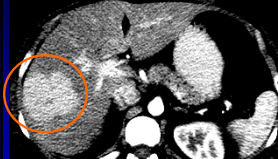
Pre-Op CT/PET 3/05



2 yrs post-op 3/07



37 yo WF, abd. pain, OCPs, 7 cm FNH, Jehovah's Witness
Lap. partial R. hepatic lobectomy with Lap Habib 4X



Laparoscopic Hepatic resection for Cancer:

Author	Year	Journal	# cases	Cancer	Survival rate
Geller et al	2007	pending	67	HCC, CRC	2 yr - 90%
Koffron et al	2006	Hepatology	105	HCC, CRC	NA
Cherqui et al	2006	Ann Surg	27	HCC	3 yr - 93%
Vibert et al	2006	Br J Surg	65	HCC, CRC	3 yr - 87%
Belli et al	2006	J HBP Surg	7	HCC	NA
Buell et al	2005	JACS	35	HCC, CRC	NA
Kaneko et al	2005	Am J Surg	30	HCC	3 yr - 79%
Dulucq et al	2005	Surg Endosc	18	HCC, CRC	NA
Mala et al	2005	J HBP Surg	42	CRC	NA
O'Rourke et al	2004	JOGS	9	HCC, +	2 yr - 78%
Teramoto et al	2003	World J Surg	11	HCC	5 yr - 75%
Laurent et al	2003	Arch Surg	30	HCC	3 yr - 89%
Lesurtel et al	2003	JACS	6	HCC, CRC	NA
Inagaki et al	2003	J HBP Surg	30	HCC	NA
Gigot et al	2002	Ann Surg	37	HCC, CRC	2 yr - 76%
Fong et al	2000	Arch Surg	11	HCC, CRC	NA
Descottes et al	2000	Ann Surg	16	HCC	NA

LAPAROSCOPIC ADRENALECTOMY

ANTERIOR TRANSPERITONEAL APPROACH VERSUS LATERAL AND POSTERIOR APPROACH

OPEN ADRENALECTOMY

Anterior Approach

The anterior approach was the most employed in open surgery and it had a number of advantages: whole exposure of the operative field, easy exploration of the entire abdomen and of the contralateral adrenal gland, an early control of the adrenal vein (recommended in pheochromocytoma and suspected malignant lesions).

Disadvantages were mainly related to the long abdominal incision, and the possible long term sequelae as adhesion and incisional hernia. Furthermore the need for bowel manipulation increases the risk of organ lesions (as bowel, spleen and pancreas) as well as of intra abdominal abscesses.

Posterior Approach

This approach has been advocated mainly by endocrine and urologic surgeons to avoid the above mentioned complications and the manipulation of intra-abdominal organs.

Thoracophreno access

It was utilized only for large and invasive masses.

In open surgery the existence of different approaches is generally related to the fact that none optimises either the surgeon or the patient's expectations and similarly it occurred in laparoscopic surgery.

LAPAROSCOPIC ADRENALECTOMY

In 1991, Clayman first described the technique of laparoscopic nephrectomy.

In 1992 Gagner reported three cases of laparoscopic adrenalectomy, performed by the lateral approach with the patient in lateral decubitus position (lateral flank position).

In few years the minimally invasive surgery became the goal standard for the treatment of benign and no large size abdominal masses.

At present time according to a review of the literature published by Assalia and Gagner (2004) the majority of the adrenalectomy are performed following flank approach (72,5%): the anterior and posterior (extra peritoneal) approaches are utilized respectively in 12,5% and 15% of the cases.

To describe the advantages and disadvantages of these three approaches it is suitable to differentiate the right and the left adrenalectomy.

A) RIGHT ADRENALECTOMY

Anatomy of Surgery

The main vein is situated in the medial and upper margin of the gland, generally is very short: metallic clips are recommended to close the vein and in case of large size a vascular stapler can be utilized.

An accessory vein is present in about 15-20% of the cases and it is easily closed by ultrasound or radiofrequency instrumentations.

1. Flank Approach

The patient usually is placed on the operative bed in lateral position as clearly shown in Fig. 1.

Disadvantages

- 1a) the time required to position the patient on the operative bed exceeds at least 20 minutes;
- 1b) the movements to position the anesthetized patient is not only time consuming but also potentially dangerous;
- 1c) before clamping the main vein, a wide dissection of the perineal fat is necessary in order to shift the gland and to obtain the main vein in perpendicular position to the clip-applier jaws;
- 1d) this manoeuvre may require significant manipulations of the gland in relationship to the dimension of the mass;
- 1e) in case of conversion for bleeding from the main vein or the vena cava, the patient position does not facilitate the surgeon;
- 1f) associated procedures are allowed.

Advantages

The reasons by which this procedure is utilized by the majority of surgeons are several:

- 1g) the operative field is very wide;
- 1h) the clear anatomical landmarks are easy to be identified; this facilitates the dissection of the gland and of the main vascular structures;
- 1i) the liquids produced during the perirenal fat dissection are dropped out from the working area by gravity;
- 1j) the skilled laparoscopic surgeon in case of vena cava tear can successfully suture the lesion avoiding conversion.

2. Anterior Approach

The patient is placed on the operative bed in supine position (see Fig. 2).

Disadvantages

- 2a) to obtain an adequate operative field the liver must be lifted up with a laparoscopic instrumentation that can tear the liver capsule;
- 2b) if the patient underwent previous operations at level of upper right quadrant the identification of the gland can be difficult due to adhesions;
- 2c) to remove from the operative field the produced liquids is required a suction canula. To this purpose the instrumentation of Johnson & Johnson is particularly useful because, in case of bleeding, allows also to perform the electrocoagulation during suctioning.

Advantages

- 2d) the patient is placed on the operative bed in supine position avoiding the movement of the anaesthetized patients and shortening the operative time;
- 2e) the vision of the operative field is wide and allows an excellent exposure of all the anatomical landmarks;
- 2f) the patient position is adequate to repair laparoscopically the vena cava by stitches;
- 2g) according to our strategy the first step of the operation is the dissection of the medial attachment of the gland. This manoeuvre allow to reduce significantly the arterial blood supply and determine a shift of the gland laterally that facilitates the exposition of the main vein. To perform this dissection we strongly recommend the use of ultrasound or radiofrequency instrumentations.
Once the gland is medially completely dissected the ligation of the main vein can be easily achieved by clips. In order to closure the clip tip under direct vision we utilise routinely the Acuclip (Tyco).
Once the vein has been divided, the dissection of the superior arterial branch arising from the frenal vessels is easily performed also in large masses. Ligation or Ultracision are extremely useful to shorten the operative time and to make the procedure safe;
- 2h) this approach has the same advantages described in item 1j and in case of conversion all surgeons are confident with exposure of the anatomy in supine position;
- 2i) it allows to perform bilateral adrenalectomy placing only two other trocars;
- 2j) associated procedure (ovariectomy, cholecistectomy etc) are easily performed;
- 2l) operative time is short.

3. Posterior Approach

The patient is placed on the operative table in lateral or prone position (Fig. 3)

Disadvantages

- 3a) to positioning the patients is time consuming;
- 3b) the view of the operative field is very limited;
- 3c) the anatomical landmarks are not easily identified and it is necessary a wide dissection around the gland, before to clip the main vein;
- 3d) in case of the peritoneal tear there is a diffusion of the gas with leakage of the retroperitoneum;
- 3e) if accident occur, a need to change the patient's position to supine decubitus, may be required;
- 3f) the major vein ligation can be performed only after a wide dissection of the gland.

Advantages

- 3g) the lack of pneumoperitoneum is favourable for patients with cardiovascular and respiratory distress;
- 3h) the approach is minimally invasive and doesn't need the opening of peritoneal cavity, avoiding any manipulation of abdominal organs, that can cause post-operative lesions and adhesions;
- 3i) in obese patients the dissection is less extensive than with the other two approaches;
- 3j) this approach is recommended in the case of complex intra-abdominal adhesions.

B. LEFT ADRENALECTOMY

Anatomy of surgery

The main vein is situated in the inferior margin of the gland. It originates from the renal vein, and it's longer than the right one. The identification and the ligation is easier than for the right side. The medial margin of gland is adjacent to the aorta, and from this originate several small arteries that supply the gland . Other veins and arteries come from phrenic vessels. All these vessels are easily divided by radio-frequency or ultrasound instruments.

4. Flank approach

The patient is placed on the operative bed in lateral right position as clearly shown on fig 4

Disadvantages

- 4a) the patient position on the operative bed has the same disadvantages reported for right side;
- 4b) to reach the gland a wide dissection of posterior attachments of the spleen must be performed. Occasionally it can be necessary to mobilize the colonic flexure;
- 4c) the dislocation of the spleen is facilitated by gravity, but the consequent rotation can cause traction on the short vessels and a splenic tear. The limited view of the operative field doesn't allow the surgeon to be conscious on time of the damage. In fact the patient position collect the blood far away. This regrettable event can be life-threatening in riskfull patients and particularly in those with cronic hypovolemic conditions;
- 4d) it's well known that the pneumoperitoneum determines a "physiological " compression of vena cava, with consequent reduction of cardiac pre-load;

- 4e) furthermore, according to our personal experience (unpublished data) the above mentioned hemodynamic conditions are significantly worsened by the lateral compression of vena cava by abdominal organs due to lateral position of the patient;
- 4f) the events described in items 4c,d,e, are particularly riskful in patients with haemodynamic instability. **For these reasons and due to the fact that in this approach the main vein ligation is not the first step of the operation we do not recommend the flank approach for pheochromocytoma.**

Advantages

The advantages are the same as those described in right adrenalectomy (see items 1g,h,i).

5. Anterior approach

As for right side the patient is in supine position, see Fig. 5

Disadvantages

- 5a) a wide mobilisation of the left colonic flexure must be performed. This manoeuvre requires a surgeon skilled in laparoscopic surgery;
- 5b) in case the patient underwent to previous operation or colonic diverticulitis, the mobilisation of colonic flexure can be difficult;
- 5c) to reach the adrenal gland, the pancreatic body must be gently lifted up to avoid bleeding from splenic vein and from the pancreatic parenchyma.

Advantages

- 5d) Easy rapid positioning of the patient in the supine position, with the table rotated on right by 15° and in moderate anti-trendelenburg;
- 5e) clear evidence of anatomical landmarks. The identification of the left renal vein and after, the adrenal vein is easy;
- 5f) exposure of the adrenal gland is facilitated by the use of an angled laparoscope;
- 5g) early ligation of the main adrenal vein before gland manipulation. In suspected malignancy and in pheochromocytoma no direct manipulations of the gland must be performed before vascular exclusion. An early ligation reduces the risk of catecholamine release and cell dissemination;
- 5h) the possibility to perform a bilateral LA is another advantage and doesn't require changing the patient's position.
- 5i) the possibility to perform an exploration of entire abdomen for localization of extra-adrenal tumours.
- 5j) the possibility to perform associated surgical procedures;
- 5l) immediate conversion to open surgery is easily performed in case of major bleeding and does not require to change the patient position. The site of bleeding is immediately identified after opening abdomen

6. Posterior Approach

Patient is placed in prone or lateral position, Fig. 6

Disadvantages and advantages are the same as those described for right adrenalectomy (see items 3).

7. Sub-mesocolic Anterior Transperitoneal Access

The sub-mesocolic access, is an interesting alternative for left LA, theoretically has all the advantages of the anterior approach without the perils related to the colonic splenic flexure mobilization.

Disadvantages

7a) risk of bleeding from pancreatic parenchyma

Advantages

7b) the advantages are the same reported in items 5 for the standard anterior approach

Laparoscopic technique

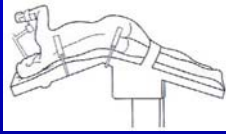
The patient is in supine decubitus position. Pneumoperitoneum is established preferably by Veress needle, and four 10-mm trocars are placed. The meso of transvers colon is lifted up and the Treitz ligament and inferior mesenteric vein (IMV), close to the inferior pancreatic margin, are identified. Laterally to IMV the peritoneum of mesocolon root is divided and the pancreatic body gently raised. By dissection manoeuvres, or immediately in thin patients, left renal and thereafter adrenal vein are visualized. This latter closed and sectioned, the adrenalectomy is carried out. When omentum and transverse colon are difficult to retract, the assistant surgeon introduces an additional 5-mm. trocar and uses both hands to grasp and keep these far away from the operating field. Actually, since obese patients were generally excluded from the sub-mesocolic access, this expedient was seldom necessary in our experience.

Conclusion

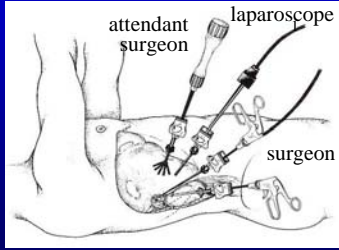
According to a recent study in publication on Surgical Endoscopy, that compares flank versus anterior sub mesocolic access, this approach has a shorter operative time, an earlier main adrenal vein ligation and a shorter hospital stay (Surg. Endosc. January 2008).

For these reasons we consider this approach as the most suitable in non obese patients for functioning and non functioning tumors smaller than 6-7 cm.

**RIGHT ADRENALECTOMY
(FLANK POSITION)**



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•FIG. 1

TROCARS PLACEMENT (4)

**RIGHT ANTERIOR APPROACH
(Supine position)**



laparoscope

attendant
surgeon

surgeon

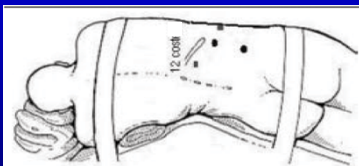
FIG. 2

TROCARS PLACEMENT(4)

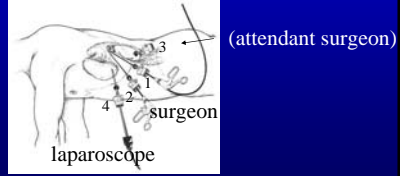
emanuele.lezoche@uniroma1.it

**RIGHT POSTERIOR APPROACH
(PRONE POSITION)**

Fig. 3



**LEFT ADRENALECTOMY
FLANK APPROACH**



•Fig. 4

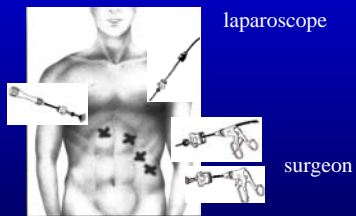
emanuele.lezoche@uniroma1.it

TROCARS PLACEMENT (3 - 4)

**LEFT ANTERIOR APPROACH
(SUPINE POSITION)**



attendant
surgeon



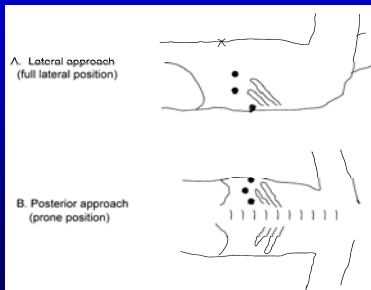
•FIG. 5

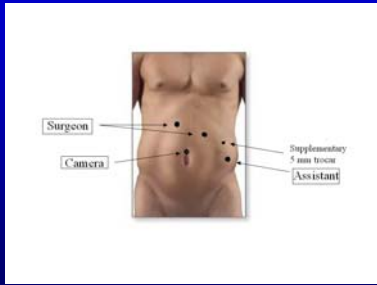
emanuele.lezoche@uniroma1.it

TROCARS PLACEMENT (4)

**LEFT POSTERIOR APPROACH
(PRONE POSITION)**

Fig. 6





•Fig. 7 Anterior sub-mesocolic access

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Limits and Strategy: Bilateral, Enlarged Adrenal and Partial Adrenalectomies

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Laparoscopic adrenalectomy is the gold-standard for surgical treatment of unilateral, small, and benign adrenal tumors. It is technically straight forward. Most patients have minimally pain from the operation and can be discharged home the next day. In this presentation, we will concentrate on the less common situations of bilateral resection, partial resection and resection for large adrenal tumors.

Bilateral Adrenalectomy

The most common indications for bilateral adrenalectomy are ACTH-dependent Cushing's syndrome and bilateral pheochromocytomas. These patients have complex endocrine problems. The main issues related to their bilateral adrenalectomy are not technical aspects of the operation, but whether or not the patient receives appropriate peri-operative and postoperative care. It is important to work closely with an endocrinologist or an endocrine surgeon colleague who has interest and expertise in the medical care of the patients with adrenal diseases.

Bilateral adrenalectomy can be performed by either lateral transabdominal or posterior retroperitoneal approach. The choice depends on the surgeon's experience. The lateral approach requires intraoperative repositioning. The posterior approach is less suitable for large tumors.

Cushing's

Compared to those with other diagnoses, patients with Cushing's syndrome who require bilateral adrenalectomy are at higher risk for death and complications. These patients have ACTH-dependent Cushing's syndrome. They either have failed pituitary treatment for Cushing's disease or have ectopic ACTH secreting tumors that can not be located or resected. Adrenalectomy is more effective in treating hypercortisolism in these patients than medication. Chronic hypercortisolism causes hypertension, diabetes, and obesity. These patients have fragile tissues and are more likely to bleed. They are also at higher risk for pulmonary embolism and needs perioperative DVT prophylaxis. They have a

higher risk of surgical site infection and need perioperative antibiotics. The hypercortisolism is controlled preoperatively by medications, such as ketoconazole. Stress dose steroid is used peri-operatively and tapered postoperatively. In contrast to patients after a unilateral adrenalectomy, patients after bilateral adrenalectomy need mineralocorticoid replacement in addition to glucocorticoid replacement.

Pheochromocytoma

Patients with bilateral pheochromocytomas most likely have one of the familial syndromes. Multiple endocrine neoplasia (MEN) type 2 is confirmed by testing for *ret* proto-oncogene mutation. Patients with MEN 2 either already have developed medullary thyroid cancer or will develop it, so thyroidectomy and lymph node dissection is almost inevitable in this group of patients. When both pheochromocytoma and medullary thyroid cancers are present, adrenalectomy is done before thyroidectomy because pheochromocytoma is more immediately life-threatening. The long-term prognosis, however, depends on the presence and stage of medullary thyroid cancer. During laparoscopic adrenalectomy the liver surface needs to be inspected for possible metastases from medullary thyroid cancer, especially if preoperative plasma level of calcitonin is elevated. Liver metastasis from medullary thyroid cancer can be very subtle and may only appear as tiny, millimeter-size white dots on the surface of the liver. Biopsy of these lesions with calcitonin immunohistochemical staining is required to make the diagnosis. If the CT and MIBG show only unilateral adrenal tumor we do not recommend bilateral adrenalectomy, because the long-term risk of hypocortisolism (Addison's) is greater than the risk of developing contralateral adrenal pheochromocytoma. Patients with von Hippel-Lindau disease may have tumors in the kidney or pancreas; these can be identified in the preoperative CT scan.

Partial Adrenalectomy

Partial adrenalectomy can be performed safely, but is only indicated in specific situation when the benefit of preserving functioning cortex outweighs the risk of local tumor recurrence. When only a unilateral adrenal resection is planned, partial resection is usually not indicated. Partial adrenalectomy is not oncologically sound if the adrenal is being resected for possible malignancy. There may be exceptions to the rule of routine total resection for unilateral adrenalectomy, for example, leaving a small amount of adrenal tissue while resecting an aldosteronoma in order to avoid injury to blood vessels in the renal hilum. For patients needing bilateral adrenalectomy for Cushing's, subtotal resection is associated with a very high risk of persistent or recurrent disease.

The patients who are likely to benefit from partial adrenalectomy are those with familial pheochromocytomas (as discussed above), who require bilateral adrenalectomy, either concurrently or sequentially. In these patients, a sufficient amount of cortex may be spared if the tumor is resected only with a small margin of the normal appearing adrenal gland. The benefit of avoiding hypocortisolism

(Addison's) can outweigh the risk of pheochromocytoma recurring in the remnant adrenal (10 to 20%).

Five millimeter ultrasonic scissors (Harmonic Scalpel) or bipolar sealing device (LigaSure) are used to transect the adrenal tissue with excellent hemostasis. It is not necessary to spare the adrenal vein to keep the remnant viable as long as the remnant is left on a broad base. The surgeon should avoid excess dissection around the remnant, both to preserve the blood supply and to anticipate potential future reoperation if the disease recurs.

Laparoscopic Adrenalectomy for Large Tumors

The two major issues for laparoscopic adrenalectomy for large adrenal tumors are oncological and technical. The risk, that an adrenal cortical tumor is malignant, increases with size, about 25% for tumors six-cm or larger. Laparoscopic adrenalectomy for large tumors is also technically more challenging. A tumor that is twice as large has four times the surface area to be dissected.

Several retrospective series have shown that, adrenal tumors larger than 6 cm can be resected safely. But, it takes longer time to dissect larger tumors and the rate of conversion to open operation is higher. Most surgeons use the lateral transabdominal approach for large tumors, instead of the posterior retroperitoneal approach, where the space for dissection is limited. Since there is a higher risk for local invasion if the tumor is malignant and a higher risk of local recurrence if the tumor is ruptured, the surgeon should have a low threshold for conversion to open resection. Conversion to hand-assisted laparoscopic adrenalectomy can be an excellent option if the dissection is difficult, but safety is not an issue.

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IMPACT OF ADRENALECTOMY OF METASTASIS ON LONG TERM OUTCOME

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Introduction

An important number of malignant tumors metastasize to the adrenal gland, most likely due to its rich sinusoidal blood supply. Metastases to the adrenal are common in patients with disseminated cancer, but are rarely found as isolated metastasis (1.2%). The incidence of adrenal metastases found at autopsy ranges from 8 to 27%.

The most common tumors metastasizing to the adrenal are primary neoplasms of the lung, kidney, breast, melanoma and GI tract. Adrenal metastases can also occur from hepatocellular carcinoma, carcinoma of the bladder, lymphoma, testicular seminoma, osteogenic sarcoma, ovarian cancer, gastric cancer, sarcoma, cholangiocarcinoma, and thyroid cancer.

Time of diagnosis of adrenal metastases has an important influence on long term survival of most primary cancers. Metastasis are described as synchronous when they are found at the time or within 6 months of diagnosis of the primary cancer, or metachronous when they are found after a disease-free period of more than 6 months. Metachronous disease is usually associated to longer survival: the longer the interval between diagnosis of primary disease and adrenal metastases, the longer the survival.

Some series have described the pattern and characteristics of adrenal metastases. One of the largest series was reported by Lam and Lo (1). They described a cohort of 464 patients with adrenal metastases. 90% of metastases were carcinomas (56.2% adenocarcinoma and 14.9% squamous cell carcinoma) and the rest were hematopoietic neoplasms, sarcomas or melanomas. Bilateral metastases were found in 49% of the patients. 30% were solitary, 22% were multiple and 44% diffuse.

Tumors that metastasize to the adrenal gland

Management of adrenal metastases is dependent on the extent of the primary disease. Surgical resection of metastasis prolongs survival provided that it is the only site of metastatic disease. However, considerations should be made for each disease. The following paragraphs are dedicated to the description of relevant characteristics of tumors metastasizing to the adrenal glands.

1. Lung

Lung cancer is the most common tumor metastasizing to the adrenal glands. Adrenal metastases occur in close to 30% of all lung cancers. Metastases from lung cancer on the other hand account for approximately 35% of all adrenal metastases. As with other distant metastases, adrenal spread is rarely isolated and tends to indicate advanced disease. Most patients with metastatic lung cancer present multiple metastases from hematogenous spread. Aggressive treatment and systemic chemotherapy is critical in this setting (2). A small amount of patients, however, may have isolated adrenal metastases. Resection of these metastases has proven to increase survival moderately and in some cases even to offer long term survival.

Up to 59% of patients with non-small cell lung carcinoma present adrenal metastases at initial presentation. This is the primary neoplasm with the highest incidence of synchronous disease. Patients with metachronous disease have a significantly longer survival when compared to patients with synchronous disease. Overall five year survival is between 23.3 and 31%, and it increases to up to 49% after resection of metachronous adrenal metastasis. The ideal case for surgical resection is a metachronous isolated adrenal metastasis that can be completely resected and is additionally treated with adjuvant chemotherapy (3).

2. Renal Cell Carcinoma (RCC)

Adrenal involvement in RCC occurs in close to 7% of patients. The incidence in small, well circumscribed renal lesions (T1-2) is approximately 1.2%, whereas in more advanced tumors (T3-4) it is close to 13%. RCC is more likely to spread locally to the adrenal gland when it is localized in the upper pole of the kidney or

it is multifocal. Lower pole and mid region tumors tend to metastasize hematogenously. Adrenalectomy is recommended in patients with local invasion as well as in those with adrenal metastasis (4,5).

3. Gastro-Intestinal tract

Metastases from primary GI tract cancer represent approximately 30% of all adrenal metastases. Gastric cancer accounts for up to 14%, esophageal cancer for close to 12%, and 5% are due to colon cancer. The highest incidence of metastases from GI tract tumors has been described in Asian populations. In western populations colorectal cancer has a highest incidence, which reaches up to 17.4%. Surgical treatment of adrenal metastases from colorectal cancer improves prognosis if they are localized and solitary. Follow up may be done with periodic measurements of serum CEA (5).

4. Melanoma

Between 3 and 18% of adrenal metastases are due to melanoma. As with all metastases from melanoma, patients with adrenal metastases have poor prognosis. Surgical treatment is recommended only for patients with limited extra-adrenal disease in whom surgical resection can render the patient disease free. In a series of 154 patients with adrenal metastases from melanoma, median survival was 6.4 months. Synchronous disease was associated with worse prognosis. Adrenalectomy or adrenalectomy with resection of additional metastatic lesions has proven to improve survival (6).

5. Hepatocellular Carcinoma

The incidence of extrahepatic metastases from hepatocellular carcinoma has increased due to earlier diagnoses and more effective therapeutic procedures. Extrahepatic metastases are found in about 13.5 to 42% of patients. They are usually identified in the presence of advanced disease. Therefore prognosis is usually poor. There is no consensus on the ideal treatment. It is generally accepted that only patients with Child-Pugh A and B or pathologic score I should undergo resection of the metastases if the number of metastases is small.

Park et al reported a series of 45 patients with adrenal metastases from HCC of whom 66% presented isolated adrenal metastases. Median survival was 11 months. When intrahepatic disease was well controlled, survival after adrenalectomy was 21.4 months. By contrast, survival with no surgical treatment was 11 months and survival with no treatment was 5.6 months (7). Adrenal metastases can be easily confused with an exophytic HCC arising from the posterior surface of the liver.

Laparoscopic adrenalectomy

Laparoscopic adrenalectomy for small isolated metastasis is a feasible treatment option. It provides many of the benefits associated to laparoscopic surgery. However, some authors (8) have described a high risk of positive margins (9.1-18%), and have recommended to take special care in getting free margins. The complication rate is approximately 9-18%.

Several groups have described series of either laparoscopic adrenalectomies for metastases, or comparisons between the open and the laparoscopic approaches. No differences in local recurrence, margin status, disease free interval or overall survival have been found. The laparoscopic approach consistently offers a shorter operative time, less blood loss, shorter hospital stay, and fewer complications (9).

Other studies comparing the results of laparoscopic adrenalectomy in primary and metastatic tumors have suggested that adrenal metastases are less amenable for laparoscopic removal. One series described 31% of conversions and 25% of incomplete macroscopic resections, with all patients dying within 2 years. Port site metastases have been rarely reported (10,11).

When is adrenalectomy for metastatic disease justified?

Although consideration should be made for each primary tumor, the decision to treat adrenal metastases should depend primarily on the extent of the primary tumor. Multiple or diffuse metastases from any cancer have poor prognosis, but resection of isolated adrenal metastases has proven to prolong survival and, in some cases to offer a long-term survival. Characteristics of metastatic lesions such as local invasion (to capsule, veins or perirenal fat) and size should be also considered. Lesions smaller than 4.5cm have a significantly better prognosis. Signs of local invasion tend to suggest that complete resection is not feasible.

Laparoscopic resection seems to offer the same oncologic results along to the benefits of minimally invasive surgery such as shorter hospital stay and faster recovery, but requires a higher level of expertise.

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Live Kidney Donor: Left or Right? HALS or Pure Lap?

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Whether performed laparoscopically or open, live donor nephrectomy for kidney transplantation has traditionally favored utilization of the left kidney in order to maximize vessel length. Relative contraindications to the use of the left kidney include: (1) multiple left renal arteries or veins; (2) a small accessory lower pole artery potentially supplying the left ureter (3) a small right kidney and/or disproportionately low split renal function of the right kidney; (4) an indeterminate cystic lesion or stone in the right kidney; (5) an extra-renal lesion on the right side requiring concomitant evaluation or treatment; (6) an extra-renal lesion or anatomic variation on the left that could increase operative risk to the donor. Due to differences in adjacent anatomy (inferior vena cava, duodenum, and liver), the need to transect the short right renal vein, as well as relatively limited surgeon experience with laparoscopic right-sided donor nephrectomy, some have argued that the added technical challenges of laparoscopic right donor nephrectomy warrant the use of an open approach on the right side.

Since laparoscopic donor nephrectomy was first described in 1997, minimally-invasive procurement of live donor kidneys has become the standard of care in most major transplant centers (1). When compared with the traditional open approach, the laparoscopic technique has resulted in less blood loss, less

pain, earlier oral intake, shorter hospital stay, fewer complications, and a faster return to normal activities for live kidney donors (2). At the same time, multiple centers have documented recipient outcomes and allograft function (as defined by rates of delayed graft function, postoperative creatinine clearance, and long-term graft survival) which are equivalent to the open approach. In addition, the introduction of the laparoscopic approach has been shown to increase rates of organ donation, a point which is particularly important in the setting of limited organ resources that are grossly exceeded by the current demand (3)

Despite these potential advantages, the laparoscopic approach to live kidney procurement is technically challenging. The procedure requires advanced laparoscopic skills in order to allow for the safe dissection, vascular control, and removal of an intact, and uninjured solid organ. Disadvantages of purely laparoscopic nephrectomy include the lack of tactile feedback during dissection and retraction of adjacent structures, the potential for trauma to the kidney and/or adjacent organs by laparoscopic instruments, and difficulty with vascular division and kidney extraction which may lead to increases in warm ischemia time. Hand-assisted techniques offer solutions to many of these problems while offering most of the potential benefits of a minimally invasive approach.

When compared with purely laparoscopic nephrectomy, multiple studies have demonstrated the hand-assisted technique to be similar with respect to postoperative pain and narcotic requirements, time to oral intake, length of stay, and time to convalescence. At the same time, hand-assisted laparoscopic donor nephrectomy (HALDN) facilitates the minimally invasive approach by restoring

tactile feedback and allowing for manual manipulation of the kidney. As a result, operative times and warm ischemia times for HALDN are very reasonable and approach those of the standard open operation. In our institution, the transition from a purely laparoscopic approach to a hand-assisted approach resulted in a 56-minute reduction ($p = 0.0001$) in mean operative time (4). This was achieved with no differences in blood loss, length of stay, total charges, or rate of return to normal activity. From a technical standpoint, we have found that the extraction dilemma is eliminated by allowing for kidney removal through the same abdominal incision used for insertion of the hand-assist device.

One potential advantage of the pure lap approach, however, is improved cosmesis. Typically, this approach involves 3 or 4 ports (5-12 mm) and a low pfannensteil extraction incision. The donor kidney is extracted using an endoscopic retrieval bag, which is a bit more challenging than the hand-assisted extraction and is associated with slightly longer warm ischemia times. In our institution, this approach has generally been offered to young females who wish to minimize abdominal scars.

In our experience, hand-assisted laparoscopic donor nephrectomy is best performed using a midline, periumbilical hand-assist incision and two accessory (12-mm) trocars. The hand-assist incision (7 cm) is made at the outset of the procedure, and the surgeon's non-dominant hand is used primarily for retraction and (occasionally) blunt dissection. On the right side, one additional (5 mm) port is required for retraction of the right lobe of the liver (Figure 1). For HAL left donor nephrectomy, the camera port and the surgeon's right hand operating

(instrument) port remain constant throughout the case (Figure 2). For right nephrectomy, the division of the short right renal vein and artery require that the hand position and utilization of the camera / instrument ports be altered during the extraction portion of the procedure (which generally takes less than 60 seconds). For this maneuver, the camera is placed through the superior port and the articulating linear vascular stapler (2.0 mm / gray load endo-GIA) is brought in through the inferior port using the surgeon's left hand. The surgeon's right hand is placed intra-peritoneal and elevates the kidney to maximize length on the vessels during vascular transaction. The artery is divided first (well behind the IVC to maximize vessel length), followed by the vein (using a second stapler). By bringing the stapler in through inferior port, the stapler can be placed perfectly parallel to the inferior vena cava and the right renal vein can be divided flush with the vena cava. The kidney is then rapidly extracted through the base ring of the hand-assist device.

Utilizing the technique described above, we routinely perform HAL right donor nephrectomy when removal of the left kidney is contraindicated. The most common reason for choosing the left kidney is the presence of multiple renal arteries on the left, particularly if the accessory artery supplies the lower pole, and thrombosis of that vessel in the recipient would therefore jeopardize the blood supply to the left ureter. The other primary indication for using the right kidney is either a size or split renal function discrepancy >20% between the right and left kidney. In this case, the larger or more normal-appearing kidney stays with the donor.

In a recent analysis of 218 hand-assisted laparoscopic donor nephrectomies in our institution, 49 right kidneys were utilized (23%). For the donor operations, there were no statistical differences in operative time (180 min left vs 179 min right, $p = 0.20$), blood loss (89 mL left vs 99 mL right, $p = 0.87$), or extraction time (48 sec left vs 50 sec right, $p = 0.66$). Six patients (2.8%) in the left nephrectomy group experienced significant perioperative complications: splenic injury requiring splenectomy (1), chemical pancreatitis (2), chylous ascites (2) and perioperative blood transfusion (1). There were no major complications in the right donor group. There were no conversions to open surgery and no re-operations in either group. Postoperatively, length of stay (3.93 vs. 4.00 days, $p=.41$), wound infections (5.26% vs. 9.09%, $p=.42$), incisional paresthesias (3.91% vs. 3.13%, $p=1.0$), incisional hernias (3.1% vs. 0.00%, $p=1.0$), and total complications (13.7% vs. 11.1%, $p=.64$), were not different for left vs right donor nephrectomy.

The recipients in both groups were of similar age, sex, and BMI. For the recipient procedures, there were no significant differences between left and right groups in terms of cold ischemia (37.6 ± 15.2 min vs 34.5 ± 17.3 min), warm ischemia (37.7 ± 11.2 min vs 36.4 ± 10.8 min), or EBL (322 vs 228 cc). No vascular interposition grafts were required for the extension of donor renal vessels and there were no major intra-operative complications in either recipient group. Delayed allograft function, defined by transient ATN or the need for temporary dialysis was not significantly different for left vs right-sided nephrectomy (7.4% vs. 13.0%, $p = 0.41$). There was one early graft loss in the

left HALDN group related to a recipient intimal flap dissection in a highly calcified iliac artery. The median discharge serum creatinine (left vs right) for recipients was similar (1.75 vs 2.05 g/dL). One-year graft survival in left and right recipient groups was 98% and 100%, respectively. These same conclusions have been derived from multiple other studies which show no differences in any parameters compared between laparoscopically-procured left and right kidneys (5). These include equivalent operative and cold ischemia times as well as long term graft survival (>97%).

Hand-assisted laparoscopic right nephrectomy is a safe approach to live donor organ procurement. Despite the perceived difficulty of removing and implanting a laparoscopically-procured right kidney, this procedure does not appear to result in either increased perioperative donor or recipient morbidity or longer graft ischemia times. In addition, early graft function and long-term graft survival are equivalent for right and left kidneys.

For right donor nephrectomy, the technical considerations of dealing with the adjacent anatomy (IVC, duodenum, and liver) as well as the added difficulty of transecting a short renal vein can make the procedure (and particularly the rapid extraction of the kidney) slightly more challenging than left nephrectomy. Compared with pure laparoscopic nephrectomy, the hand-assisted approach reduces operative time and blood loss without increasing total hospital charges or length of stay. This approach also maintains the benefits of a minimally-invasive approach in that donor morbidity remains substantially less than the traditional open procedure. (6). When applied to the procurement of organs for

live donor renal transplantation, the use of hand-assisted laparoscopic right donor nephrectomy is well-supported and offers the most appropriate solution for both the donor and the recipient when anatomic and functional criteria are applied to the preoperative task of choosing the “correct” kidney for donation. With proven equivalency in outcomes for the minimally-invasive procurement of both right and left donor kidneys, the selection of the most appropriate kidney for donation should be based upon the same criteria utilized for the traditional open approach.

Figure 1

HAL Right Nephrectomy

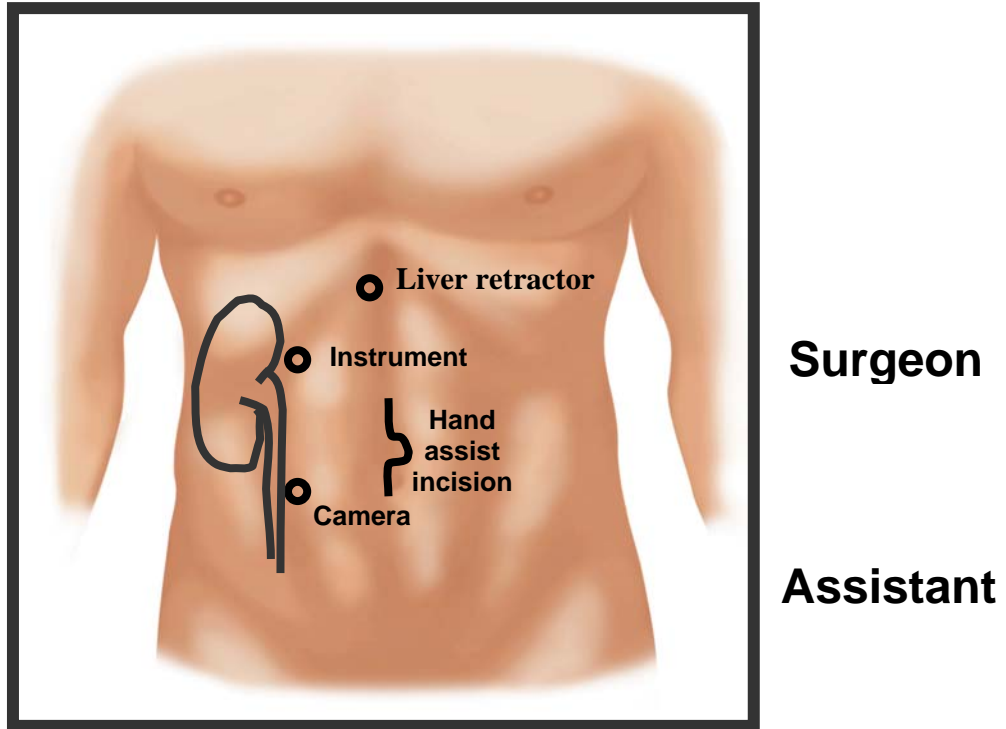
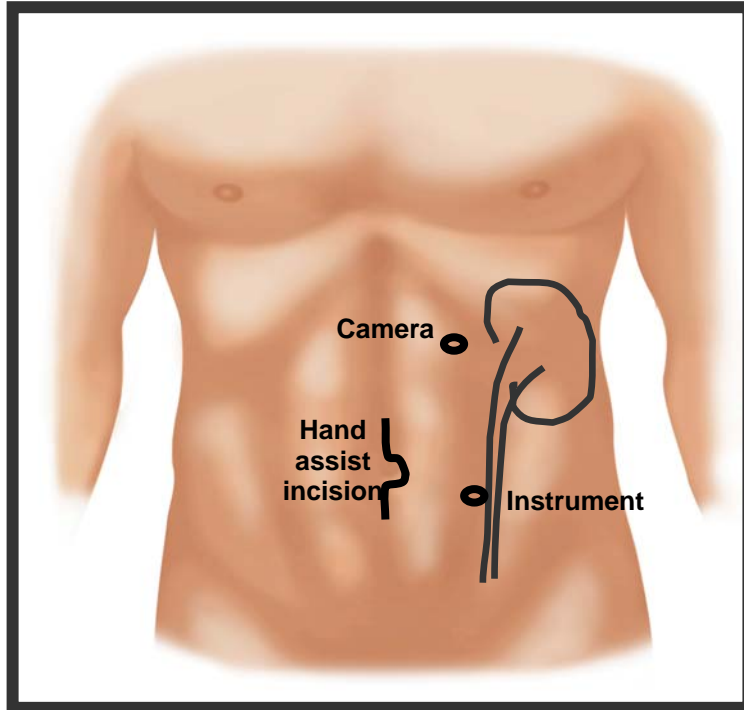


Figure 2

HAL Left Nephrectomy

Assistant

Surgeon



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SAGES Solid Organ Course Syllabus

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Laparoscopic nephrectomy for cancer

Laparoscopic nephrectomy was first described in 1990 by Clayman and has since achieved widespread acceptance by urologists. The fact that there have been CPT codes for nephroureterectomy (50548), radical nephrectomy (50545) since around 1999 and partial nephrectomy (50543) since 2003 reinforces the acceptance of these procedures. In the United Kingdom, the National Institute for Health and Clinical Excellence (NICE) issues guidelines for the treatment of renal cancer using laparoscopic nephrectomy in 2005 and laparoscopic partial nephrectomy in 2006. There has been general recognition that the principles of cancer surgery are not compromised by the laparoscopic approach (1, 2) and a randomized trial of open versus laparoscopic nephrectomy reproduced the functional benefits of other laparoscopic procedures (3).

Initial publications reported operative times from six to nine hours. Through mastery of the technical challenges, growing experience with laparoscopy as an operative modality and the more widespread use of hand assist techniques, prolonged operative time is now no longer an issue in most circumstances. The purpose of this syllabus is to describe surgical strategies and techniques that will prepare the general surgeon for oncologically safe laparoscopic nephrectomy.

Credentialing for laparoscopic kidney surgery

This discussion would not be complete without first considering the problem of surgical turf. The boundaries of urologic and general surgery are blurred when considering the kidney. General surgeons perform donor and trauma nephrectomy. Renal transplant surgeons come from the ranks of general, vascular, and urologic surgeons. Once general surgeons begin treating renal cancer and other renal pathologies they are likely to attract the attention of a territorial Chief of Urology. Urologic procedures beget urologic complications that may well require the intervention of a urologist so bear in mind that their willingness to help may be tempered by the feeling that turf has been infringed. Credentialing is defined at a local hospital level and can rise to the level of an art form in its ability to restrict your right to practice what you are good at. That said, the relevance to a general surgeon of surgery in this area may be more in the context of helping a urologist with a large tumor mass displacing other abdominal viscera owned by general surgery. Unless you are making a career of treating diseases usually treated by another specialty, it would be wise to ask whether you are the right person to do this surgery.

Transperitoneal versus retroperitoneal

I will not address transperitoneal versus retroperitoneal exposure in detail as this has no particular oncologic import. If you are an occasional nephrectomist, do yourself a favor: operate facing the decubitus patient's abdomen and go transperitoneally. The ease alone with which you can navigate laparoscopically justifies this approach.

Surgical strategy for renal malignancy

Transitional cell cancers behave more aggressively than renal cell tumors and the full field of transitional epithelium must be resected, including a bladder cuff if the tumor is in the ureter. The biologic aggressiveness of these tumors is clear from reports of port site tumor implants and recurrence following laparoscopic resection highlighting the need for meticulous surgical technique (4,5). Renal cell tumors can be locally excised provided margins are clear and there is a growing trend to nephron sparing surgery in most cases of small (<4 cm), localized masses regardless of whether the traditional indications of prior nephrectomy, bilateral tumors are present or not. Some groups are even performing partial resections for centrally placed tumors (6). Overall survival after removal of small, node negative, M0 renal cell cancers is better than 99% at three years. Open partial nephrectomy is now well accepted. The more challenging laparoscopic partial nephrectomy is less widely available but in the absence of clear EBM guidelines for its use, concerns have been expressed that partial nephrectomy may be underutilized in favor of radical laparoscopic resection although a recent study does not support this criticism (7).

Conceptually, nephrectomy is a simple ablative procedure. Control of the vascular pedicle, division of the ureter and removal of the kidney from its anatomic bed are not complicated requirements. Preoperative identification of unfavorable tumor biology such as renal vein or caval extension, choice of approach and exposure, early interruption of the lymphovascular pedicle, preservation of the tumor envelope and radical extirpation of perirenal fat with or without the ipsilateral adrenal distinguish resection for cancer from surgery for benign diseases.

In one way nephrectomy for tumor is easier than simple nephrectomy, in which the kidney is shelled out of its fatty envelope. Experience with laparoscopic donor nephrectomy taught us that intentionally leaving intact the perirenal fat shrouding the capsule and dissecting in the plane between fat and muscle actually simplified the operation. Fewer injuries such as capsular cracks, parenchymal punctures or capsular vessel avulsion occurred. No vessels other than the main pedicle traverse the plane and blood loss for this part of the procedure is essentially eliminated. In any case, for cancer leave the perirenal fat on the kidney, and if the tumor is exophytic, take a generous chunk of tissue around it for clearance.

When, where and how are the vessels divided?

A fundamental axiom of cancer surgery is early interruption of the lymphovascular pedicle. There may not be much science to support what is basically good housekeeping, but in the case of renal cell cancer, it is particularly relevant because of the tendency for the tumor to grow out of the kidney within the renal vein. Recent imaging of the kidney is preferable to plan the optimal approach. On the left the tumor has a lot further to grow and considerable time can elapse before tumor reaches the cava. On the right the vein is very short and the importance of a recent scan to show tumor extension is greater. It is better to decide in advance if a tongue of tumor ascending the cava will require the help of a vascular surgeon to retrieve and that a laparoscopic approach is not appropriate.

The anatomic landmarks (renal vein, ureter, adrenal gland) are fairly simple to find in slim patients but as is often the case in the North American population, perirenal fat is abundant. It is essential to have a reliable technique that will facilitate localization of the renal vein accurately. Unlike the ureter which does not fight back and can eventually be sacrificed, the renal vein will reward a clumsy dissection with frighteningly brisk hemorrhage that can quickly lead down a perilous path.

On the left, you need to know how to peel mesocolon from the hilum and ureteric bundle and stay in the correct avascular plane. Once that is done, if you do not know how to come straight down onto the renal vein, or cannot see its bluish tinge through the hilar fat, find it by following the gonadal vein cephalad. The gonadal vein is usually easy to find parallel to the inferior mesenteric vein but in its own separate compartment. Preoperative imaging should have defined the number and position of the arteries and these should be interrupted first.

The safest and most secure way to divide artery or vein is to clip or staple it with a non-cutting stapler first, inspect the completeness of the clip or staple line and then divide. If clipping, at least two locking plastic clips (Hemolok) should be applied. If metal clips have been used in any part of the dissection, it is wiser to avoid use of a stapler lest the jaws be inadvertently closed on a clip during application of the stapler, causing a misfire. After location and preliminary dissection, the artery should be ligated first, if just with a single clip to prevent any further inflow. The vein itself should be carefully palpated with the finger to ensure it does not contain tumor before proceeding. The surgeon's attention can then focus on accurate exposure, circumferential dissection, ligation and division of the vein. This order of events makes exposure of the artery easier.

Hand assist or not?

I am not a fan of morcellating cancer to allow a tumor to be removed through a laparoscopic puncture. The strength and cellular imperviousness of retrieval bags has been well established but unless you have a lot of experience with the technique, it would be too easy to cause a tumor spill and it is better to leave the kidney intact. Moreover it has been suggested that morcellation may prevent accurate staging of small but advanced pT(3a) lesions (8). Thus for tumors 7-8cm or greater, a similar length of extraction incision will be necessary and this can be used to advantage as a hand port. Very large tumors test the surgeon whose laparoscopic instruments are straight. Pressure on the mass with a straight instrument shaft trying to work around a corner risks cracking the kidney or tumor. A hand in the field confers obvious proprioceptive and geometric advantages to the three dimensional operative tasks of retraction, dissection and mobilization deprived of degrees of freedom by the fixed fulcra of laparoscopic entry points.

Total or partial nephrectomy?

Partial nephrectomy when performed with vascular isolation is a challenging procedure and is not usually within the scope of a general surgeon. What many urologists actually perform is more precisely a tumorectomy with margin, similar to non-anatomic resection of a liver metastasis. Indeed small tumors located in an upper or lower pole can often be treated this way. Large centrally located tumors usually require total nephrectomy to achieve an adequate margin because of proximity to the hilar vessels although with experience smaller tumors in this site can be successfully resected (6). Positive margins may necessitate completion of a radical nephrectomy as shown by a large multi-center study (9). Laparoscopic partial resection while realizing the predicted benefits of reduced pain, blood loss, operative time and hospital stay was associated with greater morbidity than open surgery (10)

With or without adrenalectomy?

It is not necessary to remove the adrenal if an adequate margin has been achieved by partial or total nephrectomy, as for example with a lower pole tumor. Exophytic renal tumors that are contiguous with or adjacent to the adrenal on preoperative imaging should be removed within the envelope of Gerota's fascia. This standard may need to be modified if the patient has had a contralateral adrenalectomy.

Advanced surgical permutations

When nephron sparing is paramount in an unfavorably sited cancer that would be too difficult to remove in situ, other possibilities include laparoscopic nephrectomy, back table removal of the tumor and autotransplantation or allograft transplantation (11).

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