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editorial-review

Laparoscopy in solid organ transplantation: a comprehensive review of the literature

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Introduction

In the last decades, laparoscopy has revolutionized the field of surgery. Video-laparoscopy was officially born in 1987, when Prof. Phillipe Mouret performed the first cholecystectomy in Lyon, France (1). Many procedures previously performed with the open technique are now performed with the laparoscopic approach. Several advantages are commonly observed adopting laparoscopic surgery versus an open procedure: these include reduced pain due to smaller incisions and hemorrhaging, shorter hospital length of stay and a lower incidence of wound infections.

Similarly, organ transplantation has revolutionized the care for many patients with end-organ failure. Today, several organs could be transplanted, obtaining excellent results in terms of survival. The first transplant experiences were performed in the 50ies and 60ies (2,3), but only clinical introduction of new immunosuppressive drugs in 80ies has been related to an effective increase in the results (4).

Combination of these two medical fields, which represent ones of the most continuously in evolution, represents an evident scientific progress. Nowadays, well selected groups of solid-organ recipients can safety undergo a laparoscopic procedure.

Intent of our review is to underline the current role of diagnostic and therapeutic laparoscopy in solid-organ transplant recipients.

Kidney transplantation

Kidney transplantation (KT) represents the standard of care for the patients with end-stage renal disease.

The first KT was performed in 1954 by Prof. Joseph Murray in Boston, United States (2): the procedure was done between identical twins to eliminate any problems of an immune reaction. Introduction of cyclosporine (4) in the clinical practice in 1983 substantially increased the results, consenting also a more safe use of deceased donors.

KT could be classified in deceased-donor or in living-donor transplantation depending on the source of the donor organ. Great differences can be observed across the countries regarding to the use of living- or deceased-donors: nowadays, the majority of grafts come from deceased donors, but the percentage of transplants from living donors is increasing worldwide.

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a. Pretransplant surgery

Native kidney nephrectomy

In the last decade, several experiences have been reported on laparoscopic nephrectomy in patients with Autosomal Dominant Polycystic Kidney Disease (ADPKD) awaiting for KT (5-7). However, no complete agreement still exists on the better surgical strategy to be used: staged *vs* bilateral approach and systematic use of laparoscopy are under debate (8,9). Bilateral laparoscopic hand assisted nephrectomy represents a safe and reliable option in well selected patients: rather than performing staged nephrectomies, hand assisted laparoscopic nephrectomy allows the single administration of general anesthesia and provides effective relief of bothersome symptoms. Patients with a kidney volume of greater than 3,500 cc are at increased risk for open conversion and they may have improved outcomes if open nephrectomy is attempted from the outset (10).

b. Living donor nephrectomy

Patients with an end-stage renal disease who are waiting for a KT are increasing in number year after year worldwide. In the United States, in the period between 1998 and 2009, this value has doubled, with more than 76.000 candidates (11). Living donor kidney transplantation (LDKT) represents a way to increase the donor pool: nowadays, in the United States more than one third of the performed transplants is from a living donation (Fig. 1).

Donation for LDKT is considered a safe procedure, with a mortality rate of 0.02-0.03%, (12,13) a brief donor hospitalization and an optimal cost/effectiveness. (14) Moreover, live donor kidney grafts tend to perform better than those from deceased donors (15). On the other side, despite these excellent results, LDKT has developed very heterogeneously worldwide. Such heterogeneity highlights persistent ethical issue (16). Organ trafficking is emerging as an organized transplant tourism reinforcing the need for strong national legal frameworks (17). Starting from these considerations, many strategies have been adopted with the intent to increase the living donor transplant rates, including the adoption of innovative surgical approaches, and reducing the need for attractive but unrealistic solutions of the problem.

Traditional donor nephrectomy is commonly performed through a single 10-20 cm in length lombotomy; however, in the last decades this approach has been progressively substituted by laparoscopy.

Starting from the first experience reported by Ratner et al. in 1995 (18), year by year laparoscopic donor nephrectomy (LDN) has been accepted as an alternative to the open surgical approach and now is considered by many to be the gold standard for live-donor kidney donation.

Basically, laparoscopic approach is related to reduced pain, convalescence period and long-term

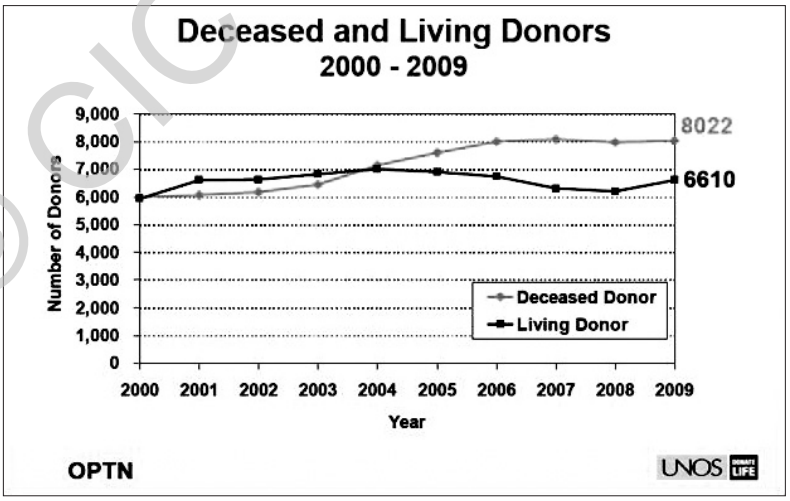

Fig. 1 - Deceased and living donors in the United States. Spring 2010 Regional Meeting Data. (http://www.unos.org/donation/index.php?topic=data_resources).

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complication rates respect to open surgery, determining a potential incentive to donate (19). Additionally, immediate restoration of the remnant kidney's function has been shown after laparoscopic donation (20).

Several studies have investigated traditional and mini-invasive surgery (Fig. 2): in a large meta-analysis (73 studies analyzed; 6594 patients) (21), in which open and LDN were compared, traditional open approach showed shorter operative and warm ischemia times, while patients undergoing laparoscopic nephrectomy benefited from a shorter hospital stay and a faster return to work. Both the procedures showed optimal results in terms of donor safety and post-LDKT graft function.

In a recent review of the literature (22) in which open surgery, hybrid hand-assisted laparoscopy and pure laparoscopy were compared, this last technique resulted as the best approach in terms of blood loss, analgesic requirements, duration of hospital stay and convalescence. Despite longer warm ischemia times were reported in laparoscopic technique, postoperative graft function was not significantly different between the various forms of donor nephrectomy.

In another study (23) in which LDN and hand-assisted LDN were compared, data reported suggested that intraoperative injuries are more common in LDN while minor postoperative complications are more common in hybrid approach.

A meta-analysis (24) compared mini-open, standard open donor nephrectomy and LDN (9 studies, 1038 patients), mini-open approach showing both the advantages of open surgery and laparoscopy (shorter operative time, less post-operative surgical pain, shorter hospital stay).

Starting from these reported studies, the best surgical approach to be used for living donation is still under debate: in fact, despite its evident benefits, laparoscopy is related to some discomforts for the donor (25).

Use of potential alternatives reported in literature, such as LDN with vaginal extraction may present some advantages (i.e. more desirable cosmetic results) (26).

In the last years, robotic surgery has developed as a useful help or a substitute of the laparoscopy. As technology continues to evolve, robotic-assisted surgery has the potential to become a widely used attractive alternative to standard LDN: several mono-centric series have been reported in literature (27-29). Robotic approach offers the advantage of replicating the movements of the surgeon's hands with the robotic instruments, allowing the application of well-known open surgical techniques to the laparoscopic approach: moreover, robotics enhances the laparoscopist's skills, enables the surgeon to dissect meticulously and to prevent problematic bleeding more easily, and allows the surgeon to work under better ergonomic conditions. Robotics can be extremely flexible, consenting hybrid approaches, (30) and reducing the learning curve for laparoscopic nephrectomy. The main disadvantage of this technique is the cost of the robot and the increased operative time.

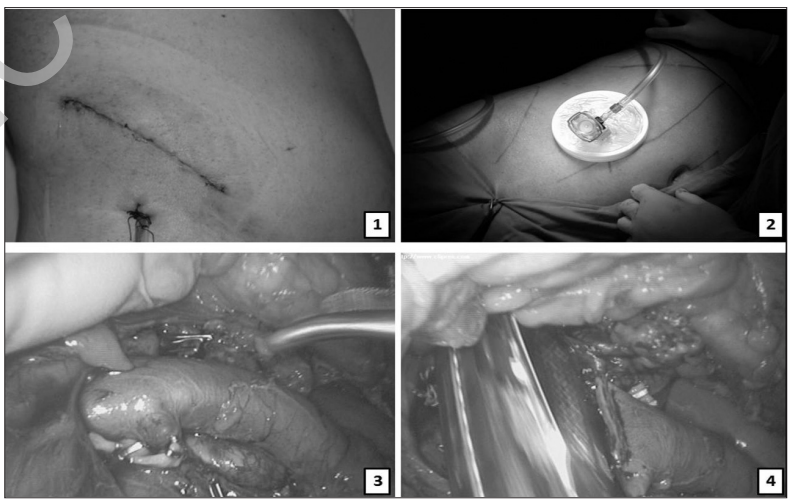

Fig. 2 - Living donor nephrectomy. Sapienza University experience. 1) Mini-lombotomy; 2-3) hand-assisted laparoscopic nephrectomy; 4) pure laparoscopic nephrectomy.

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c. Laparoscopic kidney transplantation

In 2001, Meraney et al. (31) performed the first laparoscopic renal autotransplantation in animal models, obtaining good results and considering vascular anastomoses to be feasible in laparoscopic surgery when performed by expert hands. Moreover, laparoscopic ureterovesical reimplantation is already considered a valid alternative in the context of reconstructive urologic surgery (32).

In 2002, Hoznek et al. (33) reported a case of KT using robotic assistance: however, in this case the authors did not use a minimally invasive approach, using the robotic system only to complete the vascular and ureteral anastomoses.

In 2009, Rosales et al. (34) presented the first laparoscopic transplantation of a kidney from a living, related donor. The principal reason for use of a laparoscopic approach is the expected reduction in morbidity owing to the small surgical incision. However, laparoscopic KT is a complex technique and initial laparoscopic cases have to be carefully selected. In fact, conventional laparoscopic instruments are unsuitable for the safe performance of a kidney transplant in morbidly obese patients or in patients with vascular abnormalities (Fig. 3).

Starting from these grounds, in 2009 Giulianotti et al. (35) presented the first minimally invasive, total robotic KT in a morbidly obese patient (BMI = 41 kg/m^2): no peri-operative complications were observed and the patient was discharged on postoperative day 5 with normal graft function (Fig. 4).

In conclusion, only 2 cases of laparoscopic KT have been reported in literature. Excellent results

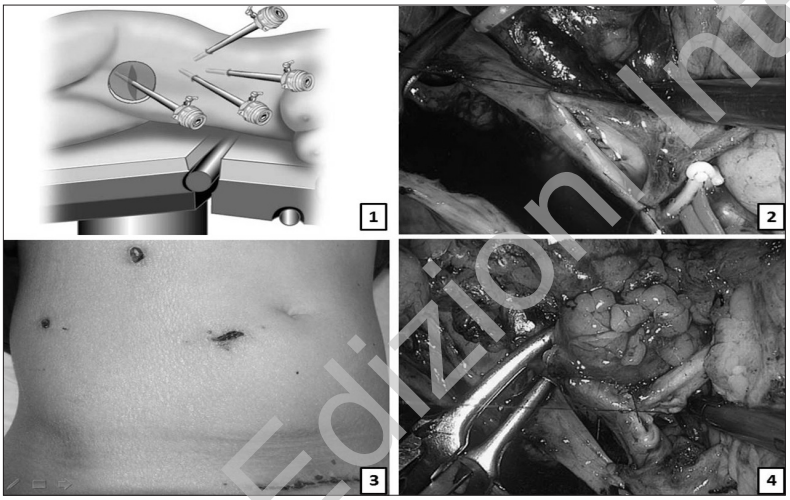

Fig. 3 - The first laparoscopic kidney transplantation. 1) Position of the trocars; 2) venous terminolateral anastomosis; 3) external view of the patient; 4) arterial terminolateral anastomosis. Taken from Rosales A et al (34), with modifications.

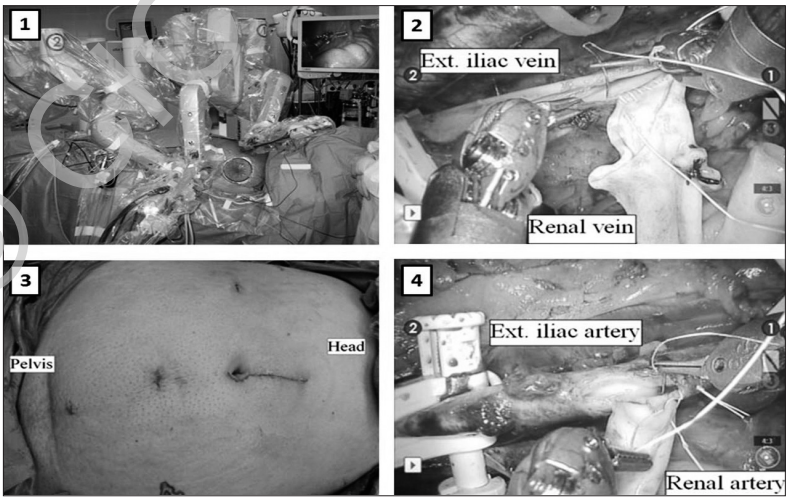

Fig. 4 - The first robotic kidney transplantation. 1) The robot in position; 2) venous terminolateral anastomosis; 3) external view of the patient; 4) arterial terminolateral anastomosis. Taken from Giulianotti P et al (35), with modifications.

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have been obtained using this approach; however, minimally invasive KT must be dedicated to extremely selected patients. New larger experiences are expected.

d. Post-transplant surgery

Renal allograft biopsy

Percutaneous biopsy after KT under ultrasound guidance is currently the standard of care for obtaining a kidney biopsy in patients with allograft dysfunction. In patients with clotting disorders, due to their higher risk of bleeding, biopsy effectuation under direct vision with a laparoscope allows immediate intervention.

Such an approach was reported by Fornara et al. (36) in 6 patients with no complications noted. Kidneys placed intra-abdominally are sometimes difficult and unsafe to biopsy percutaneously. In these instances, laparoscopy may be utilized to safely obtain tissue for diagnosis.

Laparoscopic incisional hernia repair

Incisional hernia represents one of the most common complications after KT, with a prevalence of 2-13% (37). Age, obesity, diabetes mellitus, immunosuppressant drugs, smoking, wound infection, hematoma, technical errors and unsuitable suture materials represent potential causal factors.

A monocentre experience by Harold et al. (38) reported use of laparoscopy for ventral hernia repair in 38 different transplant patients, 11 of whom had undergone a KT. After surgery, 1 mesh infection and 8% of hernia recurrence were observed in the entire cohort. Perioperative complication and hernia recurrence rates in transplant patients after laparoscopic hernia repair seem to be comparable to non-transplant patients, although the transplantation patients could present very large hernias. Laparoscopic approach should be considered to manage ventral incisional hernias post transplantation.

Lymphoceles

Lymphocele formation is a common complication after kidney transplantation, occurring in up to 15% of patients (39). Lymphoceles can be ingenerated by lymphatic leakage derived from the graft or from the iliac vessels. In the presence of symptoms (e.g. leg edema, infections, urinary retention or pain), therapeutic options must be considered, these last including drainage or peritoneal fenestration (40). Laparoscopic fenestration was reported for the first time in 1991, showing a great feasibility and reduced trauma, hospitalization, convalescence and costs. However, in some initial experiences, this procedure was considered not optimal for the treatment of lateral and either posterior or inferior lymphoceles due to their anatomic inaccessibility and technical impracticability (41). In addition, complications such as ureteral or renal pelvic injury and colon or bladder damage were reported, especially during the learning curve (40). In a recent monocentre experience in which laparoscopic and open techniques were compared, laparoscopic drainage has confirmed its benefits in terms of reduced hospital stay and costs, also resulting safe and effective. The Authors conclude that laparoscopic drainage should be considered the method of choice for the treatment of post-transplant lymphocele: open approach must be chosen only in those patients in which wound complications or small lymphocele adjacent to vital renal structures are reported (42).

Other indications

Several cases have been reported in English literature in which laparoscopy was adopted as surgical approach for the treatment of pathologies developed in renal transplanted patients.

Nowadays, for example, laparoscopic bariatric surgery is commonly performed in KT recipients: morbid obesity is often associated with pathologies related to chronic nephropathy (i.e. hypertension and type II diabetes) and with transplantation. Weiss et al. (43) reported a successful gastric banding in a patient with significant weight gain post-renal transplantation and Alexander et al. (44) also reported a successful gastric bypass in a kidney transplant recipient. Buch et al. (45) presented two cases of renal transplant recipients who experienced complications after laparoscopic gastric banding, both resolved with a laparoscopic removal of the gastric band.

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Greco et al. (46) reported the first 3 single-portal access laparoscopic radical nephrectomies performed in patients with a malignant renal tumor that developed after a renal transplant, obtaining excellent results and prompt discharges. A limitation of this procedure could be related to a still not complete evaluation of its oncological safety.

Two studies have been published with regard to laparoscopic nephrectomy for the control of post-KT severe hypertension. In a study by Fornara et al. (47) laparoscopic bilateral nephrectomy was retrospectively compared with open bilateral nephrectomy, resulting in an effective alternative for the treatment of hypertension. Peyromaure et al. (48) reported a preliminary experience of a manually assisted laparoscopic bilateral nephrectomy technique for refractory hypertension in renal transplant recipients, showing similar good results.

Chen et al. (49) presented four cases of laparoscopically assisted vaginal hysterectomy successfully performed in patients who had previously undergone KT: all the cases required operation for symptomatic adenomyosis. The median hospital stay was 4 days and no major complications were observed.

In a previously cited paper, Fornara et al. (36) reported 37 cases of transplanted patients who underwent urologic laparoscopy: 14 bilateral nephrectomies for severe drug-resistant hypertension, 9 marsupializations of symptomatic lymphoceles, 6 renal allograft biopsies in patients with clotting abnormalities, 6 unilateral nephrectomies, and 2 nephroureterectomies for recurrent episodes of pyelonephritis and symptomatic vesicoureteral reflux, respectively. Five complications (14%) and three conversions (8%) occurred; however, creatinine levels resulted stable after the procedure, showing renal allograft function was not affected by laparoscopic procedures.

Liver transplantation

Nowadays, liver transplantation (LT) is a well accepted treatment option for end-stage liver disease and acute liver failure.

The first human LT was performed in 1963 by Prof. Thomas Starzl (50) in Denver, United States: however, due to its initial poor results, LT remained an experimental therapy for several years. Only introduction of cyclosporine (4) markedly improved patient outcomes, transforming LT in a standard clinical treatment for both adult and pediatric patients with appropriate indications.

Unfortunately, also in LT the supply of liver allografts from deceased donors is far short of the number of potential recipients: on these grounds, development of living donor LT has been improved in the last years.

Adoption of innovative surgical approaches such as laparoscopy has been also applied in this field with the intent to improve the results and the number of donations.

a. Pre-transplant surgery

Liver resection

The first experiences in laparoscopic liver resection were reported only after the second half of the 90ties (51). In fact, major difficulties in terms of technology and indications were observed in liver management respect to other organs like kidney, bowel and stomach. However, after fifteen years of evolution, laparoscopic techniques are currently used to give a diagnosis, a staging and a treatment for patients with liver malignancy.

Multiple series have reported on the safety and efficacy of laparoscopic liver surgery, also after major hepatectomies: liver laparoscopic surgery does not entail major risks versus open surgery and significantly less bleeding is observed (52). Small and medium sized procedures have become commonplace in many centres: for example, nowadays left lateral sectionectomy (LLS) is more commonly performed laparoscopically (53).

A recent Consensus Conference (54) has been performed with the intent to discuss the indications for hepatic laparoscopic surgery: currently acceptable indications for laparoscopic liver resection are patients with solitary lesions, 5 cm or less, located in liver segments II to VI. The laparoscopic approach to LLS should be considered standard practice. Although all types of liver resec-

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tion can be performed laparoscopically, major liver resections (e.g. right or left hepatectomies) should be reserved for experienced surgeons facile with more advanced laparoscopic hepatic resections.

Hepatocellular carcinoma (HCC) represents the main indication for laparoscopic liver resection in patients waiting for LT. Previous open liver resection in candidates to LT may compromise subsequent LT by creating adhesions and increasing surgical difficulty. Initial laparoscopic resection as bridge to LT may reduce such technical consequences: Laurent et al. (55) reported laparoscopy facilitates the LT procedure in terms of reduced operative time, blood loss and transfusion requirements.

Radiofrequency ablation

Radiofrequency ablation for non-resectable liver malignancies has been performed with the laparoscopic and hand-assisted approach with acceptable results (56). Adoption of laparoscopic radiofrequency ablation as bridge to LT for the treatment of HCC represents a possible strategy in patients waiting for the transplant (57).

b. Donor hepatectomy

Living donor liver hepatectomy is a complex surgery, with major risks of morbidity and mortality respect to kidney donation: the reported mortality of this procedure has varied from 0.2% to 0.5% (58). Donor risk increases according to the type of performed hepatectomy, such as LLS, left hepatectomy or right hepatectomy (RH). Typically, a LLS or a left hepatectomy is sufficient in a pediatric living liver donation, while a RH is necessary for an adult-to-adult donation.

However, despite different surgical approaches could be adopted, open living donation always requires a large abdominal incision. This aspect, combined with post-operative pain, long hospital stay and long period of recovery, represents a barrier to donation, especially in young women (59).

Pediatric donation

Pediatric living donation provides similar or better short-term graft function and long term survival rates respect to cadaveric LT. The first case of laparoscopic donation was reported by Cherqui et al (59). In 2006, Soubrane et al. (60) reported the safety of laparoscopic LLS in 16 successive live donors compared with the conventional LLS (Fig. 5). According to the first series experienced, the liver graft typically includes the LLS (i.e. segments II and III according to Couinaud's classification), left branch of hepatic artery and left portal branch, left bile duct and left hepatic vein. In the last years, other new experiences have been reported worldwide (61, 62).

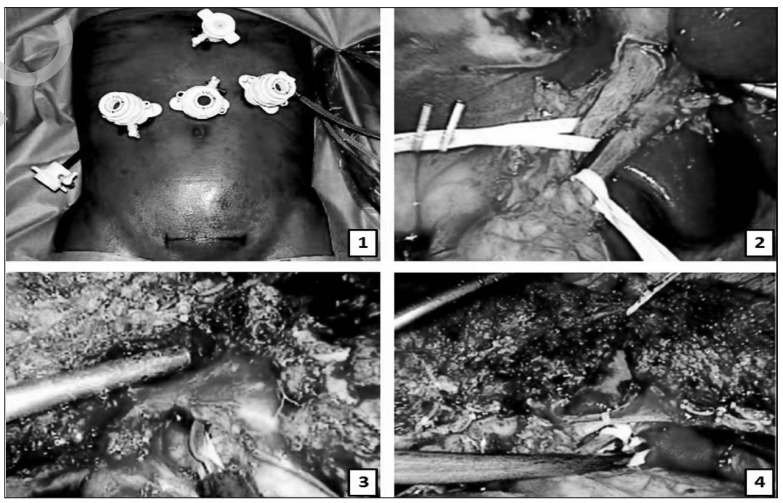

Fig. 5 - Left hepatectomy for pediatric living donor-related liver transplantation. 1) Position of the trocars; 2) the left hepatic artery and left portal vein have been dissected free and taped; 3) the left bile duct is cut; 4) the left lateral section is ready for harvesting. Taken from Soubrane O et al (60), with modifications.

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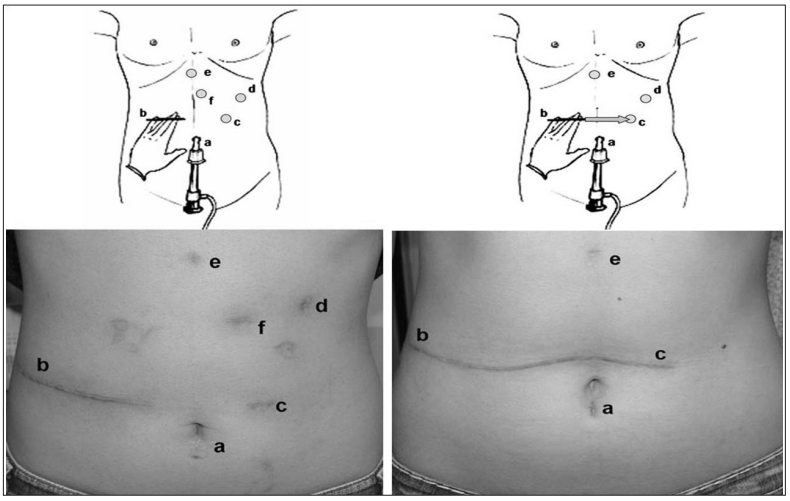

Fig. 6 - Right hepatectomy for living-donor liver transplantation. Left: port placement for a hand-assisted laparoscopic modified right hepatectomy. Right: port placement for a laparoscopy-assisted modified right hepatectomy. Taken from Suh KS et al (65,66), with modifications.

Adult donation

In 2006, Koffron et al. (63) described the first hand-assisted laparoscopic RH for live donation. Kurosaki et al. (64) reported in the same period 13 consecutive adult-to-adult hepatectomies (3 RH and 10 left ± segment I hepatectomies). From 2008, the transplant group of Seoul (65,66) reported the first series of hand-assisted laparoscopic modified RH preserving the middle hepatic vein.

Baker et al (67) reported a comparative study of 33 open *vs* 33 laparoscopic living-donor RH, suggesting that laparoscopy could present equivalent safety, resource utilization and effectiveness, with several adjunctive physical and psychological benefits (Fig. 6).

Until now, no mortalities have been encountered in laparoscopic live donor hepatectomy, whether adult or pediatric.

c. Post-transplant surgery

Post-operative laparoscopic management of patients who have undergone a LT is more uncommon respect to KT recipients: in fact, laparoscopy is easily applied after KT given the fact that the dissection is completely extraperitoneal.

In post-LT patients, laparoscopic approach is a useful strategy to solve some surgical complications; however, its use in this field is strictly connected to the surgeon's experience and versatility.

Laparoscopic incisional hernia repair

Incisional hernia has caused by several etiologies, many of whose could be concomitantly observed in LT recipients: advanced age, wound infection, ascites, steroids, diabetes, surgical technique, suture material, retransplantation, bilateral subcostal incision with midline extension and, not less important, the surgeon's experience. The most common site for incisional hernia is located at the junction of the transverse and upper midline incisions (68).

In literature, the incidence of incisional hernia varies from 5% to 17% (69). Large incisional and ventral hernias in nontransplant patients are now routinely repaired using laparoscopic technique. Laparoscopic ventral hernia repair seems to have a reduced risk of recurrence and infection compared to standard repair (70). In LT patients, laparoscopic hernia repair is safe and with similar results when compared with open repair (68, 71).

Andreoni et al. (72) reported the successful completion of 12 of 13 attempted incisional hernia repairs by the laparoscopic technique in LT patients. Gore-Tex mesh was used. At the time of publication, they report no recurrence. They concluded that laparoscopic mesh repair of incisional hernias is practical and safe in patients with a surgical history of LT transplantation, with a low incidence of infections and no recurrence. However, in a monocentre study (72), a higher rate of postoperative seroma was observed in LT- respect to no transplanted-patients (73).

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Other indications

In the last years, various possibilities of use of laparoscopy have been experienced in LT recipients. Merenda et al. (74) reported two cases of intestinal occlusion caused by adhesions and three cases of lymphocele, all approached with laparoscopic surgery. In all cases but one, the Authors were able to complete the surgery by laparoscopic means; in one of the two occlusions, the procedure was switched to laparotomy because of a choledochojejunal anastomosis lesion.

Gill et al. (75) reported a single case of a right adrenalectomy after LT in a 63-year-old female patient with a right adrenal mass and a previous story of left radical nephrectomy for a renal cell carcinoma and LT for primary biliary cirrhosis. A laparoscopic right adrenalectomy via the retroperitoneoscopic approach was successfully performed and the patient was discharged home on the first postoperative day.

DeRoover et al. (76) reported the case of a 46-year-old female transplanted for primary sclerosing cholangitis who presented multiple splenic aneurysms and abdominal pain: a laparoscopic splenectomy was performed and the patient was discharged on postoperative day 3 free of symptoms.

A Japanese experience (77) reported 5 cases of hand-assisted laparoscopic splenectomy for hypersplenism in living donor LT recipients. The Authors reported excellent results after this technique, considering it a possible standard procedure after LT.

Robles et al. (78) reported 2 cases of biliary peritonitis after T tube removal who failed conservative treatment and subsequently were treated with a laparoscopic approach. Lysis of adhesions was carried out in the right upper quadrant, a Penrose drain was laparoscopically placed and both patients were discharged home on postoperative day 4.

In 2010, Zhu et al. (79) reported the first total laparoscopic hysterectomy after LT. Authors confirmed that no viscera adhesions were observed to the undersurface of the umbilicus.

Pancreas transplantation

Pancreas transplantation (PT) represents the preferred treatment for type I diabetes mellitus (DM) and advanced diabetic nephropathy with end-stage renal disease. The first PT was performed by Kelly et al. in December 1966 (80). More than 25,000 PTs have been performed throughout the world, being 83% of them simultaneous pancreas-kidney (SPK) transplantations. The remnant PT were pancreas transplants alone (PTA) or pancreas after kidney (PAK) transplants. For many years, results after PT have lagged behind those of other solid organ transplants: this could be explained by an increased graft failure initially observed after PT, secondary to high technical failure and acute rejection rates (81). Nowadays, graft survivals have been increased after the improvement of technical aspects and the introduction of new immunosuppressive agents (82).

Use of deceased donors is strongly conditioned by donor characteristics: for example, many authors do not consider feasible for PT grafts obtained by donors younger than 10 years or older than 45 years of age as well as donors with elevated serum lipase, amylase and glucose levels or long ICU stay (83).

a. Donor pancreasectomy

PTs using living donors have not become as popular as living-donor kidney transplant, due to the higher technical difficulties of the intervention, the potential donor complications and the elevated recipient technical failures (84).

Living donor PT was introduced at the University of Minnesota in 1979. In 1999, Gruessner et al. performed the first laparoscopic donor distal pancreatectomy with hand-assisted technique (85). Laparoscopic distal pancreatectomies are more cost-effective because of the reduced length of hospital stay and reduced recovery time. (84) The first case of robotic distal pancreatectomy and nephrectomy for living donor SPK was performed by Benedetti et al. in 2006 at the University of Illinois at Chicago (85).

Accurate selection of living donor must be performed. Several tests are routinely performed for donor evaluation (i.e., body mass index (BMI) <27 kg/m2, insulin response to glucose or arginine >300% of basal insulin, HgbA1c <6%, basal insulin fasting levels <20 umol/L, plasma glucose <150

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mg/L during a 75-g oral glucose tolerance test and a glucose disposal rate >1% during an intravenous glucose tolerance test). No other family members other than the recipient could be diabetic. Other contraindications to donation included a history of gestational diabetes and previous pancreatic surgery or disorders (86). The potential donor complications include pancreatitis, leak, pseudocyst formation or splenic infarction (87). A more devastating long-term complication is the development of diabetes in the donor. This complication has been described after open donor pancreatectomies but, since 1996, none of the living pancreas donors has developed diabetes due to the adoption of more stringent selection criteria (88).

b. Post-transplant surgery

A little number of cases of laparoscopic surgery after PT has been reported in English literature.

Pancreas allograft biopsy

Nowadays, pancreatic allograft biopsy is currently done percutaneously under ultrasound or computed-tomographic guidance, or via cystoscopy. Open biopsy represents the other traditionally adopted option. However, laparoscopy could represent a feasible technique: Kayler et al. (89) published their experience with 12 laparoscopic pancreas allograft biopsies done in 11 patients with good technical success and minimal morbidity and mortality.

Other indications

Bonatti et al. (90) reported the case of a patient with significant weight gain after SPK treated with a laparoscopically placed gastric banding; the patient tolerated the laparoscopic procedure very well and was discharged from the hospital after two days.

Intestinal transplantation

Intestinal transplantation (IT) represents the unique therapy for children with short bowel syndrome and other causes of intestinal failure who do not tolerate parenteral nutrition for protracted periods and for adults with secondary short bowel syndrome due to Crohn's disease and vascular insufficiency. The first IT was performed in Boston in 1964: this was also the first living donor IT. During the following years, a few more intestinal transplants from live donors were reported to the registry.

a. Donor intestinal resection

Under normal circumstances 200–250 cm of ileum or jejuno-ileum can be safely removed from a live donor and should be enough for transplantation. It has been shown that retaining 20 cm of terminal ileum in the donor after removal of 200 cm of ileum was sufficient to maintain normal methylmalonic acid levels, indicating good vitamin B12 absorption. Similar results were observed in the recipient. Although, so far, no death or major morbidity has been reported after live small-bowel donation, there is no effective need for live donors (91,92). Since the demand for small-bowel transplantation has been calculated to be 1–2 per million population and year, there should be enough appropriate use of deceased donors (93).

Some authors have studied the laparoscopic intestinal harvesting technique in pigs, obtaining good results. However, these studies have little evidence in the scientific literature (94).

b. Laparoscopic intestinal transplantation

Many IT recipients have had multiple abdominal surgeries before reaching intestinal transplantation and have developed dense adhesions; a loss of abdominal domain also results from a decrease in or-

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gan volume in the peritoneal cavity. For these reasons, laparoscopy for IT is absolutely contraindicated (95,96).

c. Post-transplant surgery

Similar considerations must be taken with regard to post-operative laparoscopic surgery in IT recipients. As previously reported, laparoscopy is impossible to be performed in these patients (95,96).

Conclusion

Laparoscopy after solid organ transplantation is feasible. Laparoscopy gives several benefits respect to open surgery (i.e. reduced pain, shorter hospital stay, low mobility rates, rapid return to work, better cosmetic results and a lower incidence of wound-related complications). This surgical approach offers chronically ill patients a good option for the treatment of their surgical diseases. Several different applications have been already reported: however, a limited number of cases have currently available on this subject. In the next future, new surgical techniques and indications will be developed in this field.

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