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FRONTIER

Pushing the frontiers of living donor right hepatectomy

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Abstract

Living donor right hepatectomy (LDRH) is currently the most common donor surgery in adult-to-adult living donor liver transplantation although the morbidity and mortality reported in living donors still contradicts the Hippocratic tenet of "do no harm". Achieving low complication rates in LDRH remains a matter of major concern. Living donor surgery is performed worldwide as an established solution to the donor shortage. The aim of this study was to assess the current status of LDRH and comment on the future of the procedure; assessment was made from the standpoint of optimizing the donor selection criteria and reducing morbidity based on both the authors' 8-year institutional experience and a literature review. New possibilities have been explored regarding selection criteria. The safety of living donors with unfavorable conditions, such as low remnant liver volume, fatty change, or old age, should also be considered. Abdominal incisions have become shorter, even without laparoscopic assistance; upper midline laparotomy is the primary incision used in more than 400 consecutive LDRHs in the authors' institution. Various surgical techniques based on preoperative imaging technology of vascular and biliary anomalies have decreased the anatomical barriers in LDRH. Operative time has been reduced, with low blood loss. Laparoscopic or robotic LDRH has been tried in only a few selected donors. The LDRH-specific, long-term outcomes remain to be addressed. The follow-up duration of these studies should be long enough to address possible late complications. Donor safety, which is the highest priority, is ensured by three factors: preoperative selection, intraoperative surgical technique, and postoperative management. These three focus areas should be continuously refined, with the ultimate goal of zero morbidity.

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Key words: Living donor; Right hepatectomy; Liver transplantation; Donor morbidity; Donor selection

Core tip: Selection criteria for living donor right hepatectomy can be extended with advanced surgical technique and improved management without compromising donor safety.

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INTRODUCTION

Living donor right hepatectomy (LDRH) is currently the most common donor surgery in adult-to-adult living donor liver transplantation (LDLT)[1-4]. The procedure removes approximately two thirds of the donor liver, which has raised concerns and ethical issues regarding donor safety since the introduction of the procedure in 1996[5]. Foregoing the Hippocratic tenet of "do no harm", "necessary harm" is being increasingly chosen as a last resort in countries where donor organs are in short supply. Healthy individuals are volunteering to be living

donors for their loved ones, who may be destined to die without timely liver transplantation.

Reported complication rates following LDRH range from 16.0% to 78.3%[6-10]. The complications of LDRH are significantly higher compared to left donor hepatectomy[11]; this elevation is expected based on the extent of the hepatectomy.

Decreasing the complication rate of LDRH remains a major concern in the era of living donor surgery, which is performed worldwide and is becoming an increasingly common solution to the donor shortage. The outcomes of LDRH depend on the following three variables: preoperative selection, intraoperative surgical procedure, and postoperative care. Every major complication can be attributed to a small mistake regarding one of these three variables. The aim of this study was to assess the current status of LDRH and comment on the future of the procedure; assessment was performed from the standpoint of optimizing the donor selection criteria and reducing morbidity, which was based on both the authors' 8-year institutional experience and a literature review.

DONOR EVALUATION

Ideally, all living donors should voluntarily sign the informed consent form in regards to the items discussed by the Ethics Group of the Vancouver Forum[12]; all LDRHs must be approved by a national supervisory organization, such as KONOS (Korean Network for Organ Sharing) or the institution's ethical committee, following an independent full medical and psychiatric assessment of the donor by health-care professionals who are independent of the LDLT team. To safeguard against any unforeseen abnormalities, donor evaluation should include an extensive workup.

Imaging studies should include Doppler ultrasonography, computed tomography (CT) with volumetry, and intraoperative cholangiography or magnetic resonance cholangiography (MRC).

MRC accurately depicts the living liver donor biliary anatomy, as correlated with intraoperative cholangiography, and it is excellent in its complete depiction of the central, right, and left hepatic ducts[13,14]. One study showed that intraoperative cholangiography could be entirely replaced by noninvasive preoperative MRC[10].

Liver biopsy can be performed selectively in donors in whom liver steatosis is suspected, given their history, physical examination, or imaging study results. Upper and lower endoscopy examinations should be considered in donor candidates who are older than 40 and 50, respectively, or who have any gastrointestinal symptoms. Potential donors with any concomitant abnormal medical or psychological conditions should not be allowed to undergo the donor operation. Furthermore, a donor candidate who has smoked or taken oral contraceptives within a minimum of 6 wk prior to LDRH should not be accepted to reduce the risk of venous thromboembolic disease[15,16].

DONOR SELECTION

Selecting living liver donors while considering safety is one of the most important and difficult issues to address in LDLT. Ideally, a living donor should be in perfect health. However, due to the scarcity of deceased donors or suitable living donors, grafts from unusual sources (which are not preferentially used) may ultimately be considered; this type of donor has been provisionally called the "marginal living donor". This approach is only justified when donor safety is not compromised. It should be noted that placing a healthy person on an operating table to help a patient already crosses the ethical border; therefore, trying to extend the criteria for living donors has been criticized for donor safety.

The exact criteria for living donor selection remain to be determined; they may evolve with improved surgical management and accumulated experience. Controversial donors include those with a small remnant liver volume, fatty liver, previous abdominal surgery, accompanying medical illness, hepatitis B surface antigen or hepatitis C antibody-positive, and elderly donors over 60 years of age. Each potential donor must be considered case by case basis, taking into account different parameters, and their selection must be based on the experience and judgment of the transplant team. In every case, the safety of the donor is the primary concern.

Remnant liver volume

As is the case with all liver surgeries, there is a prerequisite that a remnant liver must have adequate vascular inflow, outflow, and biliary flow. Any compromise in these flows may reduce the actual functional liver volume, increasing the risk of functional small-for-size syndrome. Remnant liver volume should be considered under the premise of complete vascular and biliary flow.

It is generally accepted that donor safety requires a remnant liver of > 30% of the original liver volume, with complete venous drainage[11]. Selection criteria for liver donation are evolving as surgical technique and management improves with time and experience.

It has been reported that LDRH with a remnant-to-total volume ratio less than 30% could be safely performed by carefully selected living donors using three selection criteria: preservation of middle hepatic vein (MHV), age under 50 years old, and no or mild fatty change in healthy adults[17].

Although the exact relationships are unknown, other criteria must be considered, such as age, body mass index, fatty liver, and so forth.

Fatty liver

The use of steatotic liver may increase the risk of primary nonfunction in LDLT. Cold preservation of the fatty liver graft leads to the fusion and expansion of fats, which press on the sinusoids and hepatocytes; this phenomenon leads to circulation disturbances in the sinusoids and graft injury[18]. LDLT has the advantage of reducing cold

preservation time. However, there is no clear upper limit for fatty change to be used as a graft. A previous study reported that a moderately fatty liver with macrovesicular steatosis of 20%-50% can be used in LDLT[19]. In non-urgent situations, diet and exercise is recommended to reduce the steatosis, which leads to better outcomes in both the donor and recipient[20].

Previous abdominal surgery

Previous abdominal surgery can make donor surgery even more complicated and difficult because of adhesion formation, which causes the intestines or other abdominal structures to adhere to the surface of the liver and abdominal wall. This is considered a relative contraindication to donation[21]. The potential for bowel injury and difficulty in visualizing the hilar vascular structures during relaparotomy may dissuade surgeons from performing LDRH in donors with previous abdominal surgery.

In the authors' experience, which included 10 donors who had previous small or large bowel surgery, cholecystectomy, or other surgeries, LDRH was feasible and safe; in these cases, operative time was longer, and incidental bowel injuries were encountered in 2 donors, which were repaired on the spot.

Accompanying medical illness

Hypertension, hyperlipidemia, obesity, and diabetes mellitus may pose a higher risk for postoperative complications after donor surgery; these diseases are commonly encountered when evaluating middle and old-aged donor candidates. It is important to check whether these diseases are well-controlled in patients undergoing surgery and whether these patients have any complication from medical illnesses. In well-controlled, complication-free donors, donor surgery may be selectively considered (with proper perioperative management) following careful individual assessment of the particular donor.

It is also recommended that the screening workup include coagulation disorders to prevent unexpected bleeding or venous thromboembolic events during the postoperative period[22].

Hepatitis B surface antigen/hepatitis C antibody-positive donors

Donors who are HBV core antibody and hepatitis B surface antigen (HBsAg) negative have been successfully used as living liver donors[23,24]. However, the positivity of HBsAg or hepatitis C virus antibody (HCVAb) is contraindicated in living donation in the majority of cases. Anecdotally, LDRH has been reported to have been performed in a HBsAg-positive donor whose graft was transplanted into a HBsAg-positive recipient[25]. In the authors' institution, HBsAg or HCVAb-positive living donors with normal liver function are carefully selected for LDRH in HBsAg or HCVAb-positive patients, respectively, if they test negative for HBV DNA and HCV RNA.

Old aged donors

Previous reports have defined "older donors" as those over 44 or 50[26,27]. These donors have been linked to poor recipient outcomes and higher donor complication rates. Right hepatectomy leading to an estimated remnant liver volume less than 35% should be avoided in living donors who are 50 years old or older[27]. The use of elderly donors to expand the living donor pool raises ethical issues, including providing a lower quality graft to the recipient. In addition, there has been apprehension regarding donor safety due to the perceived increased risk of morbidity to the donor. However, there is currently insufficient evidence, from the standpoints of both donor and recipient outcomes, to define an upper age limit for donation in LDLT.

In the authors' experience, a total of 10 living donors, aged 60 and above, who underwent LDRH showed comparable outcomes (both in donors and recipients) based on the selection criteria, which included preservation of middle hepatic vein, a remnant liver volume greater than 30%, and no or mild fatty change in healthy condition.

SURGICAL PROCEDURE

Living donors can be evaluated as a homogenous adult group who are selected through a strict medical and ethical evaluation process. As such, there is no exaggeration in saying that their physical and mental health has been evaluated by medical experts. In other words, these individuals have a normal liver with no serious underlying disease. Therefore, compared to other patients with pathologic liver or underlying illness, a standardized operation is more likely to be established, with the expectation of lowering operative morbidity.

LDRH procedures are always performed under general anesthesia, with endotracheal intubation and controlled ventilation. The operative procedure consists of laparotomy, liver mobilization, hilar vascular dissection, parenchymal transection, cutting right hepatic duct, artery, portal vein, and hepatic vein, graft removal, and abdominal wall closure. There may be some differences in the order of operative procedures; for example, after complete parenchymal transection, the right Glisson's pedicle can be dissected from the right hepatic artery, portal vein, and hepatic duct. Variations of the hepatic artery, portal vein, hepatic vein, and bile duct may be encountered[28]; as such, donor surgeons should be well-informed and prepared for these variations by preoperative three phase CT scan and MR cholangiography. The proper vascular and biliary dissection for anastomosis should be based on the premise of not compromising the blood inflow, outflow, and bile flow in the remnant left liver.

It is been reported that the dose of heparin administered systemically immediately before graft harvesting can be reduced without increasing the risk of vascular thrombosis or donor complications[29]. Currently,

Table 1 Modifications in technique and management of living donor right hepatectomy in the authors' institution

Modifications	From case No. onwards
Use of an electric coagulator to pierce abdominal wall for a drainage tube instead of using a cutting end connected to a closed-suction drain	45
Upper midline incision above umbilicus	55
Dosage reduction of intravenous heparin given before graft removal from 50 IU/kg to 25 IU/kg	93
Use of surgical wound protector	112
Hanging maneuver from the start of liver parenchymal transection by initial Glisson's approach	165
Intraoperative cholangiography replaced by MRC	165
No intensive care unit stay after surgery	167
No central venous catheterization	169
Bile duct cut just 2 mm to the right side of the confluence changed from 1 mm	200
Dosage reduction of intravenous heparin given before graft removal from 25 IU/kg to 5 IU/kg	271

MRC: Magnetic resonance cholangiography.

there is no consensus regarding the optimum dose of heparin. The dose of heparin may further be decreased or stopped altogether, which may lead to less bleeding complications. The proper dosage or necessity of heparin use remains to be studied.

The operative technique for LDRH has been refined since the inception of the LDLT program in 2005 at the authors' institution[30,31]. Since its introduction, various notable modifications in surgical technique, management over time, and experience have been introduced (Table 1)[10]; this result illustrates the efforts to standardize the surgical procedures of various aspect of LDRH to maximize its accuracy, reduce operative time, and use as small an abdominal incision as possible, without compromising donor safety.

The current surgical technique is as follows. An upper midline incision above the umbilicus is used, and a wound protector is installed. After mobilizing the right liver while saving the large inferior right hepatic veins (if present), the right Glisson's pedicle is dissected; this step is performed following cholecystectomy and transection of the inferior parenchyma of the caudate lobe up to the hepatic hilum. A tape is located along the inferior vena cava, with its upper end between the right and middle hepatic veins and its lower end between the right and left Glisson's pedicles (located on the left side of the saved inferior right hepatic vein, if present). A hanging maneuver is consistently employed from the start of the liver parenchymal transection until the tape is exposed[32]. Any MHV branch over 5 mm in diameter is saved for reconstruction. In the case of a right liver graft with MHV, the main trunk of the MHV is exposed early; it is followed along its left side, all the way up to the junction with the segment 4b hepatic vein and cut immediately proximal to the junction. After complete parenchymal transection, heparin (5 IU/kg) is given intravenously. The right Glisson's pedicle is then dissected from the right hepatic artery, portal vein, and hepatic duct. The right hepatic duct is cut just 2 mm to the right side of the confluence under clear visualization. The stump is then closed. The right hepatic artery, portal vein, and hepatic vein are divided at each bifurcation without narrowing the remnant stumps before the recipient operation. The graft is removed to a basin containing histidine-tryptophan-ketoglutarate solution. The falciform ligament is reconstructed to maintain the remnant of the left liver in original anatomic position. A drain is placed in the right liver fossa.

Innovations and refinements in LDRH techniques have been introduced over the past few decades. However, improvements can still be made. Donor safety and outcomes should not be compromised; as such, three major areas for future studies to focus on may include the reduction of blood loss, operative time, and laparotomy size.

Blood loss and operative time

Two major criteria for assessing technical proficiency are blood loss and operating time. The former should take precedence in determining the safety of the surgery. The operative blood loss is expected to be low in most high-volume transplant centers, but one should be prepared for the possibility of unexpected massive bleeding. However, this is unlikely in the modern era of advanced liver surgery. The amount of blood loss and the need for blood transfusions should be kept at a minimum, as these factors lead to operative morbidity and mortality after partial hepatectomy[33,34]. Neither vascular inflow nor outflow occlusion is usually employed during parenchymal transection. If major bleeding occurs, this technique can be used temporarily to control bleeding. Low central venous pressure (less than 5 mmHg) during transection has been reported to reduce operative blood loss and the associated morbidity and mortality[35]. In the authors' institution, central vein cannulation was stopped from donor no. 169 in 2009 onwards because LDRH proved to be stable. This simplification leads to the avoidance of catheter-related complication, such as pneumothorax. Fluid infusion is restricted during parenchymal transection by the anesthesiologist.

The operation time should also be reduced to be as short as possible. Right-liver donation and prolonged donor operation time have been shown to be independent risk factors for major complications in donors[1]. Reducing operative time may be considered only after ensuring the safety and preciseness of LDRH.

There should be limited blood loss and no compromise of blood inflow, blood outflow, or bile flow in both the right liver graft and remnant left liver.

A significant reduction of operation time can be achieved not only by technical innovation and proficiency but also by coordinating the recipient operation. Donor operative time may be lengthened unnecessarily by unanticipated long waiting times in difficult recipient hepatectomies. This is particular true for patients who have a history of previous liver resection. The liver hanging maneuver is a useful suspension technique that results in shorter parenchymal transection time and less blood loss[31,36,37].

Laparotomy incision

Over the past decade, minimally invasive surgery has grown in popularity. The growing interest in laparoscopic surgery has prompted the exploration of minimally invasive techniques for use in LDRH. The first laparoscopy-assisted LDRH was described in 2006[38]. Subsequently, efforts were extended to pure laparoscopy or robot-assisted LDRH[39,40]. However, this approach was reported only in a small number of selected donors. Limitations include the longer operative time, the required instruments, expenditure, and the surgeon's comfort with both hepatectomy and laparoscopic or robotic surgery. Recently, the upper midline incision (without laparoscopic assistance) above the umbilicus has been reported in LDRH application, leading to reduced pain without sacrificing safety[30]. The technical reproducibility, effectivity, safety, and universality of conventional open LDRH has been demonstrated in more than 200 consecutive LDRHs, regardless of body mass index and past history of previous abdominal surgery[10].

The minimum size of the abdominal incision depends on the size of the harvested liver graft. Considering that there are additional incisions for three to five ports required in the laparoscopic or robotic approach, the total length of the incisions seems to make little difference compared to the open technique using an upper midline incision. The only notable difference was that the main incision for delivery of the graft was able to be made on the lower abdomen (*i.e.*, pfannenstiel incision) instead of several small incisions for port sites. The so-called "minimally invasive surgery" may be accurately termed "minimal incisional surgery". However, minimally invasive surgery does not strictly mean minimal incisional surgery. Prolonged operative time, large blood loss, unanticipated injury to other internal organs, and any near-missed event should also be considered in the potential invasiveness to patients. Moreover, the large operative field exposure using a conventional chevron or J-shaped incision or long operative time is likely to be associated with significant heat losses. Hypothermia inhibits the enzymes of the coagulation cascade[41], which may contribute to intraoperative blood loss.

Therefore, the safety and effectiveness of each procedure should be demonstrated with randomized controlled trials.

POSTOPERATIVE CARE AND FOLLOW UP

Postoperative care should be started before donors leave the operating room, with appropriate counselling and preparation. The current postoperative management and follow up in the authors' institution are as follows. Prophylaxis for thromboembolism with early mobilization and compressive stockings is started on the day before the operation and continued until discharge; low-molecular weight heparin is used selectively in donors over the age of 60 or with other risk factors for 1 wk postoperatively. Intravenous patient-controlled analgesia is used for 3 d after surgery. Early feeding and early ambulation are encouraged if the donor's underlying condition permit. A prophylactic drain is removed once the serous drainage has stopped or has become less than approximately 100 mL/d, usually no later than 5 d after surgery. Routine laboratory tests are checked daily for three consecutive postoperative days and then every other day during the length of the hospital stay. Follow up CT is routinely performed at 1 wk, 1 mo, and 1 year after the operation. After discharge, all donors are followed with routine laboratory tests after LDRH at one and 3 mo; thereafter, laboratory tests are performed every 6 mo for at least 5 years.

Long-term regular follow up is mandatory, as the majority of donors suffer physically, mentally, and socially in the first few months after donor surgery[42]. One third of rehospitalizations for living liver donors occur more than 90 d after donation[43].

OPERATIVE OUTCOMES, MORBIDITY, AND MORTALITY

Results from studies evaluating operative outcomes for LDRH are shown in Table 2. Outcome measures included the number of donors, operative time, blood loss, morbidity, and mortality. The operation time ranged widely among studies: the shortest was 146 min, and the longest was 932 min. The operative blood loss also varied widely among studies, ranging from 20 to 1670 mL. Inter- and intra-study variation in both outcomes were notable, likely reflecting the learning curve regarding surgical proficiency.

For the assessment of complications in living donor surgery, Clavien's classification and severity scoring system has been widely adopted[44,45]. Overall complication rates vary widely from study to study, with three studies reporting mortality (one in each study). LDRH mortality has been reported in 14 donors of a total of 18 live liver donor deaths[46]. A national study of all live liver donors in the United States over a 17-year period recently demonstrated that the risk of death after liver donation was 1.7 per 1000 donors; the risk of catastrophic outcomes, including early death and acute liver failure, was 2.9 per 1000 donors[47].

At the authors' institution, an increase in the surgeon'

Table 2 Operative outcomes from studies for living donor right hepatectomy *n* (%)

Ref.	Number of donors	Blood loss (mL)	Operative time (min)	Morbidity	Mortality
Ito *et al*[64], 2003	200	260 (20-1670)	384 (198-672)	69 (34.5)	0
Chan *et al*[42], 2007	200	362 (42-1600)	468 (304-932)	41 (20.5)	1 (0.5)
Yi *et al*[9], 2007	83	491.9 ± 225.2	287.1 ± 42.4	65 (78.3)	0
Gruttadauria *et al*[7], 2008	75	NA	7.90 ± 1.75 h	23 (30.6)	0
Baker *et al*[65], 2009	66	484 ± 265	291 ± 55	14 (21.2)	0
Adcock *et al*[66], 2010	202	997 ± 484	443 ± 85	57 (28)	0
Azoulay *et al*[6], 2011	91	702 ± 593	283 ± 45	51 (56.0)	0
Kim *et al*[67], 2012	500	NA	339 ± 63	139 (27.8)	0
Nagai *et al*[68], 2012	58	367 ± 52	367 ± 52	14 (24.1)	0
Salah *et al*[69], 2012	100	485 ± 396	364 ± 60	38 (38)	1 (1)
Kim *et al*[10], 2013	300	300 (100-1400)	257 (146-414)	48 (16)	0
Facciuto *et al*[70], 2013	137	NA	NA	45 (33)	1 (0.7)

NA: Not available.

s experience significantly reduced the operative time, hospital stay, and overall and grade Ⅲb complication rates, while operative blood loss was kept consistently low. In the most recent 100 donors, the morbidity was 3% without any major morbidity, reoperation, or blood transfusion during or after surgery[10]. All donors fully recovered and returned to their previous functional lifestyles. These morbidity outcomes can be compared to those of various studies from single centers and multicenter consortia[48,49], where there have been no observed reductions in donor morbidity with increasing center experience.

Numerous complications can occur after live donation, including intraoperative injuries, biliary leaks, biliary strictures, abscesses, bowel obstruction, hepatic artery thrombosis, portal vein thrombosis, inferior vena cava thrombosis, infections, and many other complications[48,50-52]. The fact that complications can occur in living donors (as in other surgery patients) does not mean that postoperative morbidity should be accepted as an inherent limitation of LDRH. Of course, complications may occur regardless of precautions, such as intracerebral hemorrhage or pulmonary embolism[53,54]. The causes for these complications have yet to be investigated. However, almost all complications in living donors selected through a strict donor selection process are likely caused by problems in surgical technique and/or intra- and post-operative management. Whenever a complication is encountered, the cause should be reviewed, and any problems should be rectified to prevent recurrence. Postoperative bleeding, which occurred and required reoperation in 10 donors (in the early period of the authors' experience), might have been considered careless enough to discourage and prevent our LDLT program from continuing. From this painful experience, we learned that delayed bleeding, undetected until closure of the abdominal wall, can occur at the dissected wall of the common bile duct, dissected perihepatic ligaments, and the tract of the drainage tube through the abdominal wall punctured for drainage. Since then, we began careful hemostasis by placing reinforcing sutures at suspect dissected areas; in addition, we used an electric coagulator to pierce the abdominal wall for the drainage tube. The bleeding complication has not since been encountered.

Biliary complications have been reported as the most common and feared complications in living donors; these complications are more frequent and severe for right and extended right lobe donation than for non-right lobe donation[55]. In the authors' institution, meticulous suture or ligation is placed at any Glisson's pedicle more than 1 mm in the cut surface of the parenchyma, and the bile duct is divided by cutting the right hepatic duct at least 2 mm to the right side of the confluence with sharp dissection following complete parenchymal transection to prevent biliary leakage or stricture. Reoperation for biliary stricture in one donor demonstrated that the bile duct stump cut just 1 mm from the bifurcation, repaired by a continuous oversewing suture, could compromise bile flow of the bifurcation by fibrosis and adhesion in the remnant bile duct.

Rarely, serious complications involving rhabdomyolysis and diaphragmatic hernia can occur. Rhabdomyolysis is a condition in which damaged skeletal muscle tissue breaks down rapidly. It has multiple causes, including inherited muscle disorders and confinement to a fixed position in prolonged surgery[56]. After experiencing one case of rhabdomyolysis, the donor evaluation in the authors' institution has broadened to include any history of underlying muscle disease. If suspected, further investigation, including measuring the level of creatine kinase in the blood, electromyography, and muscle biopsy, is planned to exclude any donor candidate who may experience rhabdomyolysis. Safe and quick surgery may also be helpful in preventing rhabdomyolysis in cases of this unexpected situation.

A diaphragmatic hernia after LDRH has been reported as a rare donor complication that can occur 2-3 years after surgery[57,58]. A diaphragmatic hernia detected after LDRH is likely to result from thermal injury by an electrosurgical device (often referred to as a "Bovie") during right liver mobilization. It is important to take care not to injure the diaphragm during liver mobilization; if any injury is suspected, reinforcing sutures should be placed. The delayed presentation may be explained by the evolution of any unrecognized injury into a small defect. This defect may then enlarge over time and

allow herniation of bowel contents, caused by pressure differences between the abdominal and thoracic cavities. As such, long-term follow-up is warranted for this possible late complication.

Another major complication that has few reports is intraoperative "no go" donor hepatectomy. Aborted donor hepatectomies are reported to occur in 1%-5% of cases[59-61]. In our own cohort, there were two cases of aborted donor hepatectomy in the early period of the LDLT program[62]. The first case was severe fatty change found by routine intra-operative biopsy in a patient with normal liver function and mild fatty change on pre-operative CT scan. This problem could have been detected by pre-operative biopsy. In the second case, intra-abdominal metastasis in a recurrent hepatocellular carcinoma patient, who had undergone previous partial hepatectomy, was not detected by the pre-operative imaging studies but was found late during the operation. Since then, in LDLT for liver cancer, the donor operation has been started only after confirming the absence of intraabdominal metastasis with full exploration in the recipient. With precise preoperative evaluations, improved surgical technique, and extended selection criteria for living donor, the rate of 'no go' donor hepatectomies is expected to decrease. However, the donor surgeon should be prepared to abort the procedure because the unpredictable may occur, such as intraoperative recipient death before procurement of a living donor graft[63].

CONCLUSION

Donor safety, a matter of utmost importance, is ensured by three factors: preoperative evaluation of the donor, intraoperative surgical technique, and postoperative care. The selection criteria for LDRH can be extended with advanced surgical technique and improved management without compromising donor safety. Surgical technique is a priority for determining the outcome of donors. As such, donor surgeons should be prepared to be fully informed regarding the case; in addition, they should acknowledge their strengths and weaknesses. Care and vigilance should be exercised to limit the possibility of serious morbidity during routine LDRH. The three focus areas should be continuously refined, with the ultimate goal of zero morbidity.

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