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ORIGINAL ARTICLE

Use of an Upper Midline Incision for Living Donor Partial Hepatectomy: A Series of 143 Consecutive Cases

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Over a period of 2 years, we used an upper midline incision (UMI) without laparoscopic assistance in 143 consecutive living donor partial hepatectomy (LDPH) procedures, regardless of the graft type or the donor age, sex, body mass index, or body shape. Here we report surgical recommendations based on our experience with the use of UMIs in this context. The celiac axis (CA) depth ratio (the depth-to-width ratio for the trunk at the CA) was measured to define the shape of the abdominal cavity. A questionnaire was used to assess satisfaction and cosmetic outcomes in this population of donors. One hundred forty-one of the grafts (98.6%) were right grafts or extended right grafts; there were no donor deaths. The mean time of the operation up to graft retrieval in 141 right side grafts was 3 hours 1 minute. All donors recovered fully and returned to their previous activities. Major complications occurred in 9 patients (6.4%) and included reoperation due to bleeding (4), the insertion of a percutaneous drain (4), and rhabdomyolysis (1). Male sex, a large graft (>900 kg), a fatty liver (large fatty changes $\geq$ 10%), and a deep truncal cavity (a CA depth ratio $>$ 0.35) were significant risk factors for a long graft retrieval time. The use of a wound protector significantly reduced wound complications. The cosmetic outcomes were more satisfactory when a UMI preceded partial hepatectomy instead of a conventional J-shaped incision ($P = 0.01$). In conclusion, a UMI without laparoscopic assistance can be safely used for LDPH, regardless of the graft type or the donor characteristics. However, the procedure after a UMI is more difficult in male donors with large fatty livers and deep truncal cavities. Accordingly, these features can be used as exclusion criteria for surgeons not accustomed to this modified procedure. ***Liver Transpl 17:969-975, 2011.*** © **2011 AASLD.**

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A major concern for individuals who volunteer to be living donors of liver tissue is the length of the incision that will be made. There have been several attempts to reduce the length of these incisions. Several laparoscopy-assisted approaches have been reported; these have yielded good results, but the procedures have tended to be complex and expensive.[1–4] Furthermore, they have been undertaken only in a small number of patients. We introduced an upper midline incision (UMI) without any laparoscopic assistance for living donor right hepatectomy.[5] We have subsequently used this incision in all living donors, regardless of the graft type or the donor age, sex, body mass index (BMI), or body shape. Recently, we successfully performed 143 consecutive living donor partial hepatectomy (LDPH) procedures with UMIs. In

Abbreviations: BMI, body mass index; CA, celiac axis; CAD, celiac artery distance; CAW, celiac axis width; LDPH, living donor partial hepatectomy; NS, not significant; UMI, upper midline incision.

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this report, we review our experience with LDPH after a UMI, and we provide surgical recommendations for overcoming the limitations associated with a small incision in this context.

PATIENTS AND METHODS

Patients and Selection Criteria for Donors

The study population consisted of 143 consecutive living donors who underwent partial hepatectomy after a UMI between February 2008 and February 2010. This study was approved by our institutional review board. Two surgeons (K.W.L. and S.H.K.) performed the LDPH procedures. Twenty donors who underwent LDPH after a conventional J-shaped incision before the introduction of the UMI were used as a historical control group when we were analyzing responses to a questionnaire on patient satisfaction. With respect to the demographics or the characteristics of the surgical operations, there were no statistical differences between the group receiving the conventional J-shaped incision and the group receiving the UMI.

Data on 2 left lobe liver donors were excluded from analyses of the demographics, outcomes, and risk factors related to the difficulty of the operation.

Healthy volunteers ranging in age from 16 to 59 years were accepted as potential donors. Sixteen years is the legal lower age limit for liver tissue donation in Korea. We considered a remnant liver volume of 30% to be a safe lower limit. However, we performed LDPH even when a remnant of less than 30% was expected when the donor was young, there were no fatty changes in the liver, and no alternative candidate was available. The acceptable level of fatty changes in the liver varied in different cases. However, hepatic macrovesicular fatty changes greater than 30% and total hepatic fatty changes greater than 50% were exclusion criteria for donation.

Surgical Technique and Recommendations

The surgical technique for LDPH after a UMI has been described previously.[5] This technique is briefly described here, step by step, with an emphasis on recommendations for overcoming surgical difficulties attributable to the small incision.

Skin Incision and Mobilization

The size of the UMIs ranged from 12 to 18 cm and depended on the shape of the abdominal cavity. It was necessary for the upper end of the incision to reach the xiphoid process to enhance exposure. After ligation of the round ligament, the falciform ligament was incised. Starting with case 50, we applied a wound protector (a large Alexis wound retractor, Applied Medical Resources, Rancho Santa Margarita, CA; Fig. 1). The rib cage was retracted in a cephalic and anterior direction with a self-retaining retractor.

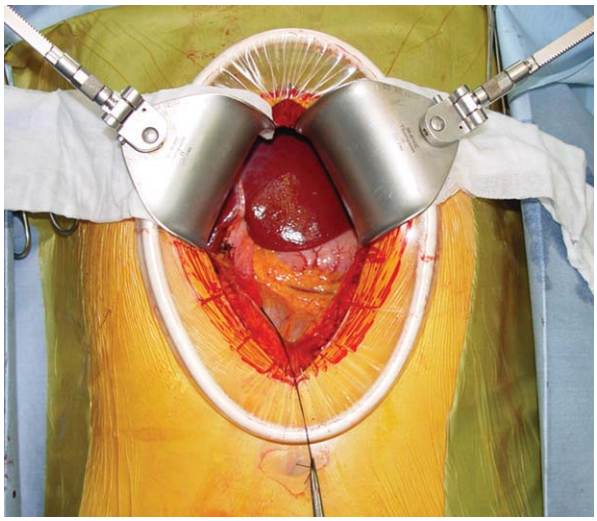

Figure 1. A wound protector was applied during partial hepatectomy, and it significantly reduced the risk of wound complications.

Mobilization started with the suprahepatic ligaments while the liver was retracted downward by assistants (falciform ligament → right coronary ligament → superior layer of the right triangular ligament). The lateral and inferior sides of the right triangular ligament were incised during the lateral or upward retraction of the liver. The remaining mobilization of the right lobe of the liver was undertaken during the lateral retraction of the liver with an assistant's hand or a blade. The left rib cage was retracted higher than the right rib cage during this procedure to reduce the compression of the liver by the left rib cage. A tape or a 7-Fr Nelaton tube was inserted between the right and middle hepatic veins to permit a hanging maneuver. Laparotomy pads were placed in a posterior position between the liver and the diaphragm after the mobilization of the liver to enhance exposure by anterior and left-sided displacement of the liver.

Dissection of the Hepatic Hilum and Parenchyma

After cholecystectomy, the right hepatic artery and the portal vein were dissected and isolated. Before the dissection of the parenchyma was begun in the midplane of the liver, the parenchyma of the right caudate lobe below the hepatic hilum was dissected. The parenchymal dissection was usually undertaken with a cavitational ultrasonic surgical aspirator. After the completion of the dissection of the lower part of the hepatic parenchyma around the right hepatic hilum, the lower end of the tape for the hanging maneuver was repositioned to the superior aspect of the hilar bifurcation. Some of the posteriorly placed laparotomy pads were removed to widen the plane of dissection. While the hanging tape was pulled in an anterior and/or caudal direction, the remaining parenchyma was dissected. Middle hepatic vein branches that were larger than 5 mm in diameter were temporarily

clamped with Hem-o-lok clips. The right bile duct was usually divided after the completion of the parenchymal dissection.

Graft Retrieval

After the bile duct was divided, the graft was removed. The right hepatic artery and the portal vein were divided normally. The right hepatic vein was usually divided with GIA (gastrointestinal anastomosis) or TA (thoracic abdominal) staplers. The graft was retrieved with the inferior tip of the graft held by hand in gauze.

Closure

After the completion of hemostasis, a closed suction drain was inserted into the right subphrenic space. The abdominal wall was closed layer by layer. After subepidermal suturing, a sterile strip was applied to the skin incision.

Body Image Questionnaire

During the postoperative follow-up, the patients were invited to complete a questionnaire that was designed to evaluate their body image, cosmetic results, and self-confidence. The original English questionnaire, which was used in a study of laparoscopic appendectomy,[6] was translated into Korean. The questionnaire included questions about a patient's attitude toward his or her body image (items 1-5) and about his or her degree of satisfaction with the appearance of the scar (items 6 and 7). Items 8 and 9 of the questionnaire asked about a patient's self-confidence before and after surgery. A high score indicated an appreciable degree of patient satisfaction.

Outcome Measures

The perioperative variables and the clinical outcomes of the donors and recipients were studied retrospectively. In our experience, partial hepatectomy after a small UMI was sometimes difficult. To identify a subgroup of patients in whom the operation was more difficult, we compared and related several variables reflecting the difficulty of the operation (eg, the operation time until graft retrieval, the length of the hospital stay, and the incidence of postoperative complications) to potential risk factors such as the donor age, sex, BMI, graft weight, and body shape and the severity of hepatic macrovesicular steatosis [the celiac axis (CA) depth ratio]. The CA depth ratio was defined as the celiac artery distance (CAD) divided by the celiac axis width (CAW; ie, the width of the trunk at the CA; Fig. 2).[7]

Wound complications were defined as serous or purulent wound exudates that required additional treatment and delayed the patient's discharge from the hospital.

The modified Clavien system was used to classify donor complications.[8]

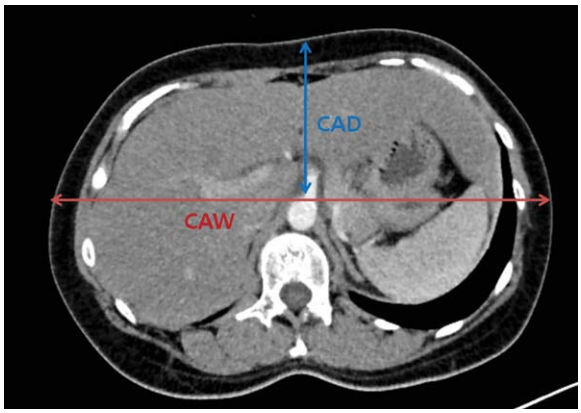

Figure 2. Representative computed tomography scan of a donor. The CA depth ratio is the ratio of CAD to CAW. CAD is the distance between the skin of the anterior abdominal wall and the root of the celiac artery, and CAW is the length of the horizontal plane at a right angle to CAD.

Statistical Analysis

Fisher's exact test and the chi-square test were used to compare clinical variables. In multivariate analyses, binary logistic regression models were used. To identify the risk factors that affected the graft retrieval time, we applied the Student *t* test in a univariate analysis and a forward stepwise multiple regression model in a multivariate analysis. Statistical analyses were conducted with SPSS version 15.0 statistical software (SPSS, Inc., Chicago, IL, and Microsoft Corp., Redmond, WA). A P value < 0.05 was considered statistically significant.

RESULTS

Demographics and Operation-Related Variables

One hundred forty-one of the grafts (98.6%) were right grafts or extended right grafts. The clinical characteristics of the 141 right lobe liver donors and recipients are summarized in Table 1. The mean age of the donors was 32.5 years. Five donors were unrelated to their recipients; 4 of these donors (2 sets) exchanged grafts with one another to overcome ABO incompatibility. The mean donor BMI was 23.2 kg/m^2. Thirty-one donors (22.0%) had a high BMI (>25 kg/m^2). The CA depth ratio for 24 donors (17.0%) was higher than 0.35. The indication for liver transplantation was mostly hepatitis B virus–related cirrhosis complicated by hepatocellular carcinoma. Twenty-five donors (17.7%) had macrovesicular steatosis greater than or equal to 10%. In 14 donors (9.9%), the total fatty changes exceeded 30%. The mean operation time from the skin incision to graft retrieval was 3 hours 1 minute. The mean total operation time was 4 hours 14 minutes.

Clinical Outcomes of the 141 Right Lobe Liver Donors and Their Recipients (Table 2)

All donors received follow-up care for at least 5 months after the operation. No deaths occurred in the

TABLE 1. Clinical Characteristics of the 141 Right Lobe Liver Donors and Their Recipients

Factor	Value
Donors	
Age (years)	32.5 ± 10.6 (16-59)
Male sex (%)	58.2
Related to the recipient (%)	95.7
Height (cm)	166.8 ± 8.1 (148.6-183)
Weight (kg)	64.7 ± 10.4 (42-95.7)
BMI (kg/m^2)	23.2 ± 2.8 (17.0-34.3)
CA depth ratio	0.31 ± 0.04 (0.20-0.45)
Recipients	
Age (years)	53.7 ± 7.9
Male sex (%)	75.9
Laboratory Model for End-Stage Liver Disease score	17.9 ± 9.7
Indication for liver transplantation [n (%)]	
Hepatocellular carcinoma	108 (76.6)
Cirrhosis	22 (15.6)
Fulminant hepatitis	4 (2.8)
Other	7 (5.0)
Donor operation–related factors	
Graft weight (g)	709.4 ± 139.7 (420-1222)
Macrovesicular steatosis ≥ 10% [n (%)]	25 (17.7)
Remnant left liver volume (%)	36.6 ± 4.4 (23-49)
Time to graft retrieval (hours and minutes)	3:01 ± 0:33 (1:55-4:54)
Operation time (hours and minutes)	4:14 ± 0:47 (2:36-5:58)
Estimated blood loss (mL)	352.3 ± 144.3 (100-800)
Cold ischemia time (hours and minutes)	1:14 ± 0:31 (0:20-4:48)

NOTE: Two left lobe liver donors were excluded.

donor population. All donors recovered fully and returned to their previous activities. Reoperation was necessary in 4 donors because of postoperative bleeding. The bleeding sources in 2 cases were the falciform ligament and the bile duct. No definite source of bleeding was found in the other 2 cases. Bleeding was controlled with the same UMI in all cases. No intraoperative or postoperative blood transfusions were administered. In 4 cases, a percutaneous drain was inserted to drain a collection of bile. There was no leakage of bile from the main bile duct or formation of a biliary stricture during follow-up.

One patient's postoperative course was complicated by rhabdomyolysis; no risk factor for this condition had been apparent before the operation. This patient developed acute renal failure and underwent dialysis. He recovered and was discharged in a satisfactory condition on postoperative day 35. A genetic defect was suspected in this case.

Six donors developed wound complications. Five donors developed collections of fluid without any associated clinical symptoms or signs. In 3 donors, mild portal vein stenosis was apparent on a follow-up computed tomography scan. No interventional procedure was performed in any of these cases.

Two donors developed postoperative ileus that was resolved with conservative management.

All grafts functioned well in the recipients. However, 5 recipients (3.5%) died in the hospital (4 from sepsis and 1 from intracranial hemorrhaging). In 5 patients, reoperation was performed for bleeding in the immediate postoperative period; the bleeding sites were not related to the graft. In a few cases, a subcapsular hematoma of the graft developed, and it was managed conservatively.

During follow-up, 36 recipients developed biliary complications, and 6 developed vascular complications (4 had hepatic artery occlusions, and 2 had pseudo-aneurysms of the hepatic artery). Six patients died because of the recurrence of hepatocellular carcinoma during follow-up.

LDPH and Potential Risk Factors

Among several potential risk factors related to the difficulty of the operation, a large graft (>900 g), severe hepatic macrovesicular steatosis (≥10%), and a deep truncal cavity (a CA depth ratio > 0.35) were found to be significant risk factors for a long operation time up to graft retrieval in a multivariate analysis (Table 3). No significant risk factor for the length of the hospital stay or the rate of complications was identified.

Risk Factors for Wound Complications

Possible risk factors for wound infections were investigated. Several donor variables (the donor age, sex, BMI, and degree of hepatic fatty changes) and operation-related variables (the surgeon, the use of a wound protector, the method of skin suturing, and

TABLE 2. Outcomes of the 141 Right Lobe Liver Donors and Their Recipients

Factor	Value
Donors	
Hospital deaths [n (%)]	0 (0)
Hospital stay (days)	10.3 ± 3.1 (7-35)
Complications [n (%)]	
Grade I	
Wound infection	6 (4.3)
Fluid collection	5 (3.5)
Portal vein stenosis	3 (2.1)
Grade II: ileus	2 (1.4)
Grade IIIA: collection of bile (percutaneous drain insertion)	4 (2.8)
Grade IIIB: bleeding (reoperation)	4 (2.8)
Grade IV: rhabdomyolysis	1 (0.7)
Recipients	
Hospital deaths [n (%)]	5 (3.5)
Complications [n (%)]	
Bleeding (reoperation)	5 (3.5)
Biliary complications	36 (25.5)
Vascular complications	6 (4.3)
Other*	4 (2.8)
Death during follow-up [n (%)]†	6 (4.3)

NOTE: Two left lobe liver donors were excluded.
*A pancreatic fistula (1), ileus (1), a bleeding duodenal ulcer (1), and perforation of a duodenal ulcer (1).
†All deaths were due to the recurrence of hepatocellular carcinoma.

the operation time) were included in a multivariate analysis. Only the use of a wound protector was found to significantly reduce the risk of wound infections in an adjusted analysis (hazard ratio = 0.176, 95% confidence interval = 0.034-0.897, $P = 0.037$).

Cosmetic Outcomes

The results of the questionnaires from 130 donors with UMIs are summarized in Table 4. The replies of 13 patients could not be obtained. No significant differences were identified in the body image or self-confidence scores of the patients in the conventional J-shaped incision group and the patients in the UMI group. However, a significant difference between the groups that favored the UMI group was apparent for the cosmetic score ($P = 0.01$; Table 4).

DISCUSSION

In a previous study analyzing the first 23 patients who underwent LDPH after a UMI, we reported the feasibility and safety of this LDPH modification, and we described the advantages of a UMI versus a conventional J-shaped incision.[5] The group of patients who received a UMI had a shorter operation time, a shorter period of analgesic use, and less frequent complaints of wound pain after discharge. We continued to use a UMI for LDPH in all subsequent donors

TABLE 3. Risk Factors for Long Graft Retrieval Times in 141 Right LDPH Procedures

Univariate Analysis

Potential Risk Factor	Graft Retrieval Time (Minutes)	*P* Value
Sex		
Female (n = 59)	171.4 ± 27.7	<0.01
Male (n = 82)	188.1 ± 35.1	
Age		
≤50 years (n = 130)	180.4 ± 32.5	0.50
>50 years (n = 11)	189.4 ± 41.0	
BMI		
≤25 kg/m^2 (n = 110)	177.9 ± 32.1	0.04
>25 kg/m^2 (n = 31)	192.6 ± 35.0	
Surgeon		
A (n = 79)	174.8 ± 32.4	0.01
B (n = 62)	189.2 ± 32.6	
Graft weight		
≤900 g (n = 131)	178.5 ± 30.8	0.03
>900 g (n = 10)	215 ± 45.0	
Macrovesicular steatosis		
<10% (n = 116)	176.8 ± 32.3	<0.01
≥10% (n = 25)	201.2 ± 30.3	
CA depth ratio		
≤0.35 (n = 117)	177.3 ± 33.2	<0.01
>0.35 (n = 24)	200.0 ± 26.4	

Multivariate Analysis

Potential Risk Factor	Graft Retrieval Time (Minutes) B (95% Confidence Interval)	*P* Value
Sex Female = 1 Male = 2	11.5 (1.1-21.9)	0.03
Age ≤50 years = 1 >50 years = 2	—	NS
BMI ≤25 kg/m^2 = 1 >25 kg/m^2 = 2	—	NS
Surgeon A = 1 B = 2	—	NS
Graft weight ≤900 g = 1 >900 g = 2	24.9 (4.7-45.2)	0.02
Macrovesicular steatosis <10% = 1 ≥10% = 2	16.6 (4.7-28.5)	0.01
CA depth ratio ≤0.35 = 1 >0.35 = 2	15.6 (2.0-29.2)	0.03

NOTE: The graft retrieval time is the period from the skin incision to the graft retrieval.

TABLE 4. Comparison of the Satisfaction Scores for the Donors Who Underwent Partial Hepatectomy: the Conventional J-Shaped Incision Group and the UMI Group

Score	Scale	Conventional Group (n = 20)	UMI Group (n = 130)	*P* Value
Body image				
Are you less satisfied with your body since the operation?	1. Yes, extremely 2. Quite a bit 3. A little bit 4. No, not at all	2.90 ± 0.97	2.90 ± 0.92	1.00
Do you think the operation has damaged your body?	1. Yes, extremely 2. Quite a bit 3. A little bit 4. No, not at all	3.80 ± 0.70	3.46 ± 0.74	0.55
Do you feel less attractive as a result of your operation?	1. Yes, extremely 2. Quite a bit 3. A little bit 4. No, not at all	3.20 ± 0.95	3.31 ± 0.86	0.608
Do you feel less feminine/masculine as a result of your operation?	1. Yes, extremely 2. Quite a bit 3. A little bit 4. No, not at all	3.50 ± 0.89	3.57 ± 0.74	0.704
Is it difficult to look at yourself naked?	1. Yes, extremely 2. Quite a bit 3. A little bit 4. No, not at all	3.45 ± 0.89	3.32 ± 0.89	0.529
Sum		16.85 ± 3.27	16.33 ± 3.31	0.521
Cosmetic				
On a scale from 1 to 7, how satisfied are you with your (incisional) scar?	1. Very unsatisfied 7. Very satisfied	3.70 ± 1.42	4.66 ± 1.70	0.018
Could you score your own scar on a scale from 1 to 10?		5.20 ± 2.31	6.52 ± 2.38	0.022
Sum		8.90 ± 3.16	11.18 ± 3.85	0.013
Self-confidence				
How confident were you before your operation?	1. Not very confident 10. Very confident	6.55 ± 2.98	7.36 ± 2.23	0.255
How confident were you after your operation?	1. Not very confident 10. Very confident	6.85 ± 2.93	7.45 ± 2.31	0.302
Sum		13.40 ± 5.34	14.53 ± 4.16	0.297

NOTE: The satisfaction scores were derived from returned questionnaires.

without exception. After 143 consecutive patients had successfully undergone LDPH, we came to the same conclusions reached in the preliminary report: in none of these patients was a conversion to a conventional J-shaped incision necessary. The rate of reoperation due to postoperative bleeding was 2.8%; the rate was 8.7% in the group receiving a conventional J-shaped incision.[5] We preferred early reoperation for bleeding to avoid blood transfusions; in this way, the risk of blood transfusions could be reduced for the donors. The mean operation time from the skin incision to graft retrieval was 3 hours 1 minute, and the mean total operation time was 4 hours 14 minutes. In agreement with our preliminary study, the operation time for the UMI group was significantly shorter than the operation time for the conventional J-shaped incision group.[5] We used a UMI for left hepatectomy in 2 cases. In our experience, left partial hepatectomy or left lateral sectionectomy is easier after a UMI than right partial hepatectomy because left liver mobilization is easier than right liver mobilization.

The transplanted grafts functioned well in all cases. The causes of the hospital deaths for 6 graft recipients (including 1 patient after left lobe liver transplantation) were not directly related to graft function. The causes of postoperative bleeding in the recipients who underwent a second operation were also not related to the grafts. The rate of biliary complications in the recipients was appreciable in this study. However, we believe that the risk from bile duct manipulation after a UMI is minimal because the surgical views and the bile duct manipulation techniques are similar after a UMI and after a conventional J-shaped incision.

In most cases, the donors were satisfied with the small incision. Even though a few patients developed large keloids, the questionnaire responses indicated that the cosmetic outcomes of the UMI group were

generally better than those of the conventional J-shaped incision group.

On the basis of our experience with 143 consecutive LDPH procedures after a UMI, we are confident that this modified procedure can be applied in most cases, regardless of the donor age, sex, BMI, or body shape. However, most surgeons have concerns about the risk of the operation to donors or the quality of the graft because of the limitations of the operative view. In advocating the modified procedure used in this study, we make several surgical recommendations designed to overcome the limitations of a small incision.

The location of the incision and its length are important. The incision should be located at a high position (up to the level of the xiphoid process) to facilitate improved exposure of the hepatic parenchyma and the suprahepatic region. One of the potential advantages of a UMI versus a conventional J-shaped incision is that a wound protector can be used. The use of the Alexis wound protector has been reported to protect surgical wounds from contamination by bacteria and, consequently, to prevent infection during gastrointestinal surgery.[9] Horiuchi et al.[10] reported that the use of the Alexis retractor at incision sites during gastric and colorectal surgery significantly reduced the incidence of wound infections (superficial infections at the sites of surgical incisions) in a randomized controlled study. The same wound protector also significantly reduced the risk of wound complications in this study. It prevents not only bacterial contamination but also wound desiccation during surgery. The prevention of wound complications is important because they can result in the formation of large scars and poor cosmetic outcomes.

We used a UMI in all donor operations. However, partial hepatectomy after a UMI was difficult in some cases. In our experience, the operation was more difficult in donors with a deep upper abdominal cavity. The CA depth ratio is a good marker for defining the shape of the abdominal cavity. It has been reported that in patients with a CA depth ratio > 0.37, upper abdominal surgery is more difficult because of the depth of the abdominal cavity.[7] In this study, we found a CA depth ratio > 0.35 to be a significant risk factor for a long operation time up to graft retrieval. Male sex is another risk factor for a long operation time up to graft retrieval. In comparison with females, the operation is usually more difficult in males, especially in those with a muscular abdominal wall and a deep abdominal cavity. Another risk factor is a large graft. If the donor liver is large and the midplane of the liver is thick, deep parenchymal dissection is necessary. Deep parenchymal dissection after a small UMI is more difficult and demanding because the direction of the insertion of instruments inevitably has to be more vertical. Parenchymal dissection is also more difficult if there is severe steatosis in the liver. A severely steatotic parenchyma is more fragile and bleeds easily. Even in difficult cases, however, we have safely performed LDPH after the extension of a UMI down to a point immediately above the umbilicus. Nevertheless, if a surgeon is unfamiliar with the procedure, we suggest that male donors with large fatty livers and deep abdominal cavities be excluded from undergoing this modified operation. Additional procedures such as laparoscopy-assisted mobilization may be required to reduce the risks of the operation after a UMI in this subgroup of patients.

In conclusion, a UMI without laparoscopic assistance can be used safely for LDPH regardless of the graft type or the donor characteristics. LDPH after a small incision is associated with improved cosmetic outcomes.

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