Decreasing the operation time of living donor liver transplantation in the era of laparoscopic living donor hepatectomy

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Background: To analyze the mean operating time of donors and recipients during living donor liver transplantation.

Methods: Donors and recipients who underwent living donor liver transplantation during the period of 2016 to 2020 were included in the study. Mean operating time, which was defined as the duration between the entrance and exit from the operating room, was calculated. The mean operating time for donors and recipients according to the year performed were compared using the independent t-test.

Results: A total of 472 cases of living donor liver transplantation cases were included to the study. Laparoscopic donor hepatectomy comprised 80.3% of cases in 2016, reaching 100% in 2020. Mean recipient operating time was 643.7±88.0 minutes in 2016, decreasing to 488.0±75.3 minutes in 2020. Mean donor operating time was 375.6±60.5 minutes in 2016, decreasing to 265.5±38.1 minutes in 2020.

Conclusion: During a five-year period of laparoscopic living donor hepatectomy adaptation, the operating time for both recipients and donors decreased significantly.

Keywords: Liver transplantation; Living donor liver transplantation; Operating time

INTRODUCTION

Liver transplantation is a lifesaving procedure for both chronic liver disease and hepatocellular carcinoma. While deceased donor liver transplantation can give recipients the opportunity to receive a whole liver, countries such as the Republic of Korea have a small number of donations after brain death, while liver disease is one of the key reasons for morbidity and mortality nationally. Instead, living donor liver

transplantation (LDLT) using a partial liver graft is predominantly performed, with donation by families and relatives of the recipient. Despite the fact that LDLT can be performed with a partial liver, the ischemic injury of the graft can be minimized, and the operation performed, in the daytime, which is preferable for surgical and anesthesiology teams. Since LDLT can be performed in a controlled environment compared to deceased donor liver transplantation, in regards to the condition of the recipient, donor, and surgical

teams involved, it can be managed as a routine procedure; thus, medical teams can accumulate experience for quality improvement. This study focused on operating times during LDLT, which can be a parameter for the learning curve of the entire surgical team.

MATERIALS AND METHODS

Patients and Data

Patients who underwent LDLT from January 2016 to December 2020 at Samsung Medical Center were included in the study. Patient demographics, along with operation-related data and follow-up data, were collected. Operation time was defined as the time between patients' entrance and exit from the operating room.

Statistical Analysis

Patient characteristics and operation details were summarized. The mean duration of the operations was analyzed according to the year of the surgery. The difference between the mean operation time according to the year of transplantation was analyzed using the independent t-test. Two-sided p-values <0.05 were used as an indicator of statistical significance. All statistical analyses were done using IBM SPSS Statistics software Version 20.0 (IBM, Armonk, New York, USA). This study was approved by the Institutional Review Board of Samsung Medical Center (IRB No.2021-05-063).

RESULTS

During the study period 472 patients underwent LDLT. Table 1 summarizes patient characteristics and outcomes of liver transplantation. The number of cases was 55 in 2016, which gradually increased, reaching up to 117 and 112 in 2019 and 2020, respectively. Male patients comprised 71.6% of the total LDLT (n=338). The mean recipient age was 53.3±13.7 years. ABO incompatible LDLT accounted for 24.8% of the cases (n=117). Nearly two-thirds of patients had hepatocellular carcinoma (n=303, 64.2%). Six cases (1.3%) involved retransplantation. Multiple bile duct openings were obtained in 126 cases (26.7%). Hepaticojejunostomies were performed in 36 LDLTs (7.6%). Two portal vein openings in the graft were obtained in 24 cases (5.1%). Two hepatic arteries in the graft were obtained in eight cases (1.7%). Inferior hepatic vein reconstruction was performed in 84 cases (17.8%) and middle hepatic vein reconstruction was performed in 240 cases (50.8%).

Male donors accounted for 57.2% of total donors (n=270). Median donor age was 34 years with an interquartile range (IQR) of 25 to 45. Laparoscopic donor hepatectomy was performed in 379 cases (80.3%). Right liver graft was the predominant graft type (n=435, 92.2%). Left liver graft, left lateral graft, and right posterior graft were 11 (2.3%), 14 (3.0%) and 12 (2.5%), respectively. Median

Table 1. Demographical data and surgical outcome of living donor liver transplantation

	No of cases	%
Year of transplantation		
2016	55	11.7
2017	82	17.4
2018	106	22.5
2019	117	24.8
2020	112	23.7
Recipient sex (Male/female)	338/134	71.6
Recipient age, mean	53.3±13.7	
ABO incompatible case (n)	117	24.8
Hepatocellular carcinoma	303	64.2
Retransplantation	6	1.3
Multiple bile duct	126	26.7
Hepaticojejunostomy	36	7.6
Two portal vein opening	24	5.1
Two hepatic artery	8	1.7
Inferior hepatic vein reconstruction	84	17.8
Middle hepatic vein reconstruction	240	50.8
Donor laparoscopy	379	80.3
Donor sex (Male/female)	270/202	57.2
Donor age, median	34 (25–45)	
Graft type		
Right/extended right	435	92.2
Left/extended left	11	2.3
Left lateral	14	3.0
Right posterior	12	2.5
Graft weight, median	685 (600–786)	
Graft-recipient-weight ratio, mean	1.11±0.39	
Donor complication	67	14.2
Clavien-Dindo classification		
None	409	86.7
I	2	0.4
II	46	9.7
IIIa	11	2.3
IIIb	4	0.8
Graft failure	28	5.9
Death	45	9.5

graft weight was 685 g (IQR 600–786). Mean graft-recipient-weight ratio was 1.11 ± 0.39 . Donor complication rate was 14.2%, with most of the complication included in grade II Clavien-Dindo classification ($n=46$, 9.7%) [1]. There were 11 cases (2.3%) with grade IIIa complication requiring intervention, and 4 cases (0.8%) with grade IIIb complication requiring surgery [1].

Graft failure occurred in 5.9% of cases ($n=28$) while death occurred in 45 cases (9.5%).

Total Operation Time According to the Year of Transplantation

Table 2 summarizes the mean operation time for recipients and donors according to the year of transplantation. Mean recipient operation times were 643.7 ± 88.0 , 577.0 ± 92.8 , 508.9 ± 97.9 , 494.3 ± 73.6 , and 488.0 ± 75.3 minutes in the years 2016, 2017, 2018, 2019, and 2020, respectively. Mean donor operation times were 375.6 ± 60.5 , 342.5 ± 43.6 , 303.5 ± 47.8 , 285.1 ± 32.6 , and 265.5 ± 38.1 in the years 2016, 2017, 2018, 2019, and 2020, respectively.

Mean recipient operation time significantly decreased between 2016 and 2017 ($p < 0.001$) and 2017 to 2018 ($p < 0.001$), while changes between 2018 and 2019 ($p = 0.241$) and 2019 to 2020 ($p = 0.533$) were not statistically significant. Mean donor operation time significantly decreased during the entire study period. Fig. 1 shows the change in mean operation time for recipients and donors.

DISCUSSION

This study analyzed total operating time, which was defined as the time between the entrance and exit of the patient from the operating room. By calculating the operating time during the five-year interval, starting from 2016 to 2020, we found that the mean operating time gradually decreased, eventually reaching an 8-hour procedure for

recipients. While recipients' operating time only showed a significant decrease during the period from 2016 to 2018, donor operating time significantly decreased year to year. In 2020, the mean operating time for donor operations was around 4 hours 25 minutes. In the participating center, the donor entered the operating room at 8 A.M. while the recipient entered the operating room at 8:30 A.M. On average, the calculated operating time showed that the donor exited the operating room around 12:25 PM while the recipient exited the operating room around 16:38 P.M.

Operating time itself cannot represent qualitative aspects of the procedure. However, when surgical procedures become protocolized, shorter operation times can be considered a consequence of expertise.

Liver transplantation requires multidisciplinary management not only by the surgical team but also by the anesthesiology, radiology, intensive care, and surgical assisting teams, including scrub nurses. Therefore, thorough communication between teams is essential for improving outcomes. Furthermore, many cases of LDLT experience are needed since trial errors will become improvement points after multidisciplinary team review.

The center performed more than 2,400 cases of liver transplantation, including more than 1700 cases of LDLT, over a quarter of a century. The recent 5 years have been a very important period due to the initiation of a laparoscopic donor hepatectomy program. As summarized in Table 2 and Fig. 2, donor operation time has gradually decreased every year. During the five-year period, 80.3% of donor hepatectomy cases were performed laparoscopically. In 2016, the laparoscopy rate was only 34.5%, which increased to 100.0% in 2020. We have also published many studies

Table 2. Mean operating time of recipient and donor of living donor liver transplantation

	Recipient total operation time	p-value*	Donor total operation time	p-value*
2016	643.7 ± 88.0		375.6 ± 60.5	
2017	577.0 ± 92.8	<0.001	342.5 ± 43.6	0.001
2018	508.9 ± 97.9	<0.001	303.5 ± 47.8	<0.001
2019	494.3 ± 73.6	0.241	285.1 ± 32.6	0.002
2020	488.0 ± 75.3	0.533	265.5 ± 38.1	<0.001

*p-value calculated by comparing the value to the previous year.

Fig. 1. Mean operating time of the living donor liver transplantation recipient during the period from 2016 to 2020.

Operation time for living donor liver transplantation

Fig. 2. Mean operating time of the living donor liver transplantation donor during the period from 2016 to 2020.

related to the feasibility and safety of laparoscopic donor hepatectomy in that time [2-8]. The published studies analyzed the outcome of the donors as well as the outcome of the recipients [4-8]. Anesthesia during laparoscopic liver resection is also important for facilitating the procedure. Marginal volume status of the donor can minimize bleeding during transection, which is guaranteed only in minimal bleeding surgical fields. Major bleeding during transection will lead to volume resuscitation, which will eventually lead to more bleeding. Therefore, harmony between the surgical and anesthesiology teams is essential [9]. Improvement in surgical skills in laparoscopic surgery, which is reflected in decreasing operating times, has a positive impact on recipient surgery. Simplification of surgical procedures during recipient surgery was also a key to decreasing operating time for recipients. Using a cadaveric cryopreserved vessel graft instead of the recipient's autograft harvested from another part of the body can save a significant amount of time in collaboration with the center's tissue bank. Selectively performing a portocaval shunt for the recipient with minimal portosystemic collateral can save additional time. However, the decision requires thorough communication with the anesthesiology team to determine if the patient can endure decreased systemic venous return along with the surgical team's judgement on whether bowel congestion will be tolerable.

The center's policy to use intraoperative cell salvage for retrieving red blood cells from the surgical field and to auto-transfuse the recipient might also have had a positive impact in decreasing operating time. By using a cell saver, prompt transfusion can be done and additional transfusion requests to the blood bank can be minimized [10]. This can

also be beneficial for the surgical team by minimizing consumptive coagulopathy.

While most of the published studies on laparoscopic living donor hepatectomy focused on the operation time of the donor, the operation time of the recipient was not a topic of interest [11,12]. This study analyzed operation times for both the donor and recipient which gradually decreased throughout the study period. This can be interpreted that the surgical quality of the surgical team improved not only for laparoscopic living donor hepatectomy, but also for the recipient operation.

One limitation of this study is that it only analyzed the final outcome, which is represented as operating time. Operating time can be influenced by many factors, both quantitative and qualitative. Nevertheless, since systematically analyzing the causative factors for the decrease in operating time would be extremely difficult, we only discussed the details of the procedure descriptively. However, as a high-volume center both in liver transplantation and LDLT, especially laparoscopic LDLT, we find it valuable to summarize our data regarding adaptation to these procedures and to share our experience.

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CONFLICT OF INTEREST

All authors have no conflicts of interest to declare.

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Conceptualization: All. Data curation: All. Formal analysis: All. Funding acquisition: All. Investigation: All. Methodology: All. Project administration: All. Resources: All. Software: All. Supervision: All. Validation: All. Visualization: All. Writing - original draft: All. Writing - review & editing: All.

REFERENCES

1. Dindo D, Clavien PA. What is a surgical complication? *World J Surg* 2008;32:939-941.
2. Kwon CHD, Choi GS, Kim JM, Cho CW, Rhu J, Soo Kim G, et al. Laparoscopic donor hepatectomy for adult living donor liver transplantation recipients. *Liver Transpl* 2018;24:1545-1553.
3. Park J, Kwon DCH, Choi GS, Kim SJ, Lee SK, Kim JM, et al. Safety and risk factors of pure laparoscopic living donor right hepatectomy: comparison to open technique in propensity score-matched analysis. *Transplantation* 2019;103:e308-e316.
4. Rhu J, Choi GS, Kim JM, Joh JW, Kwon CHD. Feasibility of total laparoscopic living donor right hepatectomy compared with open surgery: comprehensive review of 100 cases of the initial stage. *J Hepatobiliary Pancreat Sci* 2020;27:16-25.
5. Rhu J, Choi GS, Kim JM, Kwon CHD, Joh JW. Intraoperative ultrasonography as a guidance for dividing bile duct during laparoscopic living donor hepatectomy. *Ann Transplant* 2019;24:115-122.
6. Rhu J, Choi GS, Kim MS, Kim JM, Joh JW. Image guidance using two-dimensional illustrations and three-dimensional modeling of donor anatomy during living donor hepatectomy. *Clin Transplant* 2021;35:e14164.
7. Rhu J, Choi GS, Kwon CHD, Kim JM, Joh JW. Learning curve of laparoscopic living donor right hepatectomy. *Br J Surg* 2020;107:278-288.
8. Rhu J, Kim MS, Choi GS, Jeong WK, Kim JM, Joh JW. A novel technique for bile duct division during laparoscopic living donor hepatectomy to overcome biliary complications in liver transplantation recipients: 'cut and clip' rather than 'clip and cut'. *Transplantation* 2020. [Epub ahead of print]
9. Jeong JS, Wi W, Chung YJ, Kim JM, Choi GS, Kwon CHD, et al. Comparison of perioperative outcomes between pure laparoscopic surgery and open right hepatectomy in living donor hepatectomy: propensity score matching analysis. *Sci Rep* 2020;10:5314.
10. Jeong JY, Jee HS, Koo BS, Cho SH, Kim SH, Kim G. Liver transplantation in Jehovah's Witnesses: two cases report. *Korean J Anesthesiol* 2017;70:350-355.
11. Suh KS, Hong SK, Lee KW, Yi NJ, Kim HS, Ahn SW, et al. Pure laparoscopic living donor hepatectomy: focus on 55 donors undergoing right hepatectomy. *Am J Transplant* 2018;18:434-443.
12. Lee B, Choi Y, Han HS, Yoon YS, Cho JY, Kim S, et al. Comparison of pure laparoscopic and open living donor right hepatectomy after a learning curve. *Clin Transplant* 2019;33:e13683.