Global Outcomes of Open Versus Laparoscopic Versus Robotic Donor Hepatectomy: A Prospective Study From the International LDLT Registry (LDLTregistry.org)

The LDLTregistry.org Collaborative[1,*]

Background. Living donor liver transplantation is a critical solution to the global organ shortage. Comparisons of donor short-term outcomes according to the surgical approach are limited to a few single-center retrospective studies. This study aimed to evaluate the short-term outcomes of open, laparoscopic, and robotic surgical approaches to living donor hepatectomy using data from the prospective International Living Donor Liver Transplantation Registry (LDLTregistry.org). **Methods.** Data from 2600 living donors undergoing hepatectomy were prospectively collected from September 2023 to February 2025. Donors were grouped into open (1726; 66.4%), laparoscopic (242; 9.3%), and robotic (632; 24.3%) approaches. **Results.** The mean donor age was 33 (SD 9.4) y, with 45% women and a mean body mass index of 24.7 kg/m² (SD 6.5). Conversion rates were 15.3% for laparoscopic and 5.1% for robotic approaches (odds ratio, 0.30; 95% confidence interval, 0.17-0.50; $P < 0.001$). Robotic hepatectomy was associated with the lowest intraoperative blood loss (70 mL; interquartile range, 50–100), lowest pain scores on postoperative day 1 (visual analog scale, 2.3; SD 1.9), and shortest hospital stay (4 d; interquartile range, 3–5). Robotic hepatectomy was associated with the lowest overall (grade ≥1; 4.6%) and major (grade ≥3a; 0.3%) complication rates compared with laparoscopic (16.5% overall, 3.7% major) and open (10.4% overall, 1.9% major) approaches ($P < 0.001$). **Conclusions.** This is the first global study to show evidence that robotic living donor hepatectomy offers superior short-term outcomes compared with laparoscopic and open approaches. Although open surgery remains the most common approach, robotic techniques show promise for improving donor safety and recovery.

(*Transplantation* 2026;110: e197–e203).

INTRODUCTION

Living donor liver transplantation (LDLT) is a vital strategy to address the global shortage of liver grafts. The safety and outcomes of living donors are paramount, as they are healthy individuals undergoing major surgery that is not medically necessary for themselves. The choice of surgical approach, namely open, laparoscopic, or robotic, has evolved over time, with each method offering distinct advantages and challenges.[1]

Minimally invasive surgery was introduced across several surgical disciplines, offering favorable outcomes in certain fields and patient populations. More recently, minimally invasive techniques have entered the transplantation arena,[1] including both living liver donors and recipients,[2,3] as well as all other solid organ transplants.[1,4] The first robotic living donor hepatectomy was performed in the United States in 2011[5] and was subsequently adopted in Taiwan[6] in 2013 and South Korea[7] in 2016.[8] Over time, the technique spread to other regions, including the United States, Saudi Arabia,[9,2] and India,[10,11] before finally being introduced in Europe.[12] This regional variation in the adoption of robotic donor hepatectomy was largely

Received 13 April 2025. Revision received 15 June 2025.

Accepted 14 August 2025.

[1] Division of Transplant Surgery, Department of Surgery, University of Colorado Health, Denver, CO.

This project has received support from the International Liver Transplantation Society, Chicago, IL, and the International Living Donor Liver Transplantation Group.

The authors declare no conflicts of interest.

Full authorship details of LDLTregistry.org Collaborative are available at* ***Supplemental Group Authorship* *(**SDC,** https://links.lww.com/TP/D303).*

For the individual author contributions, see ***Supplemental Material*** *(**SDC,** https://links.lww.com/TP/D303).*

The registry is in partnership with the International Liver Transplantation Society, the International Living Donor Liver Transplantation group, and The Transplantation Society.

ISRCT registration N84544531.

Supplemental digital content (SDC) is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (www.transplantjournal.com).

Visual abstract is available online at doi.org/ 10.1097/TP.0000000000005530.

Correspondence: Elizabeth Anne Pomfret, MD, PhD, Division of Transplant Surgery, Department of Surgery, University of Colorado Anschutz Medical Campus, Anschutz Outpatient Pavilion, 1635 Aurora Ct, 7th Floor, Mail Stop C318, Aurora, CO 80045. (elizabeth.pomfret@cuanschutz.edu).

ISSN: 0041-1337/20/1101-e197

DOI: 10.1097/TP.0000000000005530

driven by differences in local technology availability and accessibility.

Despite these advancements, open donor hepatectomy remains the most common approach at centers worldwide. Existing studies comparing minimally invasive approaches are limited, often retrospective in nature,[2,13] and typically confined to single-center experiences or national collectives.[14] Consequently, international guidelines[15,16] were unable to definitively recommend 1 approach over the other, despite emerging evidence suggesting potential advantages of the robotic approach.[2] Although laparoscopic equipment is widely available, robotic systems are less accessible to surgeons, further limiting their adoption.[1]

This study represents the first global effort, with an adequate sample size, to compare the short-term outcomes of open, laparoscopic, and robotic living donor hepatectomies using unified, multicenter, prospective data from the International LDLT Registry (LDLTregistry.org).[17] By addressing the limitations of previous studies, this research aims to provide stronger evidence to guide surgical practice and improve donor safety and outcomes in LDLT.

MATERIALS AND METHODS

Study Design and Participants

This study included 2600 living liver donors from 62 centers worldwide, with data prospectively collected from September 1, 2023, to February 19, 2025. All centers involved in LDLT were eligible to participate. Donors were categorized into 3 groups based on the surgical approach, namely open, laparoscopic, and robotic. All consecutive donors were included on an intention-to-treat basis, with conversions to open surgery clearly documented and reported. Submissions with significant data omissions were excluded from the analysis (128/2728; 4.7%). This global study was approved with the identification "AO_2023-00013,"[17] conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments, and adheres to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cohort studies (**Supplemental Methods, SDC,** https://links.lww.com/TP/D303; ISRCT Registration N84544531).

Variables, Data Sources, and Measurement

Data were prospectively collected using a dedicated, uniform electronic Case Report Form available at LDLTregistry.org,[18] which included demographic, clinical, surgical, and outcome data for donors. The Case Report Form contains all variable definitions and was designed to mandate data entry for certain fields (eg, morbidity, mortality) and it has set maximum and minimum values for each variable to reduce errors in data caption and enhance the quality of data collection. Discrete variables were recorded using dropdown selections for standardized data capture. Center volume was stratified as low (≤25 cases) versus high (>25 cases), based on distributional analysis (75th quartile) and literature linking >25 annual LDLT cases to improved outcomes.[19]

Outcome Variables

The predefined primary endpoints for both the univariate and multivariable analyses included donor morbidity as captured by the Clavien-Dindo Classification of Surgical Complications.[20] Grade ≥1 represented a complication of any severity (overall), and grade ≥3a represented major complications. Major complications were strictly defined according to the Clavien-Dindo Classification as grade 3a (surgical/radiological/endoscopic intervention under local anesthesia), grade 3b (intervention under general anesthesia), grade 4a (single organ dysfunction requiring intensive care unit [ICU] admission), and grade 4b (multiorgan dysfunction). Secondary endpoints included conversions to open surgery, estimated intraoperative blood loss, pain scores, laboratory values, length of ICU and hospital stay, and the different types of complications after donor hepatectomy. All such short-term outcomes were prospectively captured during the index hospitalization and through 90 d postoperatively.

Statistical Analysis

Continuous variables were compared using ANOVA or Kruskal-Wallis tests, whereas categorical variables were analyzed using the chi-square or Fisher exact test. Multivariable binary logistic regression analysis was performed to assess the association between preselected covariates and major complications (grade ≥3a). Covariates were chosen based on clinical relevance and included donor age, sex, body mass index (BMI), American Society of Anesthesiologists grade, type of hepatectomy, and surgical approach. A P value of <0.05 was considered statistically significant. Statistical analysis was performed using R version 3.3.2 (R Core Team, GNU GPL version 2 License), R Studio version 1.0.44 (RStudio Inc, GNU Affero General Public License version 3, Boston, MA) with the graphical user interface rBiostatistics.com.[21]

RESULTS

Center Characteristics

A total of 62 centers from 27 countries across 5 continents participated in this study, contributing a total of 2600 donor cases (Figure 1). The average number of cases per center was 42, with a median of 7 cases (interquartile range [IQR], 2–22) and a wide overall range of 1 to 584 cases (**Figure S1, SDC,** https://links.lww.com/TP/D303). The distribution of surgical approaches across participating centers is illustrated in Figure 2. The majority of the centers performed open hepatectomy alone (41/62; 66.1%). A smaller number of centers combined open with laparoscopic (10/62; 16.2%) or robotic (6/62; 9.7%) approaches. Three centers exclusively performed laparoscopic (3/62; 4.8%) and 1 robotic (1/62; 1.6%) donor hepatectomy. Additionally, 1 center (1/62; 1.6%) used a combination of laparoscopic and robotic approaches, whereas another (1/62; 1.6%) used all 3 techniques (open, laparoscopic, and robotic). High-volume centers (>25 cases; 88.5% of cohort) performed 93.8% (820/874) of minimally invasive cases (laparoscopic/robotic), compared with 6.2% (54/874) in low-volume centers (odds ratio [OR], 2.51; 95% confidence interval [CI], 1.84-3.48; $P < 0.001$).

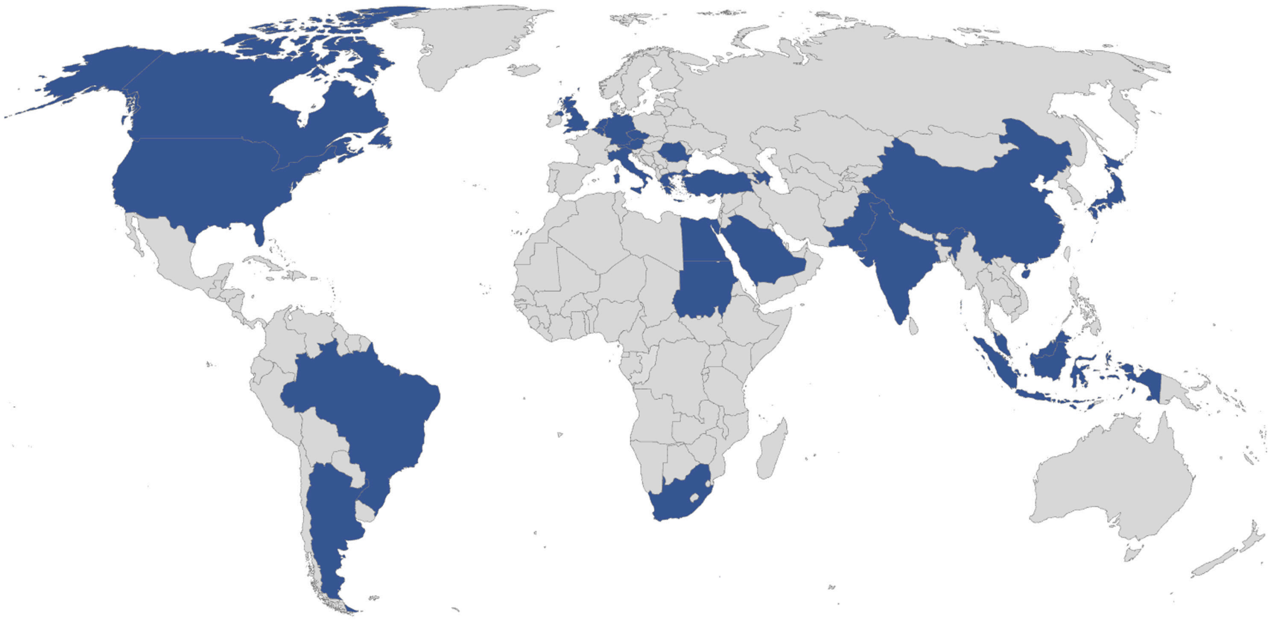

FIGURE 1. Map illustrating the geographic distribution of institutions (dark) that contributed valid cases to this LDLTregistry.org study.

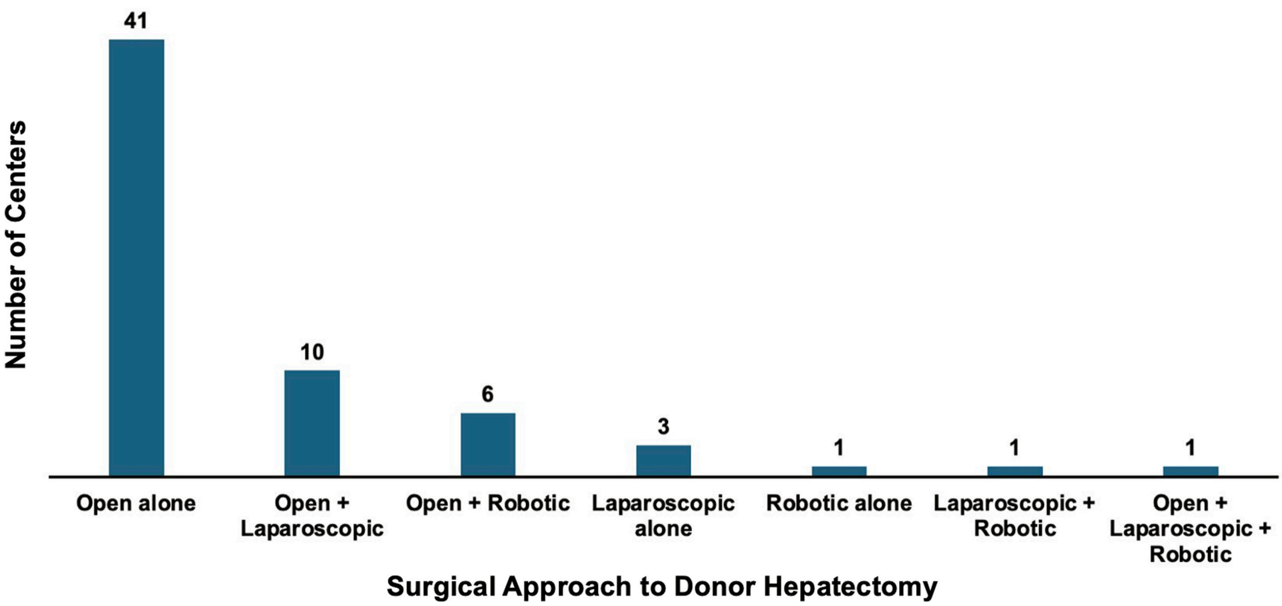

FIGURE 2. Number of centers performing open, laparoscopic, or robotic donor hepatectomy, including combinations of the surgical approaches.

Donor Characteristics

The mean age of donors was 33 y (SD 9.4), with 1169 (45.0%) being women. The mean BMI was 24.7 kg/m² (SD 6.5). Open hepatectomy was the most common approach (1726; 66.4%), followed by robotic (632; 24.3%) and laparoscopic (242; 9.3%) approaches. The majority of donors were of South Asian (847; 33.6%) and Middle Eastern (621; 24.7%) ethnicity, with a smaller proportion of White (505; 20.0%) and East Asian (402; 16.0%) donors. First-degree relatives accounted for 1806 donors (69.9%), whereas second- and third-degree relatives represented 286 (11.1%) and 108 (4.2%), respectively (Table 1).

Intraoperative Donor Characteristics

Robotic donor hepatectomy was associated with the longest median operation duration (407 min; IQR, 348–475), followed by laparoscopic (374 min; IQR, 323–435) and open approaches (360 min; IQR, 281–435; $P < 0.001$). The median intraoperative blood loss was 300 (IQR, 180–400) mL for the open approach, 150 (IQR, 100–250) mL for the laparoscopic approach, and 70 (IQR, 50–100) mL for the robotic approach ($P < 0.001$). Conversion rates were 15.3% for laparoscopic and 5.1% for robotic approaches (OR, 0.30; 95% CI, 0.17-0.50; $P < 0.001$). Right hepatectomy was the most performed procedure (1536; 59.2%), followed by left lateral

TABLE 1.

Donor characteristics

Donor parameters	Overall (N = 2600)	Open (N = 1726)	Laparoscopic (N = 242)	Robotic (N = 632)	*P*
Female, n (%)	1169 (45.1)	847 (49.3)	120 (49.6)	202 (32.0)	<0.001
Age, median, y (IQR)	32 (25–39)	32 (25–39)	38 (31–46)	30 (25–36)	<0.001
BMI, median, y (IQR)	24 (22–27)	24 (21–27)	25 (23–28)	25 (23–28)	0.004
ASA status, n(%)					
I	2114 (87.8)	1528 (94.0)	137 (90.1)	449 (71.2)	<0.001
II	290 (12.0)	94 (5.8)	15 (9.9)	181 (28.7)	–
Graft type, n(%)					
Left lateral	644 (24.8)	446 (25.8)	42 (17.4)	156 (24.7)	<0.001
Left	408 (15.7)	179 (10.4)	96 (39.7)	133 (21.0)	–
Right	1548 (59.5)	1,101 (63.8)	104 (43.0)	343 (54.3)	–
Conversion to open, n (%)	–	–	37 (15.3%)	32 (5.1%)	<0.001
Estimated blood loss, mL. median (IQR)	200 (100–350)	300 (180–400)	150 (100–250)	70 (50–100)	<0.001
Blood transfusion, n (%)	109 (5.5%)	100 (8.2%)	5 (4.0%)	4 (0.6%)	<0.001
Graft volume, mL, median (IQR)	673 (380–839)	664 (339–844)	687 (484–833)	691 (452–836)	0.373
Graft weight, g, median (IQR)	598 (325–759)	605 (322-768)	583 (395–752)	570 (313–742)	0.005
Operation duration, min, median (IQR)	372 (300–444)	360 (281–435)	374 (323–435)	407 (348–475)	<0.001
Biliary complications (any grade), n (%)	60 (2.3%)	48 (2.8%)	7 (2.9%)	5 (0.8%)	0.014
Biliary leak	36 (1.4%)	26 (1.5%)	5 (2.1%)	5 (0.8%)	0.267
Biloma	25 (1.0%)	23 (1.3%)	2 (0.8%)	0 (0.0%)	0.013
Infections, n (%)	16 (0.6%)	10 (0.6%)	5 (2.1%)	1 (0.1%)	0.005
In-hospital mortality, n (%)	0 (%)	0 (%)	0 (%)	0 (%)	–

ASA, American Society of Anesthesiologists; BMI, body mass index; IQR, interquartile range.

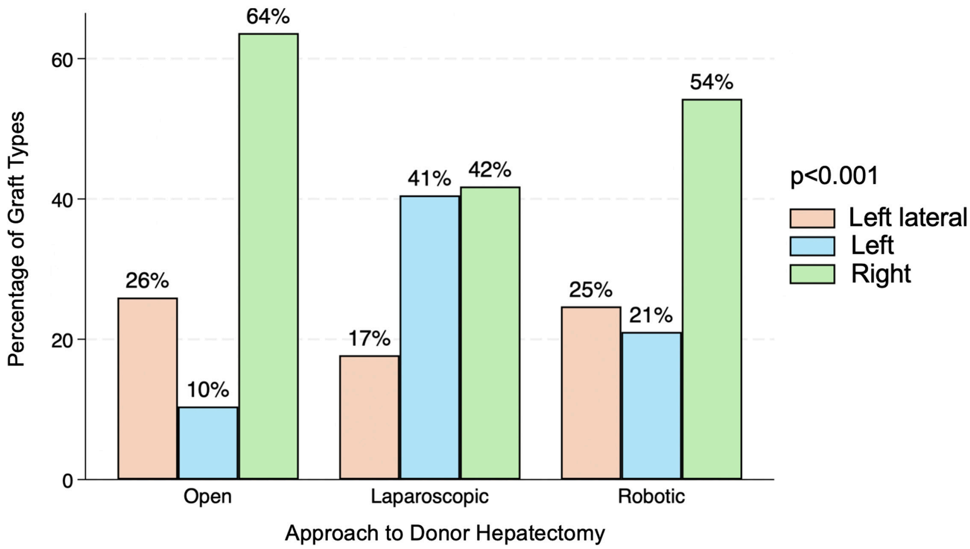

FIGURE 3. Distribution of right, left, and left lateral donor hepatectomies according to the surgical approach.

segmentectomy (644; 24.8%) and left hepatectomy (408; 15.7%; Figure 3; Table 1).

Postoperative Donor Characteristics

The mean pain score (visual analog scale, 0–10) on postoperative day 1 was 3.8 (SD 2.0) for the open approach, 3.0 (SD 2.2) for the laparoscopic approach, and 2.3 (SD 1.9) for the robotic approach ($P < 0.001$). Robotic hepatectomy was associated with the shortest median hospital stay (4 d; IQR, 3–5) compared with laparoscopic (6 d; IQR, 4–9) and open (7 d; IQR, 6–9) approaches ($P < 0.001$). The median length of stay in monitored units (ICU/high dependency unit/intermediate care unit) was 1 d (IQR, 1–2) across all approaches, with no significant differences between groups (Table 1).

Postoperative Short-term Donor Outcomes

Robotic hepatectomy was associated with the lowest overall complication rate of any severity (grade ≥1; 29/63; 4.6%) and major complication (grade ≥3a) rate (2/632; 0.3%) compared with laparoscopic (40/242; 16.5% overall, 9/242; 3.7% major) and open (180/1726; 10.4% overall, 32/1726; 1.9% major) approach ($P < 0.001$; Figure 4). The most common complications included bile leaks, wound infections, and pleural effusions, with robotic hepatectomy demonstrating significantly lower rates across all categories (Table 1).

In the multivariable analysis, robotic donor hepatectomy was independently associated with a significantly reduced risk of major complications (grade ≥3a; OR, 0.14; 95% CI, 0.02-0.49; $P = 0.009$) when adjusted for age, sex, BMI, the type of hepatectomy, and comorbidities (Figure 5).

Impact of Center Volume on Donor Outcomes

Low-volume centers had a 20.7% donor complication rate (62/299) of any severity (Clavien-Dindo grade ≥1), compared with 8.1% in high-volume centers (187/2301; OR, 2.96; 95% CI, 2.12-4.09; $P < 0.001$). The difference was even larger for major donor complications (Clavien-Dindo grade ≥3a), which occurred in 6.0% of low-volume (18/299) versus 1.1% of high-volume (25/2301) cases (OR, 5.82; 95% CI, 2.95-11.27; $P < 0.001$).

DISCUSSION

The most critical finding of this study is the demonstration that robotic donor hepatectomy matches the safety of the traditional open approach while offering important benefits, including faster recovery times and reduced complication rates. This pioneering global, multicenter study provides compelling evidence confirming its safety and efficacy for living liver donors, reinforcing observations from prior single-center or regional studies.[14-16] Even when including several low-volume centers and accounting for their learning curves, the robotic approach significantly outperformed traditional methods in terms of reduced intraoperative blood loss, lower postoperative pain scores, shorter hospital stay, and fewer complications such as bile leaks and wound infections. These results align with prior studies[14] indicating that robotic surgery offers enhanced precision, superior ergonomics, visualization, dexterity, and reduced tissue trauma, which are critical for optimizing outcomes in LDLT.

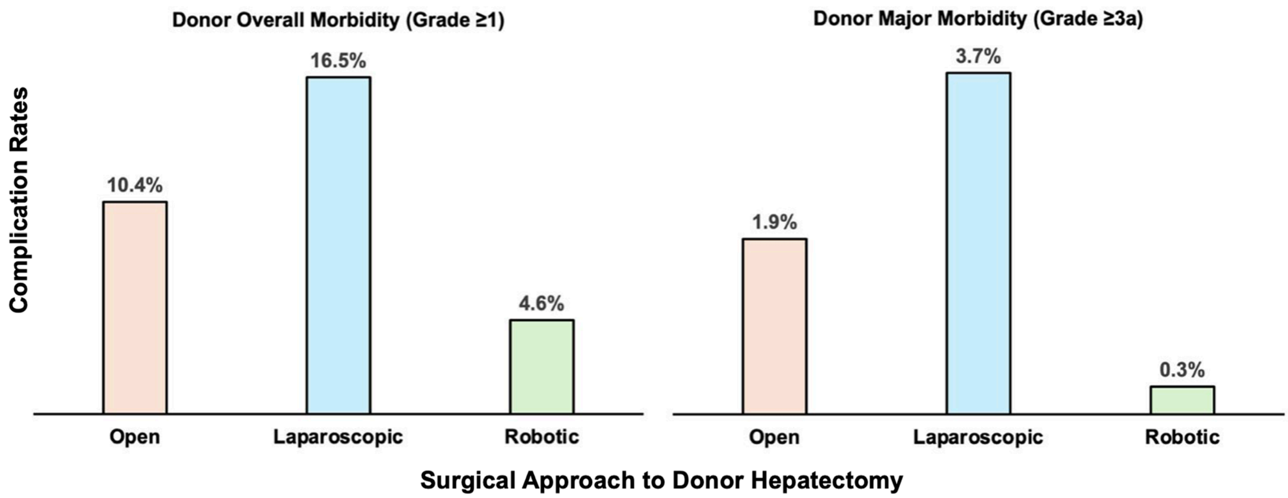

FIGURE 4. Complication rates (overall grade ≥1 and major grade ≥3a) according to the donor surgical approach.

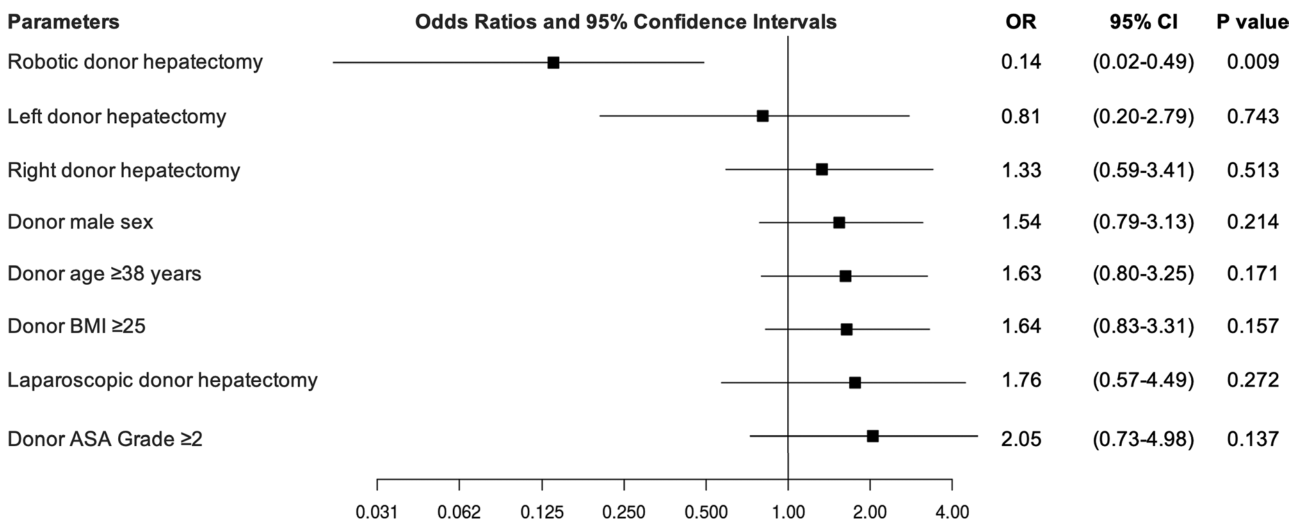

FIGURE 5. Multivariable analysis of risk factors for major complications (grade ≥3a) after donor hepatectomy. ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; OR, odds ratio.

Despite these advantages, the adoption of robotic hepatectomy remains limited, with open surgery still being the most common approach globally. This is likely due to the limited accessibility of robotic systems, the steep learning curve, and the lack of prior experience with minimally invasive surgery in hepatobiliary surgery among some surgical teams. The strong association between center experience and minimally invasive approaches further suggests their outcomes reflect both technical factors and institutional expertise. LDLT, already a highly complex field, demands a cautious approach to innovation, as the stakes are exceptionally high for both donors and recipients. The global impact of adverse events in LDLT, such as donor mortality, can have far-reaching effects, potentially stalling the progress of the entire field for years, as history has shown in the West. The variability in center experience and surgical approaches observed in this study reflects the global diversity in the adoption of minimally invasive techniques. Although open hepatectomy remains dominant, the gradual integration of laparoscopic and robotic techniques indicates a shift toward less invasive methods, although at a slower pace. These findings emphasize the need for standardized training programs and shared expertise to support broader adoption of advanced techniques, ensuring that the benefits of robotic surgery can be applied across diverse healthcare settings and that such innovations are implemented responsibly, thereby maintaining trust and safety in the field.

Although laparoscopic hepatectomy has gained attraction in regions such as Asia, its higher conversion and complication rates[13,14] compared with robotic surgery suggest that it may not offer the same level of safety and efficiency. These findings suggest the need for increased investment in robotic technology and training programs to expand access and improve outcomes for living liver donors.

Although this study did not capture cost data, the significant advantages of robotic hepatectomy, such as faster recovery and lower complication rates, may suggest potential cost-effectiveness that warrants further investigation. Although robotic systems and consumables are costly, these expenses may be offset by reduced postoperative care needs, fewer reinterventions, and faster donor recovery, which could lower indirect costs to society.[22,23] Additionally, the precision and efficiency of robotic surgery may lead to shorter operation duration and less intraoperative resource use over time as teams gain proficiency, further contributing to cost reductions. The decreased length of hospital stay and quicker return to work for donors may not only reduce direct medical costs but also enhance productivity, benefiting economic systems at large. However, these potential economic benefits remain hypothetical without formal cost data from this study, indicating the need for a dedicated cost-effectiveness analysis within the International LDLT Registry. Moreover, the improved donor experience and outcomes offered by robotic techniques could serve as a compelling incentive for more individuals to consider donation, potentially increasing the donor pool and positively impacting transplant availability. Thus, there is an urgent need for well-designed cost-effectiveness studies to quantify these trade-offs and provide a balanced assessment of the financial implications. Such research could inform healthcare systems and policymakers, showing that the higher upfront costs of robotic surgery may be justified by its clinical and economic benefits. Furthermore, in the setting of living donor hepatectomy, where donors are healthy volunteers undergoing major surgery for altruistic reasons, cost should not be the primary concern; instead, the focus should be on offering them the best possible outcomes and ensuring their safety and well-being.

This study has several limitations. First, although the data were prospectively collected, the analysis is observational, and remaining confounding may exist despite multivariable adjustments. The predominance of minimally invasive techniques in high-volume centers may prevent isolation of approach-specific effects from center experience variables. Second, the study focused on short-term outcomes, although long-term data on donor recovery, quality of life, and recipient graft function are needed to fully evaluate the impact of robotic hepatectomy. Third, this study did not capture the specific criteria influencing the selection of open, laparoscopic, or robotic approaches to donor hepatectomy at individual centers, which may introduce selection bias due to variation in practice patterns worldwide.[24] Fourth, the registry did not capture specific reasons for conversion from minimally invasive to open approaches, which represents an important area for future data collection refinement and reporting. Fifth, variability in perioperative protocols, surgical expertise, and institutional resources across centers globally may influence outcomes and contribute to such differences when comparing different surgical approaches in this study. Finally, although statistically significant differences were observed among the different surgical approach groups in parameters, such as BMI, operation duration, and blood loss, their clinical relevance requires cautious interpretation given the relatively modest absolute differences.

In conclusion, this study not only highlights the superior short-term outcomes of robotic living donor hepatectomy compared with the laparoscopic and open approaches but also signals a new era in surgical innovation for LDLT. With lower blood loss, reduced pain, shorter hospital stay, and fewer complications, robotic techniques may transform donor safety and recovery. However, long-term donor outcomes, including quality of life, remain critical areas for future research. The global predominance of open surgery indicates a critical gap in the widespread acceptance and implementation of robotic methods. To bridge this gap, substantial investments are essential in both the technological infrastructure and the training of surgical teams. In this way, the healthcare community can ensure that the benefits of robotic hepatectomy will extend universally, thereby improving donor experiences and outcomes. Future research should not only continue to assess long-term outcomes but also focus on rigorous cost-effectiveness analyses to solidify the economic and clinical case for robotic LDLT. Ultimately, these efforts will drive an evolution toward robotic techniques in transplantation, ensuring improved outcomes and enhanced care for both donors and recipients. Finally, although robotic donor hepatectomy showed superior short-term outcomes, its benefits are inseparably linked to high-volume center expertise, necessitating cautious implementation with structured training programs to ensure donor safety.

ACKNOWLEDGMENTS

The authors thank all participating centers and donors for their contributions to the International LDLT Registry (LDLTregistry.org; **Supplemental Group Authorship, SDC,** https://links.lww.com/TP/D303).

REFERENCES

1. Broering DC, Raptis DA, Malago M, et al; MIOT Collaborative. Revolutionizing organ transplantation with robotic surgery. *Ann Surg*. 2024;280:706–712.
2. Raptis DA, Elsheikh Y, Alnemary Y, et al; OTCE KFSHRC Collaborative (Appendix). Robotic living donor hepatectomy is associated with superior outcomes for both the donor and the recipient compared with laparoscopic or open—a single-center prospective registry study of 3448 cases. *Am J Transplant*. 2024;24:2080–2091.
3. Broering DC, Elsheikh Y, Malago M, et al. Outcomes of fully robotic recipient living donor liver transplant in relation to the open approach. *Transplantation*. 2024;108:2396–2402.
4. The MIOT.CC Collaborative. Recommendations from the 2024 Minimally Invasive Organ Transplant Consensus Conference – MIOT.CC. *Ann Surg*. [Epub ahead of print. December 12, 2024]. doi:10.1097/SLA.0000000000006804
5. Giulianotti PC, Tzvetanov I, Jeon H, et al. Robot-assisted right lobe donor hepatectomy. *Transplant Int*. 2012;25:e5–e9.
6. Chen PD, Wu CY, Hu RH, et al. Robotic liver donor right hepatectomy: a pure, minimally invasive approach. *Liver Transpl*. 2016;22:1509–1518.
7. Rho SY, Lee JG, Joo DJ, et al. Outcomes of robotic living donor right hepatectomy from 52 consecutive cases: comparison with open and laparoscopy-assisted donor hepatectomy. *Ann Surg*. 2022;275:e433–e442.
8. Jang EJ, Kim KW, Kang SH. Early experience of pure robotic right hepatectomy for liver donors in a small-volume center. *JSLS*. 2022;26:e2022.00063.
9. Broering D, Sturdevant ML, Zidan A. Robotic donor hepatectomy: a major breakthrough in living donor liver transplantation. *Am J Transplant*. 2022;22:14–23.
10. Rela M, Rajalingam R, Cherukuru R, et al. Experience with establishing a robotic donor hepatectomy program for pediatric liver transplantation. *Transplantation*. 2023;107:2554–2560.
11. Soin AS, Yadav KS, Valappil F, et al. Hepatic duct division during robotic living donor hepatectomy: a comparison between the novel triple C (clip-clamp-cut) and the cut-suture techniques. *J Transplant*. 2024;2024:8955970.
12. Gruttadauria S, Pagano D, Cintorino D, et al. Right hepatic lobe living donation: a 12 years single Italian center experience. *World J Gastroenterol*. 2013;19:6353–6359.
13. Hong SK, Kim JY, Lee J, et al. Pure laparoscopic donor hepatectomy: Experience of 556 cases at Seoul National University Hospital. *Am J Transplant*. 2024;24:222–238.
14. Hong SK, Choi GS, Han J, et al. Pure laparoscopic donor hepatectomy: a multicenter experience. *Liver Transpl*. 2021;27:67–76.
15. Pollok JM, Tinguely P, Berenguer M, et al; ERAS4OLT.org collaborative. Enhanced recovery for liver transplantation: recommendations from the 2022 International Liver Transplantation Society consensus conference. *Lancet Gastroenterol Hepatol*. 2023;8:81–94.
16. ILTS Toronto. Available at https://toronto.ilts.org/. Accessed March 17, 2025.
17. International LDLT Registry | LDLT registry.org. Available at https://ldltregistry.org/. Accessed March 17, 2025.
18. Case Report Form | LDLT registry.org. Available at https://ldltregistry.org/CRF. Accessed March 17, 2025.
19. Cotter TG, Minhem M, Wang J, et al. Living-donor liver transplantation in the United States: evolution of frequency, outcomes, center volumes and factors associated with outcomes. *Liver Transpl Soc*. 2021;27:1019–1031.
20. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg*. 2009;250:187–196.
21. rBiostatistics.com (alpha version) | rBiostatistics.com. Available at https://www.rbiostatistics.com/. Accessed March 7, 2025.
22. Koh YX, Zhao Y, Tan IEH, et al. Comparative cost-effectiveness of open, laparoscopic, and robotic liver resection: a systematic review and network meta-analysis. *Surgery*. 2024;176:11–23.
23. Ziogas IA, Evangeliou AP, Mylonas KS, et al. Economic analysis of open versus laparoscopic versus robotic hepatectomy: a systematic review and meta-analysis. *Eur J Health Econ*. 2021;22:585–604.
24. LDLTregistry.org Collaborative. Global variation in living donor liver transplantation practices impacts donor and recipient short-term outcomes: initial insights from the International LDLT Registry. *Am J Transplant*. 2025;25:1735–1745.