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# Assessment of the Global Practice of Living Donor Liver Transplantation.

Juliet Emamaullee MD PhD<sup>1,2</sup>, Claire Conrad BS<sup>2</sup>, Michelle Kim MD, MS<sup>1,2</sup>, Cameron Goldbeck MS<sup>1</sup>, Yong Kwon MD<sup>1,2</sup>, Pranay Singh<sup>1</sup>, Claus U. Niemann MD<sup>3,4</sup>, Linda Sher MD<sup>1,2</sup>, and Yuri Genyk MD<sup>1,2</sup>

<sup>1</sup>Department of Surgery, University of Southern California, Los Angeles, CA

<sup>2</sup>Keck School of Medicine, University of Southern California, Los Angeles, CA

<sup>3</sup>Department of Anesthesiology, University of California-San Francisco, San Francisco, CA

<sup>4</sup>Department of Surgery, University of California San Francisco, San Francisco, CA

## Authorship Contributions:

Involved in the conception or design of the work: JE, LS, YG

Data acquisition: JE, CC, MK, PS

Analysis and interpretation of data: JE, BS, CN, YK, LS, YG

Drafted the article: JE, CC, MK, LS

Critically revised the article: All contributing authors

Finally approved the version to be published: All contributing authors

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## Corresponding Author:

Juliet Emamaullee MD PhD FRCSC FACS

1510 San Pablo Street, Suite 412

Los Angeles, CA 90033

Tel: 323.442.5908

Fax: 323.442.6887

Email: Juliet.emamaullee@med.usc.edu

<https://orcid.org/0000-0003-4238-3057>

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**Abbreviations:**

- LDLT: Living Donor Liver Transplantation  
DDLT: Deceased Donor Liver Transplantation  
LT: Liver Transplantation  
GRWR: Graft to Recipient Weight Ratio  
BMI: Body Mass Index  
MRI: Magnetic Resonance Imaging  
US: Ultrasound  
WHO: World Health Organization  
IRODAT: International Registry on Organ Donation and Transplantation  
USP: U.S. Programs  
IP: International Programs  
DCD: Donation after Cardiac Death  
ILTS: International Liver Transplant Society  
PSC: Primary Sclerosing Cholangitis  
NASH: Non-Alcoholic Steatohepatitis  
A1AT: Alpha-1-Anti-Trypsin Deficiency  
A2ALL: Adult-to-Adult Living Donor Liver Transplantation

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## Abstract

Criteria that drive selection and utilization of living liver donors are limited. Herein, the global availability of living donor liver transplantation (LDLT) and components of donor selection and utilization were assessed via an international survey. There were 124 respondents representing 41 countries including 47 from Asia/Middle East (A/ME), 20 from Europe, and 57 from the Americas. Responses were obtained from 94.9% of countries with  $\geq 10$  LDLT cases/year. Most centers (82.3%) have defined donor age criteria (median 18-60 years), while pre-set recipient MELD cutoffs (median 18-30) were only reported in 54.8% of programs. Overall, 67.5% of programs have preset donor BMI ranges (median 18-30), and the mean acceptable macrosteatosis was highest for A/ME ( $20.2 \pm 9.2\%$ ) and lowest for Americas ( $16.5 \pm 8.4\%$ ,  $p=0.04$ ). Americas (56.1%) and European (60.0%) programs were more likely to consider anonymous donors versus A/ME programs (27.7%,  $p=0.01$ ). There were no differences in consideration of complex anatomical variations. Most programs (75.9%) perform donor surgery via an open approach, and A/ME programs are more likely to use microscopic arterial reconstruction. Despite variations in practice, key aspects of living donor selection were identified. These findings provide a contemporary reference point as LDLT continues to expand into areas with limited access to liver transplantation.

## Introduction

For patients with end-stage liver disease, the need for liver transplantation (LT) has outpaced the availability of organ donors. Due to regional and cultural variations affecting the availability of deceased organ donors, surgeons have innovated the use of partial liver allografts from living donors (1). With increasing experience over the past two decades, many of the early technical challenges observed in living donor liver transplantation (LDLT) have been resolved, including inflow modulation for potentially small for size grafts. Recent data have demonstrated that LDLT can provide superior graft and patient survival when compared to deceased donor liver transplant (DDLT), for both pediatric and adult recipients (2–6). However, even in experienced centers, 40% of living liver donors experience post-operative complications, and thus donor safety and informed consent remain central to the LDLT procedure (7,8).

The process of evaluation and selection of potential living liver donors varies between programs, with many contributing factors, including patient characteristics, recipient complexity, and overall willingness to accept risk by the transplant team (9–12). As well, external pressures such as limited access to deceased donor allografts can affect the decision-making algorithm (13). While technical aspects, such as Graft Weight to Recipient Weight Ratio (GWRW) are fairly well established, other specific parameters regarding the upper limits of donor age, impact of donor obesity, risk of heritable liver disease, and risk with known hypercoagulable states are not well defined. Performing a randomized trial to address each of these issues is not practical. As a result, based on prior experience and retrospective data, a number of society-authored clinical practice guidelines have been developed to address the evaluation and selection of living liver donor candidates (14–16). Even with these guidelines, it is evident that individual centers are challenged to make assessments about donor candidacy and recipient eligibility for LDLT without discrete data to inform their decisions.

Recognizing inherent geographic variations in LDLT volume and practice patterns, the aim of this study was to identify key aspects of living donor screening criteria, LDLT candidacy, living donor evaluation, and surgical considerations to inform policy development. The availability of LDLT was examined for each country in the World Health Organization (WHO) Global Observatory on Donation and Transplantation, and a comprehensive international survey was conducted to understand the contemporary practice of donor and recipient selection for LDLT (17).

## Methods

This study was approved by the Institutional Review Board at the University of Southern California (HS-18-00482) and is therefore compliant with the Declaration of Helsinki (2000) and Declaration of Istanbul (2008).

**Global Prevalence of LDLT:** Potential survey sites were identified through the WHO Global Observatory on Donation and Transplantation Registry in the most recent reporting year (2015 to 2017) (17). The data for each country included the population and total number of LDLT performed (Supplemental Table 1). Liver transplant data for countries with no LDLT cases in the WHO Registry were cross-referenced with the International Registry in Organ Donation and Transplantation (IRODAT) to identify additional LDLT cases (18). A literature search was conducted to identify LDLT cases for countries not otherwise identified with LDLT activity in either registry. Sixty eight countries with at least one LDLT case in the study period were identified, representing every United Nations Geographic Region (19). The Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) Statement and Checklist were followed in this analysis (20).

**Development and Validation of Survey Instrument:** A unique questionnaire was designed to assess factors contributing to living liver donor evaluation, utilization, and programmatic experience. Several documents, including Vancouver Forum data, society guidelines, and prior studies were considered during survey development (12,14,15,21–23). The survey evaluated four content areas: program demographics, donor assessment and selection, recipient factors that might impact utilization, and surgical techniques (full survey available in Supplemental Data). Initial survey questions were refined through a series of reviews with relevant experts within our institution and a PhD expert in biostatistical survey design. Feedback was obtained from the American Society of Transplant Surgeons Scientific Study Committee and International Liver Transplantation Society (ILTS) Leadership for survey content validity and completeness. The final set of questions was transferred to a web-based platform (Project Meridian, Akido Labs, Los Angeles, CA) for electronic distribution and piloted by research staff to identify technical issues prior to broad distribution.

**Survey Distribution:** Potential respondents from the U.S. were identified using the Organ Procurement and Transplantation Network liver transplant program director list. International respondents were identified using transplant registry contacts, center-specific publications, and personal references. An attempt was made to establish contact with at least one physician associated with programs in each country identified to have LDLT activity. In addition, we attempted to obtain responses from multiple unique programs within high volume countries (**Table 1**). Individual

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survey links were discretely associated with each respondent's email and were distributed electronically over a 6-month period in late 2018 (approximately 200 overall), and consent was obtained through voluntary survey participation.

**Data Handling and Analysis:** Data from each respondent were automatically extracted and manually reviewed for inconsistencies. For duplicate responses from a single center, the most complete survey was included, and the duplicate was excluded from the final analysis. The individual responses were combined into a single file for subsequent analysis. Responses were summarized by content area using a descriptive statistical approach, and data were reported as counts and percentages or median and interquartile ranges, where appropriate. The Fisher exact test was used to compare categorical variables, and the T-test was used to compare differences in means of continuous variables. Nonparametric variables in independent samples were compared by the Mann-Whitney test. An analysis of variance (ANOVA) was used to compare differences in means in survey respondent categories. A p-value <0.05 was considered to be significant. Statistical analysis was performed with R v4.0.3 and figures were generated using Tableau Desktop V.2019.1.

## Results

### Part I: Global Prevalence of LDLT

The global utilization of LDLT was examined to identify countries to include in our survey distribution. Overall, 68 countries were identified with LDLT activity, representing 78.2% of the global population (**Table 1**). Among these, 15 countries reported  $\geq 50$  LDLT. Nineteen percent of the global population does not have an LT program in their country, primarily in Sub-Saharan Africa, the Middle East, and parts of Southeast Asia (**Figure 1**).

### Part II: Survey Response

During the study period, 143 survey links were accessed, and 124 were completed and included in the final analysis, representing a click-through rate of 86.7%. Survey responses were obtained from 41 countries with LDLT activity. Among ‘high-volume countries’, at least two unique centers responded except in Pakistan and Russia, where, to our knowledge, there is only one active program for each (**Table 1**). For U.S. based programs, 43/44 (97.7%) responded.

Among the 124 respondents, 47 were from Asian and Middle Eastern programs (A/ME), 20 were from Europe, and 57 were from programs in North and South America (“Americas”) (**Table 2**). A/ME perform more LDLT per year (median 30 [95% CI 30,50], range up to 400) when compared to Europe (median 8 [95% CI: 8, 15], range up to 80) or the Americas (median 10 [95% CI 10,15], range up to 110)  $p<0.01$ . In parallel, A/ME programs evaluate more potential living donors (median 30 [95% CI: 25, 40], range up to 1000) versus Europe (median 20 [95% CI 20,30], range up to 200) and the Americas (median 30 [95% CI: 30, 36], range up to 300,  $p=<0.01$ ). Most survey respondents were affiliated with programs offering LDLT to both adult and pediatric recipients. Overall, 66% of programs were operational  $\geq 10$  years.

### Part III: Living Donor and Recipient Screening Criteria

The majority of programs (82.3%) reported having a defined living liver donor acceptable age range, with median range of 18 to 60 years (**Table 3**). European programs were less likely to have a defined age range (60% vs. 85.1% of A/ME programs ( $p=0.05$ ) and 87.7% of the Americas programs ( $p=0.02$ )). Only 44.8% of all programs will evaluate ABO-incompatible living donors, with the top indication being for ‘any blood group recipient’ versus ‘fulminant failure’. Two thirds of all respondents reported having donor BMI criteria for eligibility. For programs with defined cutoffs, European centers have a lower acceptable upper limit of BMI (median 30 [95%CI: 30, 30]) versus A/ME (median 31

[95%CI: 31,34], p=0.02) and the Americas (median 32 [95% CI 32, 35], p=0.01). A/ME programs are less likely to consider anonymous nondirected living donors (27.7%) versus programs from Europe (60.0%) or the Americas (56.1%). Several respondents, particularly from A/ME, indicated that anonymous donation is not permitted in their country. Willingness to consider 'transfusion-free' living donors (i.e. Jehovah's Witness patients) was infrequent (25.8%), particularly among programs in the Americas (15.8%).

Due to potential heritability, some programs may be reluctant to proceed with first degree relatives as living liver donors in recipients with certain heritable etiologies of chronic liver disease. Four recipient diagnoses were queried: Non-Alcoholic Steatohepatitis (NASH), Primary Biliary Cholangitis (PBC), Primary Sclerosing Cholangitis (PSC), and Alpha-1-Antitrypsin Deficiency (A1AT). Some indicated that these recipient diagnoses could factor into living donor candidacy, with A1AT (41.8%) and PSC (41.0%) being the most likely to lead to exclusion of potential first-degree relative donors (**Table 3**).

Criteria for LDLT recipients were also examined (**Table 3**). Nearly half (45.2%) of respondents indicated their program has no pre-defined MELD caps for recipient candidacy, with 59.6% of A/ME programs reporting no MELD caps versus 55.0% of European programs (p=0.74) and 29.8% of programs in the Americas (p=0.01 vs A/ME). For programs reporting a MELD cap, there were no regional differences, and the median upper MELD limit was 28 (95% CI: 25, 30). The majority of programs (83.9%) are willing to consider LDLT in fulminant liver failure.

#### Part IV: Living Donor Evaluation Components

Four components of the living liver donor evaluation were examined: routine imaging, assessment of hepatic steatosis, supervised weight loss programs, and hypercoagulable testing (**Table 3**). The most common imaging studies for donor evaluation were MRI (92.7%), CT (92.7%), and ultrasound (52.4%), with 46.0% of all centers routinely using all three approaches. European programs most often use all three modalities (75.0%) versus 59.6% of A/ME programs (p=0.59) and 24.6% of the Americas programs (p<0.01). Liver biopsy remains the gold standard for assessment of liver steatosis (71.8%), followed by MRI (55.6%) and ultrasound (40.3%). The overall mean maximal acceptable degree of macrosteatosis was  $18.2 \pm 8.8\%$  (range 5-40%), with A/ME indicating a higher cut off of  $20.2 \pm 9.2\%$  than the Americas programs ( $16.5 \pm 8.4$ , p=0.04). The majority of programs offer potential living donors supervised weight loss programs for both obesity (60.2%) and hepatic steatosis (59.7%).

The components of the living liver donor hypercoagulable assessment have not been well defined but are often considered to minimize risk of postoperative thromboembolic events in both the donor and the recipient. Overall, programs from Europe and the Americas often complete a more comprehensive hypercoagulable evaluation for potential donors when compared to A/E, with most European and Americas programs testing INR, PTT, Factor V Leiden, Protein C, Protein S, Antithrombin III, and Prothrombin gene mutations (**Table 3**).

#### Part V: Anatomic and Surgical Considerations for LDLT

Anatomic features of the partial allograft and surgical considerations were assessed (**Table 4**). Most programs are willing to use allografts with multiple arteries, bile ducts, and portal venous branches. A/ME programs more often use microscopic arterial reconstruction (66.0%) compared to Europe (40.0%,  $p=0.06$ ) and the Americas (38.6%,  $p=0.01$ ), and both transplant surgeons and plastic surgeons may perform this part of the procedure. Similarly, 63.8% of A/ME programs use  $>3.5\times$  magnification, which was more common than European (30.0%,  $p=0.02$ ) or Americas (43.9%,  $p=0.03$ ) programs. Most programs reconstruct middle hepatic vein branches, with 69.5% reconstructing branches  $\geq 5\text{mm}$ , 16.1% reconstructing all branches, and only 14.5% not routinely reconstructing these branches. The majority of programs perform living donor hepatectomy via an open approach (75.8%), with no geographic variation. Most living liver donors receive venous thromboembolism (VTE) prophylaxis postoperatively (73.4%). Overall, 94.7% of all programs follow living liver donors for at least one-year post-donation.

#### Discussion

To our knowledge, this study represents the first systematic evaluation of the global practice of assessment, selection, and management of living liver donors. Our analysis determined that 68 countries have LDLT centers, suggesting that up to 78% of the global population has local LDLT availability. Even with continued expansion, 19% of the population does not have any access to LDLT or DDLT in their country. A high survey response rate was achieved, with respondents from 41 countries, including 100% of those with  $>50$  LDLT/year. Our data support the concept that geographic variation in availability of deceased donors impacts LDLT practice, and some programs are evaluating up to 1000 potential living donors each year. We observed geographic variations in practice, specifically related to donor age ranges, donor BMI cut offs, acceptable graft steatosis

percent, recipient MELD caps, and donor evaluation components including imaging and hypercoagulable work up.

A recent survey of 24 predominantly high-volume centers in ten countries from Asia, Europe, and North America with LDLT activity examined several features of living liver donor evaluation (21). This study supports several of our findings including an acceptable donor age range, willingness to consider variant anatomy, approach to liver biopsy, and acceptable macrosteatosis percent. With 124 respondents from 41 countries and six continents with a more comprehensive assessment of donor candidacy, surgical issues, and recipient selection, our survey expands upon this important work and allows for comparison across geographic regions. Key parameters of living donor screening, evaluation, surgical care, and recipient candidacy are summarized in **Table 5** and provide a framework for policy development as LDLT continues to expand worldwide.

Society guidelines for living liver donation uniformly emphasize donor safety, but specific criteria have not been widely established (14,15,23). The most recent ILTS Guidelines suggest that donors are “generally between 18 and 60 years of age”, which is in keeping with the majority of our respondents and prior reports including the Adult-to-Adult Living Donor Liver Transplantation (A2ALL) cohort (7,14,21). However, nearly 20% of those surveyed in this study indicated they presently have no formal age cutoff, even among North American centers. Similarly, some programs indicated they would consider a donor as young as 16 years if the intended recipient was the donor’s biological child and the donor received medical and psychosocial clearance. Our data suggest that donors >60 years old who are medically suitable may be considered on a case-by-case basis.

The recent ILTS Guidelines state that “>30% macrosteatosis is an absolute contraindication to donation,” and our survey indicates that most programs follow this recommendation. Interestingly, one A/ME center reported they would accept up to 40% macrosteatosis, while one U.S. program reported a cutoff of 33%. The largest experience using macrosteatotic livers (10-20%) in 92 LDLT recipients in India reported acceptable donor and recipient outcomes, but this donor population was relatively young (median age  $36\pm10$  years) and not obese (BMI  $26.7\pm3.0$ ) (24). In practice, several factors including donor age, donor liver remnant volume, GRWR, recipient age and recipient underlying chronic liver disease are collectively examined when considering a fatty living donor allograft. Our data provide a reference point for acceptable macrosteatosis percent in the current practice of living liver donor selection.

In terms of BMI, the Vancouver Consensus and UK Guidelines both suggested that BMI >30 may increase the risk of surgical complications and that a liver biopsy may/should be considered if

the BMI >30 (15,23). In our study, only 67.5% of respondents reported an upper BMI cutoff, indicating that programs increasingly recognize that obesity is not always associated with hepatic steatosis and may not preclude living donor candidacy (24,25). Among respondents with BMI criteria, A/ME and Americas programs have a higher median acceptable BMI of 35 and 30, respectively, versus 26 for European programs, likely reflecting the challenge of obesity among potential donors in these regions. Indeed, in the A2ALL cohort, 16% of living liver donors had BMI  $\geq 30$ , which was only associated with one post-donation complication on multivariable analysis: an increased risk of hernia formation (7). As well, we observed that 60% of programs have adopted medically supervised weight loss programs to improve candidacy for potential donors with obesity and/or fatty livers, which has been shown to convert previously unacceptable candidates into successful donors without an increase in adverse perioperative outcomes (26). Our survey supports the concept of evaluating higher BMI donor candidates on a case-by-case basis.

Important lessons can be learned from the international experience in the application of LDLT in higher risk situations, including high MELD recipients, fulminant liver failure, and ABO-incompatible donor and recipient pairs. Our data confirm that centers from countries with limited access to DDLT (A/ME) have more liberal approaches to donor age, graft steatosis, recipient MELD. High-volume LDLT centers in Taiwan and India have demonstrated that graft and patient survival for LDLT with MELD  $>30$  is comparable to the outcome in patients with lower MELD scores.(27,28) A recent retrospective review of the more extreme situation of acute liver failure from India, involving >400 LDLT, demonstrated that acceptable donor and recipient outcomes can be achieved, even with urgent time constraints and a critically ill recipient (29). With the development of rituximab-based induction and desensitization protocols, ABO-incompatible LDLT has been expanded, particularly in South Korea and Japan. A meta-analysis examining nearly 4,000 patients determined that there was no difference in graft or patient survival for ABO-incompatible LDLT when compared to ABO-compatible cases, although there was a higher rate of biliary complications (30). Our survey findings confirm that many programs will consider LDLT under these circumstances, assuming that a recipient has limited access to a deceased donor organ and a willing and otherwise compatible living donor.

Despite variances in practice and case volumes, there are many similarities across the global experience. Nearly all programs use MRI and CT scans to evaluate donor anatomy, and liver biopsy is the preferred modality to assess hepatic steatosis when required. Most programs are comfortable with complex anatomical considerations, including multiple arteries, bile ducts, and portal veins.

Respondents from A/ME more often reported the use of microscopic arterial reconstruction, which has been associated with decreased rates of hepatic artery thrombosis (31–33). The need for reconstruction of MHV branches to prevent outflow congestion has been controversial (34–36). Our data indicate that 85.5% of all centers surveyed routinely reconstruct these branches, most often for those ≥5mm. Other similarities include offering supervised weight loss programs to potential living liver donors to improve their candidacy and the inclusion of a hypercoagulable workup. Finally, despite continued innovation of minimally invasive donor hepatectomy, the majority of respondents (75.8%) indicated that the procedure is performed via an open approach at their center, regardless of geography. This is likely related to surgeon experience, emphasis on donor safety via ability to control unexpected bleeding through an open operation, and the observation that most donors do not have negative feelings about their surgical scar (37).

Expansion of the potential living liver donor pool through anonymous donation was first performed in the U.S. in 2000 at our center and has since been reported by centers in the U.S., Canada, and Belgium (38–40). Over the past three years, there has been rapid expansion of anonymous donation in both the U.S. and Canada, with >40 anonymous living liver donors in the U.S. in 2019 alone (38). However, the ethics surrounding this donor population and potential for coercion have led to restrictive policies, particularly among high volume LDLT countries (reviewed in (38)). This is reflected in our survey response, where only 27.7% of centers in A/ME would consider anonymous donation, with some respondents indicating that existing regulations forbid it (Table 3). On the other hand, 60% of European survey respondents indicate that they would consider anonymous donors, which is in keeping with a recent review of global policies indicating that anonymous living organ donation is permitted in Sweden, Italy, Belgium, Denmark, England, Latvia, the Netherlands, Portugal, Scotland, Spain, and Switzerland, while it is prohibited in Bulgaria, the Czech Republic, Estonia, Finland, France, Germany, Hungary, and Lithuania as of 2013 (41). As centers gain experience using anonymous liver donors, consensus guidelines surrounding donor selection and graft allocation will provide standards to guide the ethical use of this unique donor population.

Although our survey was developed in a structured manner by transplant physicians and vetted through professional societies, it was not validated using principle components analysis (42). The impact of each respondent's program-specific protocol component was not linked to post-transplant donor and recipient outcomes. Relationships between various components of the living donor evaluation that might impact overall candidacy, such as age, BMI, and macrosteatosis, could

not be determined. Also, components of the psychosocial evaluation, cardiovascular evaluation, and consequence of abnormal testing during the hypercoagulable workup, such as heterozygous Factor V Leiden, were not assessed.

## Conclusion

Presently, >80% of the global population lives in a country with LT activity, and 68 countries have active LDLT programs. Through distribution of an international survey with a high response rate, key components of the living donor evaluation and recipient LDLT have been summarized and can inform policy development, particularly as LDLT continues to expand (**Table 5**). Importantly, our data provides reference points to key aspects of the donor evaluation, which should continue to emphasize donor safety. While there are considerable variations in LDLT practice and case volume, this study has confirmed that, with experience, surgeons are more comfortable with complex anatomical variations, and programs are increasingly willing to consider higher risk donors and recipients. As donor and recipient selection criteria continue to evolve, ongoing close follow up will be necessary to minimize donor morbidity and maintain acceptable outcomes after both donation and transplantation.

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### Part A: Global Distribution of Liver Transplantation

<b>Global Population</b>	<b>Million people (%)</b>
	7220.4 (100)
<b>Number of countries with reported LDLT cases</b>	68
<b>Global population with access to LDLT</b>	5634.4 (78.2)
<b>Global population with access to DDLT Only</b>	111.2 (1.5)
<b>Global population with access to LDLT Only</b>	753.7 (10.4)
<b>Global population with no access to LT</b>	1372.5 (19.0)

### Part B: Survey Response

Total countries responded

41

Responses by UN Geographic Region (No. of countries with $\geq 10$ LDLT/year)	No. of countries with completed surveys (%)	Population represented by completed surveys (Million)
<b>Africa (2)</b>	2 (100)	146.5
<b>Asia (18)</b>	17 (94.4)	3420.8
<b>Europe (12)</b>	11 (91.7)	557.9
<b>Latin America (4)</b>	4 (100)	320.8
<b>North America (3)</b>	3 (100)	490.3
<b>Oceania (0)</b>	0 (0)	0
Additional surveys from countries with <10 LDLT/year	No. of LDLT/year	Population represented by completed surveys (Million)
<b>Africa (none)</b>	n/a	0
<b>Asia (Viet Nam, Qatar)</b>	3, 3	95.6
<b>Europe (none)</b>	n/a	26.9
<b>Latin America (Costa Rica)</b>	2	4.9
<b>North America (none)</b>	n/a	0
<b>Oceania (New Zealand)</b>	3	4.7
Completed surveys from high volume LDLT countries (>50 cases/year)	No. LDLT/year	No. of centers responded
<b>India</b>	1200	11
<b>Turkey</b>	1004	4
<b>South Korea</b>	942	5
<b>Egypt</b>	450	2
<b>China</b>	408	2
<b>Japan</b>	381	3
<b>United States</b>	359	43
<b>Brazil</b>	186	2
<b>Pakistan</b>	177	1
<b>Jordan</b>	174	2

Saudi Arabia	147	2
Russia	130	1
Canada	61	2
Germany	61	3
Kazakhstan	57	2

**Table 1: Global distribution of LDLT.** Population and LT volume data are based on most recently reported year for each country in the WHO Global Observatory on Donation and Transplantation.

Individual Respondents	Total: 124	Asia/Middle East: 47	Europe: 20	Americas: 57
	Median [95% CI] Range	Median [95% CI] Range	Median [95% CI] Range	Median [95% CI] Range
No. LDLT/year	15 [15,20] (1-400)	30 [30,50] (2-400)	8 [8,15] (1-80)	10 [10,15] (1-110)
No. potential donors evaluated/ year	30 [25,40] (1-1000)	60 [60,100] (5-1000)	20 [20,30] (1-200)	30 [30,36] (1-300)
Years LDLT activity (N, %)				
#1-5	21 (16.9)	9 (19.1)	1 (5.0)	11 (19.3)
#6-10	21 (16.9)	11 (23.4)	2 (10.0)	8 (14.0)
≥10	82 (66.1)	27 (57.4)	17 (85.0)	38 (66.7)
Recipient Population (N, %)				
Pediatric Only	15 (12.1)	2 (4.3)	5 (25.0)	8 (14.0)
Adult Only	33 (26.6)	14 (29.8)	5 (25.0)	14 (24.6)
Adult and Pediatric	76 (61.3)	31 (66.0)	10 (50.0)	35 (61.4)

**Table 2: Survey Respondents.**

	Total: 124		Asia/ Middle East: 47		Europe: 20		Americas: 57		P-Values			
	N	%	N	%	N	%	N	%	Overall	A/ME vs Europe	A/ME vs Americas	Europe vs Americas
<b>Donor Screening</b>												
Defined donor age range, yes	102	82.3	40	85.1	12	60.0	50	87.7	0.03	0.05	0.78	0.02
Lower Age Limit, Median (95% CI)	18	[18,18]	18	[18,18]	18	[18,18]	18	[18,18]	0.49	0.35	0.34	0.69
Upper Age Limit, Median (95% CI)	55	[55,60]	55	[55,60]	60	[60,60]	55	[55,60]	0.29	0.17	0.22	0.98
ABO-i living donors, yes	55	44.4	24	51.1	9	45.0	22	38.6	0.44	0.79	0.24	0.79
If yes, for which recipients?												
Any blood group	33	26.6	19	40.4	6	30.0	8	14.0	0.01	0.58	<0.01	0.17
Fulminant	18	14.5	4	8.5	3	15.0	11	19.3	0.3	0.42	0.16	0.99
Defined donor BMI range, yes	83	67.5	31	67.4	14	70.0	38	66.7	0.86	0.99	0.64	0.99
Lower BMI Limit, Median (95% CI)	18	[18,19]	18	[18,20]	18	[18,19]	18.5	[18.5,20]	0.37	0.28	0.65	0.16
Upper BMI Limit, Median (95% CI)	30	[30,32]	31	[31,34]	30	[30,30]	32	[32,35]	0.04	0.02	0.79	0.01
<b>Special Situations</b>												
Anonymous nondirected donors, yes	57	46.0	13	27.7	12	60.0	32	56.1	0.01	0.03	0.01	0.8
Transfusion-free (i.e. Jehovah's Witness) donors, yes	32	25.8	15	31.9	8	40.0	9	15.8	0.04	0.58	0.06	0.03
<b>Recipient Screening</b>												
May exclude donors of first-degree relative recipients with:												
Non-Alcoholic Steatohepatitis	24	19.8	7	15.6	4	20.0	13	23.2	0.68	0.73	0.45	0.99
Primary Biliary Cholangitis	42	34.7	13	28.9	7	35.0	22	39.3	0.55	0.77	0.3	0.79
Primary Sclerosing Cholangitis	50	41.3	23	51.1	6	30.0	21	37.5	0.22	0.18	0.23	0.6
Alpha-1-Antitrypsin Deficiency	51	42.1	15	33.3	7	35.0	29	51.8	0.14	0.99	0.07	0.3
MELD Cut Off for LDLT												
None pre-defined	56	45.2	28	59.6	11	55.0	17	29.8	0.03	0.74	0.01	0.14
If pre-defined, median [95% CI]	28	[25,30]	30	[30,35]	26	[26,26]	28	[28,30]	0.48	0.39	0.24	0.6
LDLT in Fulminant Liver Failure, Yes	104	83.9	42	89.1	19	95	43	75.4	0.07	0.66	0.08	0.1
<b>Donor Evaluation</b>												
<b>Routine Imaging Modalities:</b>												
MRI	115	92.7	42	89.4	19	95.0	54	94.7	0.65	0.66	0.46	0.99
CT	115	92.7	47	100	20	100	48	84.2	<0.01	0.99	<0.01	0.1
Ultrasound	65	52.4	30	63.8	16	80.0	19	33.3	<0.01	0.26	<0.01	<0.01
Other	11	8.9	3	6.4	5	25.0	3	5.3	0.03	0.05	0.99	0.02
<b>Imaging Patterns</b>												
MRI + CT + US	57	46.0	28	59.6	15	75.0	14	24.6	<0.01	0.59	<0.01	<0.01
MRI + CT	49	39.5	14	29.8	4	20.0	31	54.4				
MRI only	7	5.6	0	0.0	0	0.0	7	12.3				
Other	11	8.9	5	10.6	1	5.0	5	8.8				

Approach to assess liver steatosis:										
MRI	69	55.6	19	40.4	12	60.0	38	66.7	0.02	0.18
Liver biopsy	89	71.8	31	66.0	13	65.0	45	78.9	0.25	0.99
Ultrasound	50	40.3	21	44.7	11	55.0	18	31.6	0.14	0.59
Other	22	17.7	15	31.9	2	10.0	5	8.8	0.01	0.07
<b>Max. macrosteatosis, mean±SD</b>	<b>18.2±8.9</b>		<b>20.2±9.2</b>		<b>18.0±9.1</b>		<b>16.5±8.4</b>		0.13	0.39
[range]	[5-40]		[5-40]		[5-35]		[5-35]		0.04	0.52
Supervised weight loss programs:										
Weight loss for BMI cut off, yes	74	60.2	32	69.6	11	55.0	31	54.4	0.25	0.27
Weight loss for hepatic steatosis, yes	74	59.7	31	66.0	13	65.0	30	52.6	0.39	0.99
Hypercoagulable Evaluation:										
INR	109	87.9	38	80.9	19	95.0	52	91.2	0.21	0.26
PTT	104	83.9	35	74.5	19	95.0	50	87.7	0.09	0.09
Factor V Leiden	70	56.5	16	34.0	14	70.0	40	70.2	<0.01	0.01
Protein C	75	60.5	24	51.1	15	75.0	36	63.2	0.17	0.1
Protein S	70	56.5	21	44.7	15	75.0	34	59.6	0.06	0.03
Antithrombin III	73	58.0	23	48.9	16	80.0	34	59.6	0.06	0.03
Prothrombin gene mutations	49	39.5	13	27.7	9	45.0	27	47.4	0.1	0.26
Fibrinogen	63	50.8	19	40.4	18	90.0	26	45.6	<0.01	<0.01
Anticardiolipin antibody	46	37.1	13	27.7	9	45.0	24	42.1	0.24	0.26
Homocysteine	38	30.6	9	19.1	8	40.0	21	36.8	0.09	0.12
Factor VIII	34	27.4	8	17.0	8	40.0	18	31.6	0.09	0.06
Other	5	4.0	1	2.1	1	5.0	3	5.3%	0.71	0.51
									0.62	0.99

**Table 3: Living Donor Screening Criteria and Evaluation.**

	Total: 124		Asia/Middle East: 47		Europe: 20		Americas: 57		P-Values				
	N	%	N	%	N	%	N	%	Overall	A/ME vs Europe	A/ME vs Americas	Europe vs Americas	
<b>Anatomic Considerations</b>													
<b>Arterial Anatomy (acceptable)</b>													
1 artery only	33	26.6	13	27.7	3	15.0	17	29.8	0.44	0.36	0.83	0.25	
>1 artery	91	73.4	34	72.3	17	85.0	40	70.2					
<b>Microscopic Arterial Reconstruction</b>													
Utilized	61	49.2	31	66.0	8	40.0	22	38.6	0.01	0.06	0.01	0.99	
<i>If yes, surgeon type:</i>													
Transplant Surgeon	43	34.7	23	48.9	6	30.0	14	24.6	0.03	0.19	0.01	0.77	
Plastic Surgeon	27	21.8	13	27.7	4	20.0	10	17.5	0.45	0.76	0.24	0.75	
Case by Case	14	11.3	5	10.6	1	5.0	8	14.0	0.6	0.66	0.77	0.43	
<b>Magnification Level</b>													
2.5x	19	15.3	8	17.0	4	20.0	7	12.3	0.02	0.02	0.03	0.46	
3.5x	44	35.5	9	19.1	10	50.0	25	43.9					
>3.5x	61	49.2	30	63.8	6	30.0	25	43.9					
<b>Portal Venous Anatomy (acceptable)</b>													
1 PV only	37	29.8	9	19.1	10	50.0	18	31.6	0.04	0.02	0.18	0.18	
>1 PV	87	70.2	38	80.9	10	50.0	39	68.4					
<b>Hepatic Venous Anatomy (acceptable)</b>													
1 HV only	13	10.6	4	8.7	2	10.0	7	12.3	0.92	0.99	0.75	0.99	
>1 HV	110	89.4	42	91.3	18	90.0	50	87.7					
<b>Reconstruction of MHV branches</b>													
No	18	14.5	2	4.3	5	25.0	11	19.3	0.08	0.05	0.05	0.73	
Yes, >5 mm	86	69.4	35	74.5	12	60.0	39	68.4					
Yes, all branches	20	16.1	10	21.3	3	15.0	7	12.3					
<b>Biliary Anatomy (acceptable)</b>													
1 bile duct only	10	8.1	3	6.4	1	5.0	6	10.5	0.24	0.14	0.22	0.64	
2 bile ducts	80	64.5	26	55.3	16	80.0	38	66.7					
3+ bile ducts	34	27.4	18	38.3	3	15.0	13	22.8					
<b>Surgical Considerations</b>													
<b>Surgical Approach</b>													
Open	94	75.8	34	72.3	13	65.0	47	82.5	0.56	0.74	0.51	0.25	
Laparoscopic, left lateral	11	8.9	5	10.6	3	15.0	3	5.3					

segments only											
Laparoscopic, left or right lobe	15	12.1	7	14.9	3	15.0	5	8.8			
<b>Post-operative thromboprophylaxis</b>											
None	24	19.4	17	36.2	1	5.0	6	10.5	<0.01	0.01	<0.01
Heparin prophylaxis	91	73.4	27	57.4	18	90.0	46	80.7			
Therapeutic anticoagulation	6	4.8	3	6.4	0	0.0	3	5.3			
<b>Duration of post-donation follow up</b>											
3 months	11	8.9	8	17.0	1	5.0	2	3.5	0.01	0.5	0.01
6 months	8	6.5	4	8.5	3	15.0	1	1.8			
1 Year	31	25.0	13	27.7	7	35.0	11	19.3			
>1 year	74	59.7	22	46.8	9	45.0	43	75.4			

**Table 4: Anatomic and Surgical Considerations.**

### Screening of Potential Living Liver Donors

<b>Age Range:</b>	18-60 years; consideration of older donors on a case-by-case basis
<b>ABO-incompatibility:</b>	Evaluate in countries with limited access to deceased donors, programs with ABO-incompatibility protocols, and/or when potential donors are willing to consider a paired exchange.
<b>Acceptable BMI:</b>	18-35 kg/m <sup>2</sup> ; Consideration of higher BMI candidates on a case-by-case basis
<b>Anonymous donation:</b>	If permitted by local regulations and program has parameters for evaluation and allocation.
<b>Transfusion-free donation:</b>	If permitted by local regulations and program has parameters for evaluation and allocation.

### Recipient Candidacy for LDLT

<b>MELD Cutoff:</b>	Judicious use of LDLT in recipients with MELD >30. At discretion of program based on experience and availability of deceased organ donors.
<b>Fulminant Liver Failure:</b>	Acceptable; at discretion of program based on experience and availability of deceased organ donors.

### Living Donor Evaluation

<b>Imaging:</b>	Minimum: MRI + CT Scan. Additional modalities per program preference.
<b>Hepatic steatosis</b>	Assessed via biopsy versus MRI depending on local resources Grafts with ≤20% macrosteatosis may be considered.
<b>Medically supervised weight loss programs</b>	Widely used to support donors who do not meet BMI and/or steatosis criteria for donation.
<b>Hypercoagulable workup:</b>	At a minimum: INR, PTT, Fibrinogen, Factor V Leiden, Protein C, Protein S, Anti-thrombin III.
<b>Anatomic Features:</b>	

<b>Arterial anatomy:</b>	≥2 widely considered acceptable, microscopic reconstruction at discretion of surgeon/program.
<b>Biliary anatomy:</b>	≥2 widely considered acceptable.
<b>MHV branch reconstruction:</b>	Performed by most centers, especially for branches ≥5mm.

*Postoperative Management of Living Liver Donors*

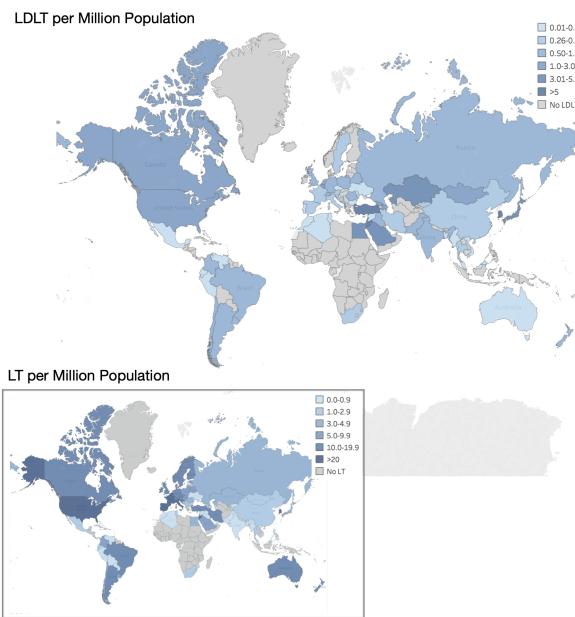
<b>VTE Prophylaxis</b>	Chemical per guidelines for major surgical procedures.
<b>Follow up</b>	≥1 year

**Table 5: Summary of donor evaluation and LDLT candidacy based on survey data.**

## Figure Legends

**Figure 1:** Global distribution of liver transplantation (inset) and living donor liver transplantation.

# Accepted Article



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