

“How much data do we need to convince us to increase adult to adult LDLT?”

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September 2025

Penn Transplant Institute

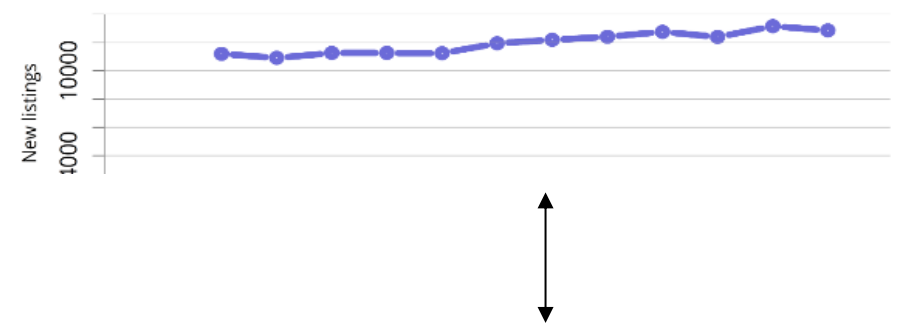


Penn Medicine

**Samir Abu-Gazala, MD –
No CI**

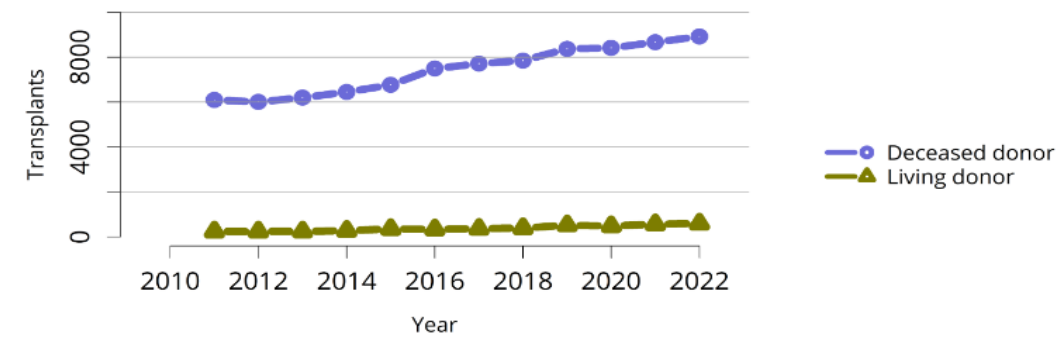


Adult liver transplantation: The problem with scarcity



Patients on Waitlist

Figure LI 55: Total liver transplants by donor type



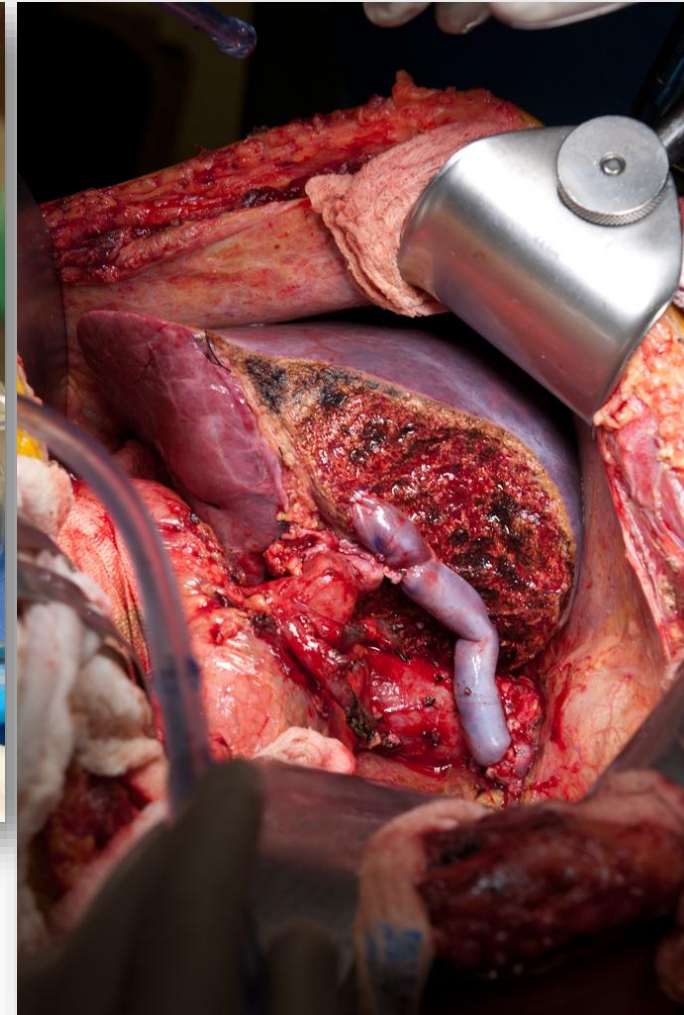
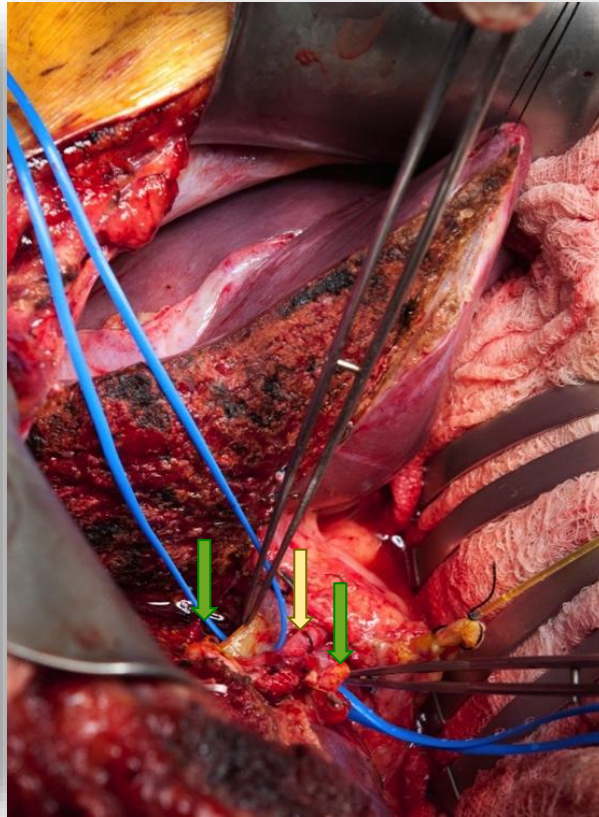
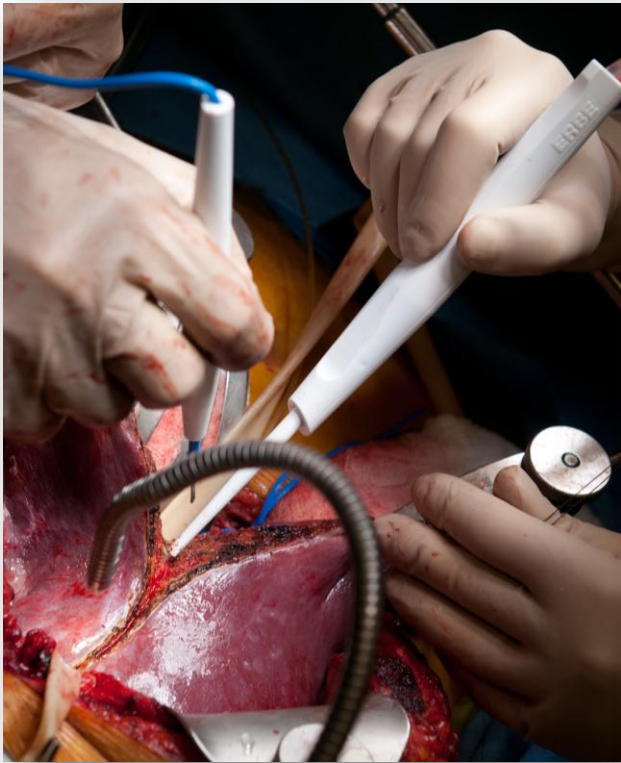
Liver Transplant

OPTN/SRTR 2022 Annual Data Report

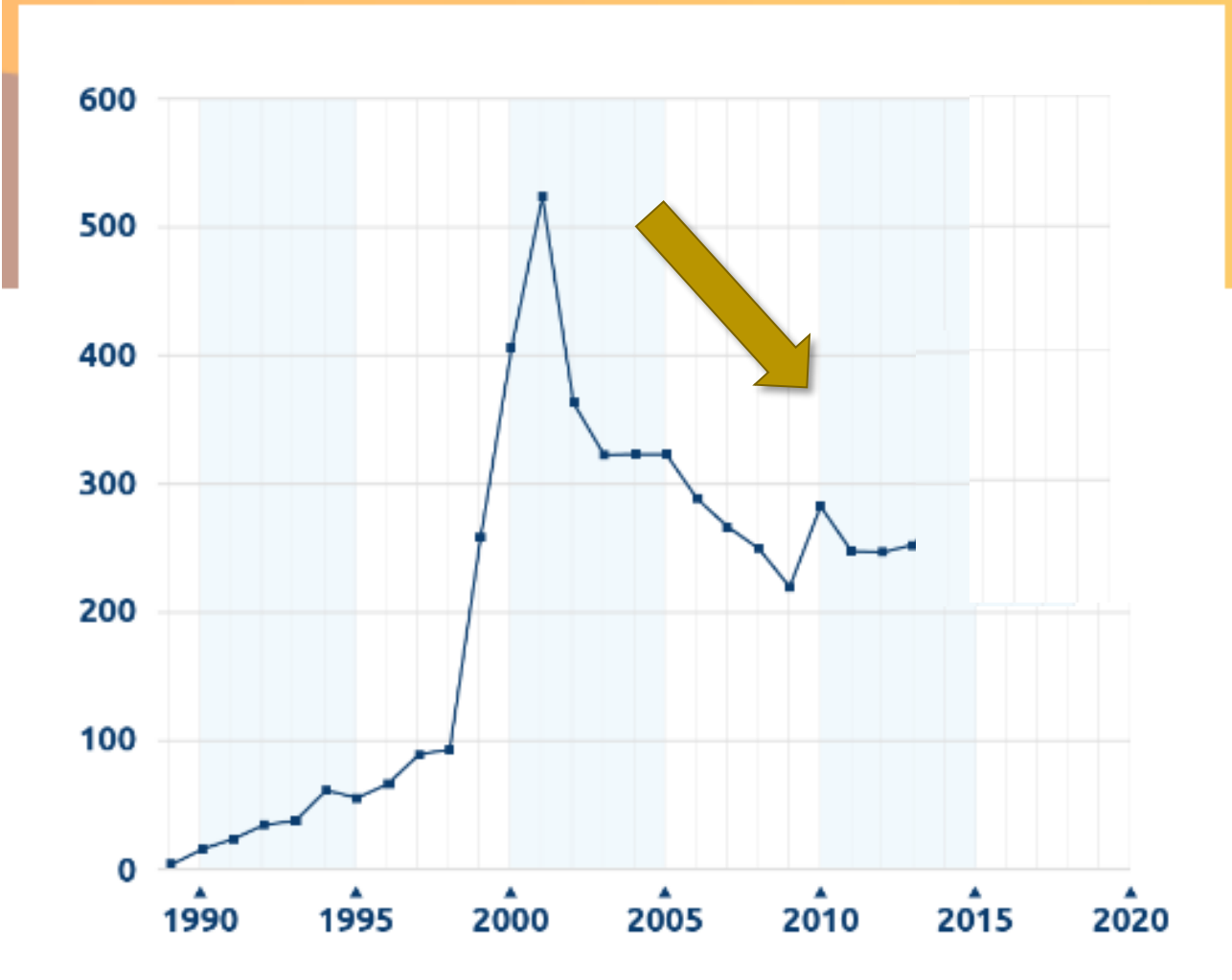


<https://doi.org/10.1111/ajt.16978>

Amazing LDLT surgery...



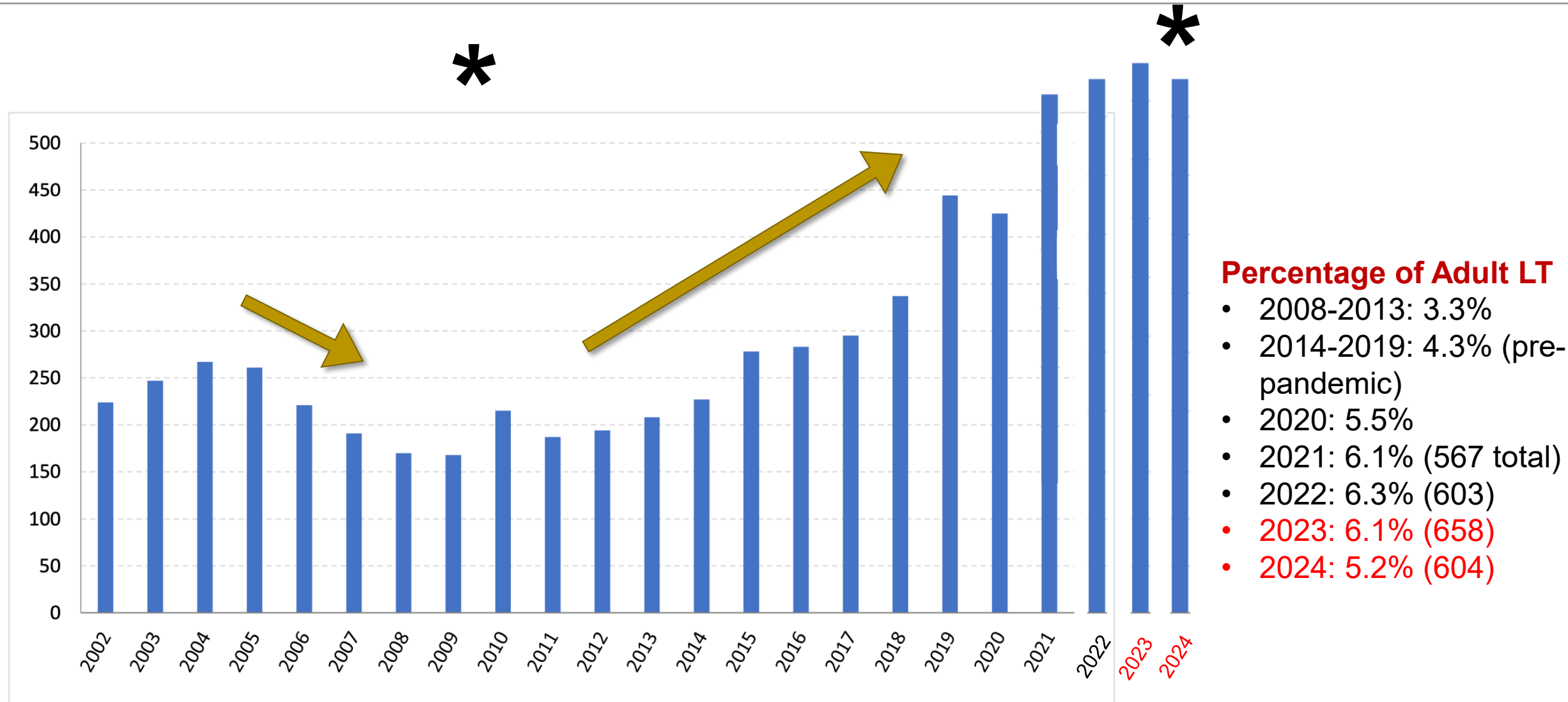
When LDLT became LESS trendy...



Living liver donor transplant volume in the US, 1989 – 2019

Based on OPTN data as of Mar. 23, 2020. Data subject to change.

LDLT cases over time (USA)



A2ALL



Adult to Adult
Living Donor Liver
Transplantation
Cohort Study

- ◆ **Consortium of 12 transplant centers**
 - NIH funded, started 2002
 - Conducted retrospective and prospective studies
 - The first multicenter LDLT prospective study
- ◆ **Primary goal: study outcomes of donors and recipients of LDLT compared to DDLT at experienced centers**

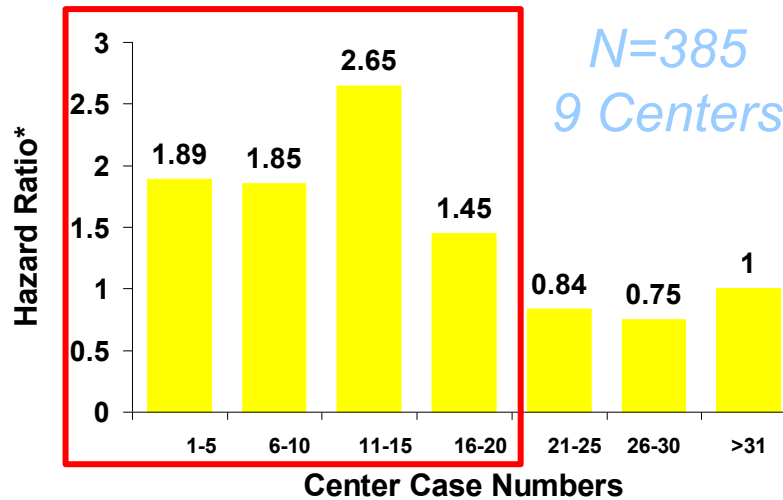
A2ALL 1 2002-2009	A2ALL 2 2009-2014
U of Colorado (Kam)	U of Colorado (Kam)
UCSF (Freise)	UCSF (Freise)
Northwestern (Abecassis)	Northwestern (Abecassis)
Columbia (Emond)	Columbia (Emond)
U Penn (Shaked)	U Penn (Olthoff)
Virginia Commonwealth (Fisher)	Virginia Commonwealth (Fisher)
U of Virginia (Pruett)	Lahey Clinic (Pomfret)
UCLA (Ghobrial)	Pittsburgh (Humar)
U North Carolina (Fair)	Toronto (Grant)
DCC – U of Michigan (Merion)	DCC – U of M/Arbor Research (Merion)

A2ALL Early Significant Findings

Outcomes of 385 Adult-to-Adult Living Donor Liver Transplant Recipients

A Report From the A2ALL Consortium

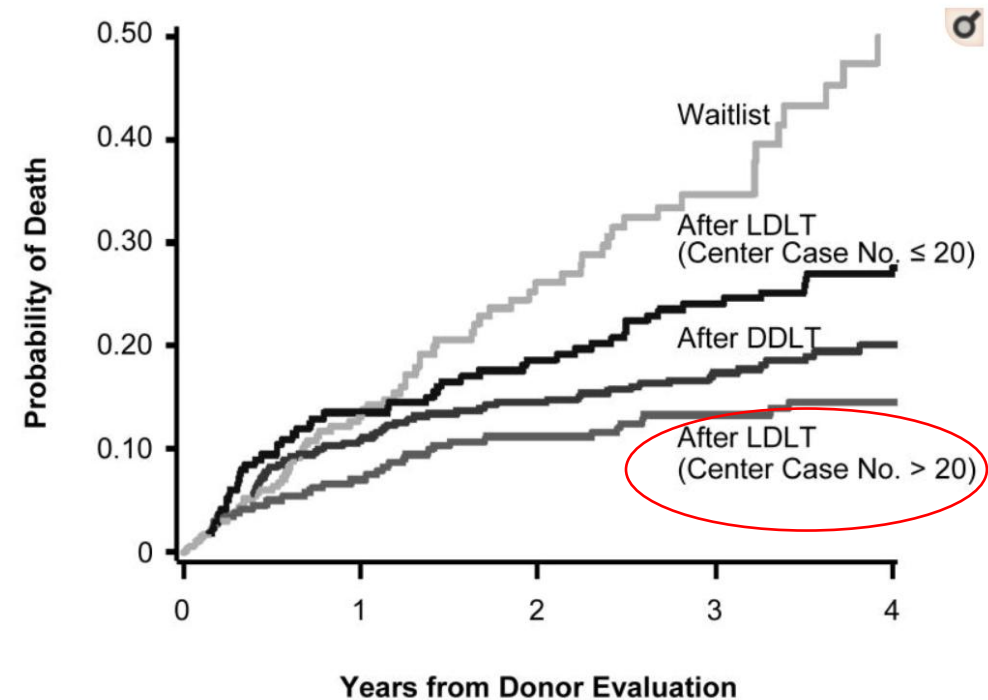
Kim M. Olthoff, MD,* Robert M. Merion, MD,†‡ Rafik M. Ghobrial, MD, PhD,§
Michael M. Abecassis, MD,|| Jeffrey H. Fair, MD,¶ Robert A. Fisher, MD,**
Chris E. Freise, MD,†† Igal Kam, MD,‡‡ Timothy L. Pruett, MD,§§ James E. Everhart, MD,|||
Tempie E. Hulbert-Shearon, MS,‡‡ Brenda W. Gillespie, PhD,||||
Jean C. Emond, MD,¶¶ and the A2ALL Study Group



Olthoff KM et al Ann Surg 2005

Improvement in Survival Associated With Adult-to-Adult Living Donor Liver Transplantation

CARL L. BERG,* BRENDA W. GILLESPIE,† ROBERT M. MERION,§ ROBERT S. BROWN Jr,|| MICHAEL M. ABECASSIS,¶
JAMES F. TROTTER,‡ ROBERT A. FISHER,** CHRIS E. FREISE,†† R. MARK GHOBRIAL,§§ ABRAHAM SHAKED,|||
JEFFREY H. FAIR,¶¶ JAMES E. EVERHART,‡‡ and the A2ALL Study Group



Berg C et al Gastroenterology 2007

Donor Complications



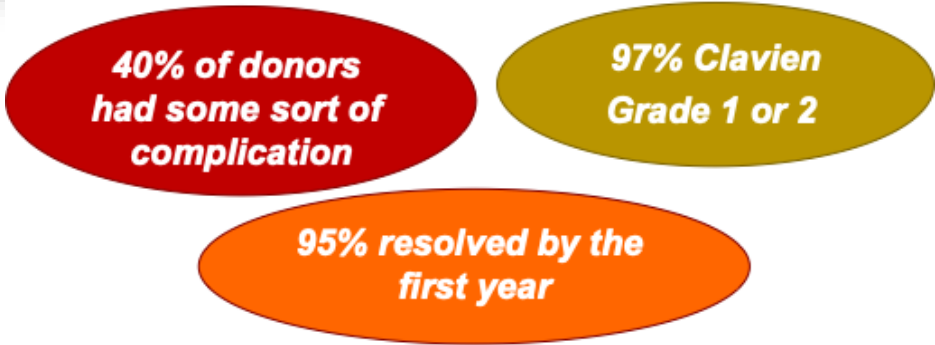
American Journal of Transplantation 2012; 12: 1208–1217
Wiley Periodicals Inc.

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and the American Society of Transplant Surgeons
doi: 10.1111/j.1600-6143.2011.03972.x

Complications of Living Donor Hepatic Lobectomy—A Comprehensive Report

M. M. Abecassis^{a,*}, R. A. Fisher^b, K. M. Olthoff^c,
C. E. Freise^d, D. R. Rodrigo^e, B. Samstein^f,
I. Kam^g, R. M. Merion^{a,h} and the A2ALL
Study Group^{k†}

760 donor procedures, 20 were aborted and 740 were completed. Forty percent of donors had complications (557 complications among 296 donors), mostly Clavien grades 1 and 2. Most severe counted by complication category; grade 1 (minor, n = 232); grade 2 (possibly life-threatening, n = 220); grade 3 (residual disability, n = 105); grade 4 (life-threatening, n = 10); grade 5 (death, n = 1).



Ghobrial et al Gastroenterology 2008
Abecassis et al, AJT 2012

ASA PAPER

Defining Benchmarks for Major Liver Surgery

A multicenter Analysis of 5202 Living Liver Donors

Fabian Rössler, MD,* Gonzalo Sapisochin, MD,† GiWon Song, MD,‡ Yu-Hung Lin, MD,§ Mary Ann Simpson, MD, PhD,¶|| Kiyoshi Hasegawa, MD, PhD,|| Andrea Laurenzi, MD,** Santiago Sánchez Cabús, MD, PhD,†† Milton Inostroza Nunez, MD,‡‡ Andrea Gatti, MD,§§ Magali Chahdi Beltrame, MD,¶¶ Ksenija Slankamenac, MD, PhD,* Paul D. Greig, MD,† Sung-Gyu Lee, MD, PhD,‡ Chao-Long Chen, MD, PhD,§ David R. Grant, MD,† Elizabeth A. Pomfret, MD, PhD,¶ Norihiro Kokudo, MD, PhD,|| Daniel Cherqui, MD,** Kim M. Olthoff, MD,|||| Abraham Shaked, MD,|||| Juan Carlos García-Valdecasas, MD, PhD,†† Jan Lerut, MD, PhD,‡‡ Roberto I. Troisi, MD, PhD,§§ Martin De Santibanes, MD,¶¶ Henrik Petrowsky, MD,* Milo A. Puhon, MD, PhD,*** and Pierre-Alain Clavien, MD, PhD*

TABLE 4. Benchmark Values			
	At Discharge	After 3 Months	After 6 Months
Any complication	26.9%	31.2%	31.2%
Major complications (≥IIIa)	6.0%	8.1%	9.2%
Minor complications (≤II)	18.9%	22.6%	22.6%
CCI	27.9	32.6	32.7
Liver failure			
ISGLS	4.8%	Same	—
With complications	3.4%	Same	—

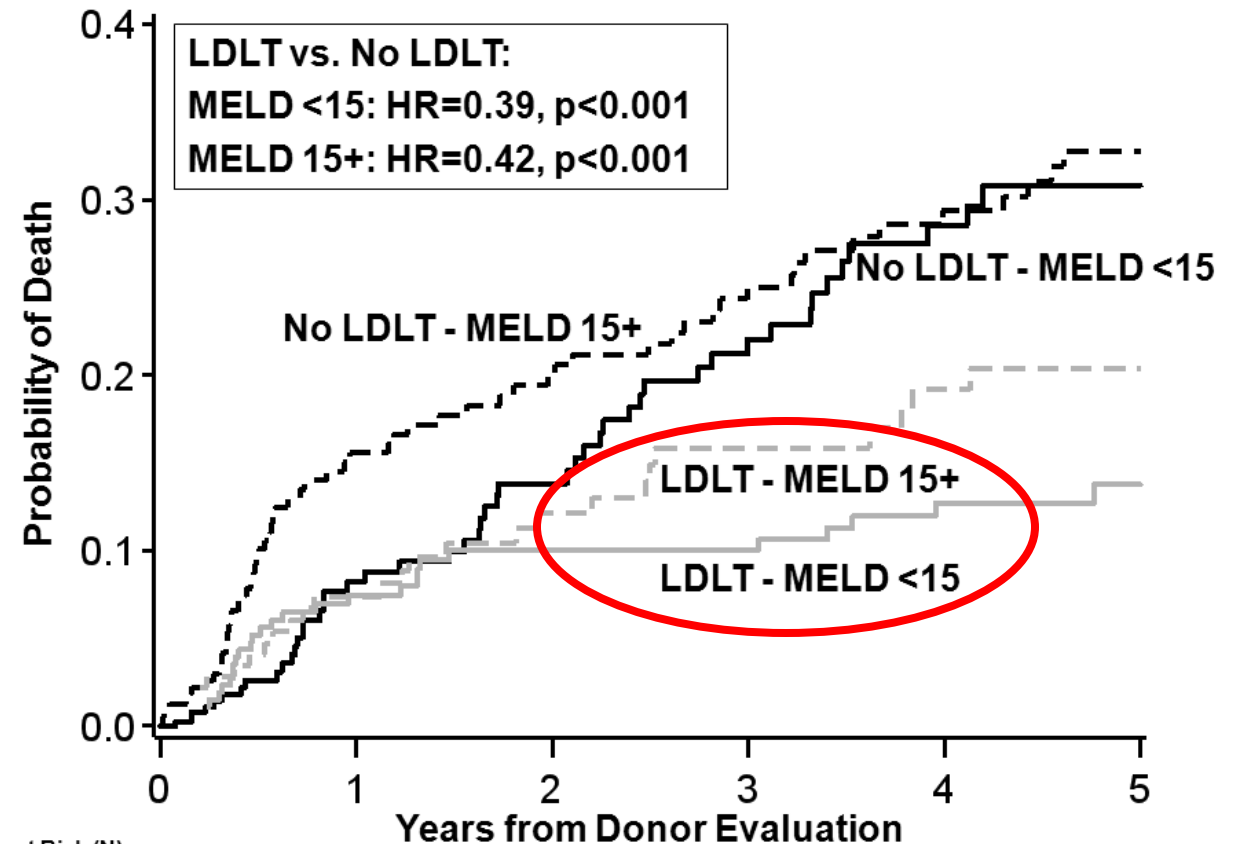
Values are the 75th percentile of median proportions. ISGLS, defined as positive according to the International Study Group for Liver Surgery, as INR ≥1.3 and bilirubin ≥1.2 mg/dL on postoperative day 5.

Rössler F et al Ann Surg 2016

Benefit of Early Transplant

Liver Transplant Recipient Survival Benefit with Living Donation in the Model for Endstage Liver Disease Allocation Era

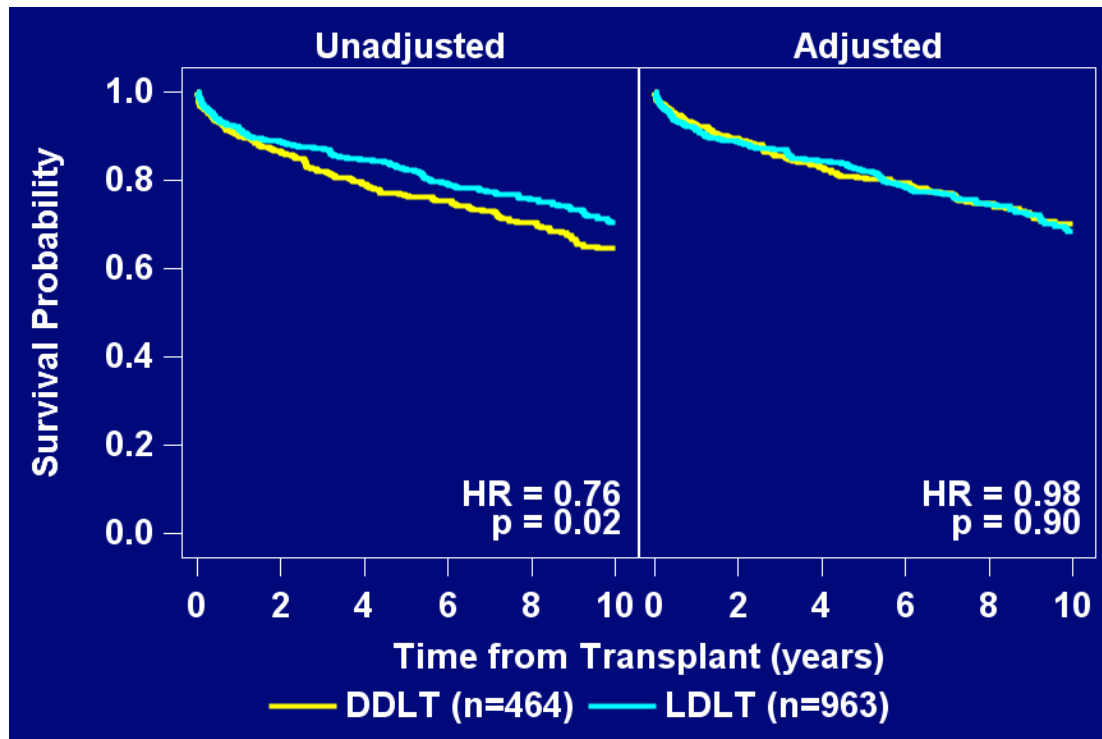
Carl L. Berg,¹ Robert M. Merion,² Tempie H. Shearon,³ Kim M. Olthoff,⁴ Robert S. Brown Jr.,⁵
 Talia B. Baker,⁶ Gregory T. Everson,⁷ Johnny C. Hong,⁸ Norah Terrault,⁹ Paul H. Hayashi,¹⁰
 Robert A. Fisher,¹¹ and James E. Everhart¹²



Patients at Risk (N)							
No LDLT-MELD 15+	415	330	274	230	193	144	
No LDLT-MELD<15	453	376	311	263	199	140	
LDLT-MELD<15	224	195	164	147	114	81	
LDLT-MELD 15+	182	162	129	109	92	68	

Berg C et al Hepatology 2011

Long-term Patient and Graft Survival: LDLT vs DDLT



LDLT provides significant benefit, allowing transplantation at **lower MELD score**, decreased death on the waitlist, and equivalent post-transplant survival to DDLT

*After adjusting for age, gender, diagnosis, HD at transplant, MELD, and donor age, the mortality risk was similar

Olthoff et al Ann Surg 2015

LDLT vs DDLT: Demographics and Outcome

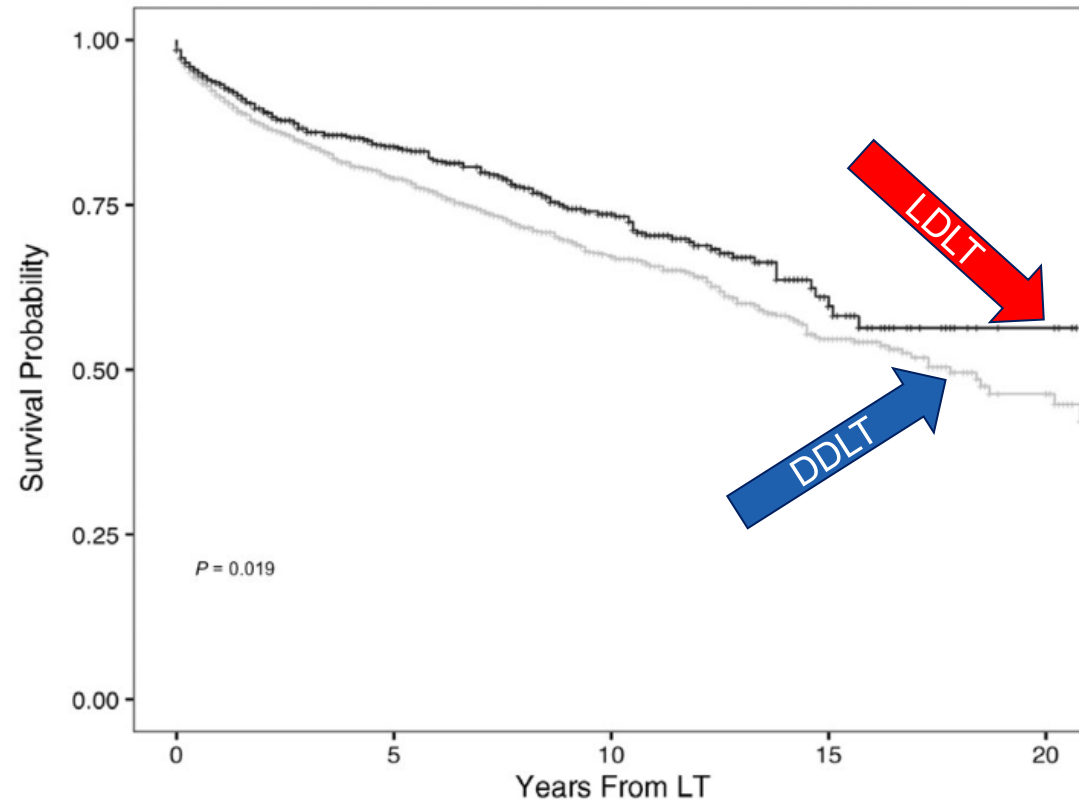
Toronto study, 2000-2020

~700 LDLT cases

- ◆ Lower MELD
- ◆ Shorter Wait-time
- ◆ Shorter LOS
- ◆ Better unadjusted survival*
1yr, 10yr, 20r
- ◆ More early Biliary complications

*similar adjusted survival

Superior Long-Term Outcomes of Adult Living Donor Liver Transplantation:
A Cumulative Single-Center Cohort
Study With 20 Years of Follow-Up



Meta-analysis of outcomes of LDLT vs DDLT

- ♦ 8600 abstracts reviewed
- ♦ 4571 LDLT and 66,826 DDLT patients examined

- ♦ **LDLT associated with:**
 - Lower mortality at 1,3,5 years
 - Lower MELD at transplant
 - Shorter waiting times
 - Lower risk of rejection
 - Higher biliary complications

Received: 11 September 2020 | Revised: 1 December 2020 | Accepted: 1 December 2020
DOI: 10.1111/ajt.16440

ORIGINAL ARTICLE

AJT

Meta-analysis and meta-regression of outcomes for adult living donor liver transplantation versus deceased donor liver transplantation

Arianna Barbetta^{1,2} | Mayada Aljehani³ | Michelle Kim^{1,2} | Christine Tien² |
Aaron Ahearn^{1,2} | Hannah Schilperoort⁴ | Linda Sher^{1,2} | Juliet Emamaullee^{1,2} 

Survival Benefit of LDLT

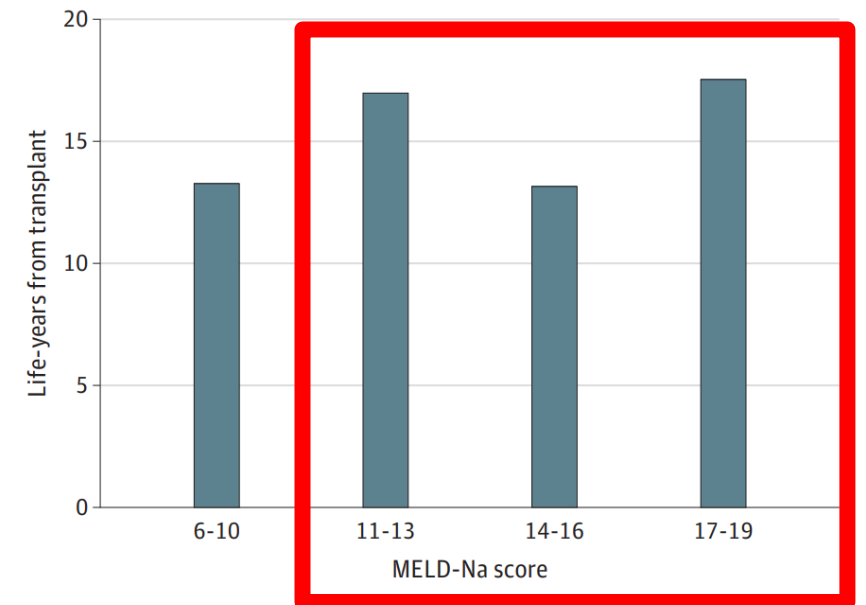
JAMA Surgery | Original Investigation

Survival Benefit of Living-Donor Liver Transplant

Whitney E. Jackson, MD; John S. Malamon, PhD; Bruce Kaplan, MD; Jessica L. Saben, PhD; Jesse D. Schold, PhD;
James J. Pomposelli, MD, PhD; Elizabeth A. Pomfret, MD, PhD

- ◆ SRTR database 2012-2021
- ◆ 119,275 liver transplant candidates
- ◆ 2820 LDLT
- ◆ Significant survival benefit for patients receiving LDLT (**MELD $\geq$ 11**)
- ◆ LDLT recipient gained an additional 13-17 life-years
 - **More than any other lifesaving procedure**
 - More than DDLT

Figure 3. Life-Years Saved After Living-Donor Liver Transplant



LDLT vs DDLT: Demographics and Outcome

Adult Living Donor Versus Deceased Donor Liver Transplant (LDLT Versus DDLT) at a Single Center

Time to Change Our Paradigm for Liver Transplant

UPMC study, 2009-2019

- ◆ Lower MELD
- ◆ More HCC
- ◆ Shorter LOS
- ◆ Fewer blood transfusions
- ◆ Less renal dysfunction
- ◆ Lower cost
- ◆ More biliary complications

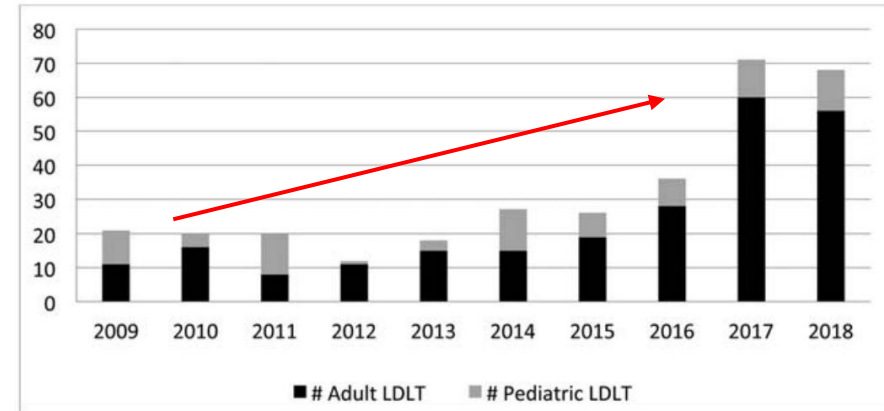
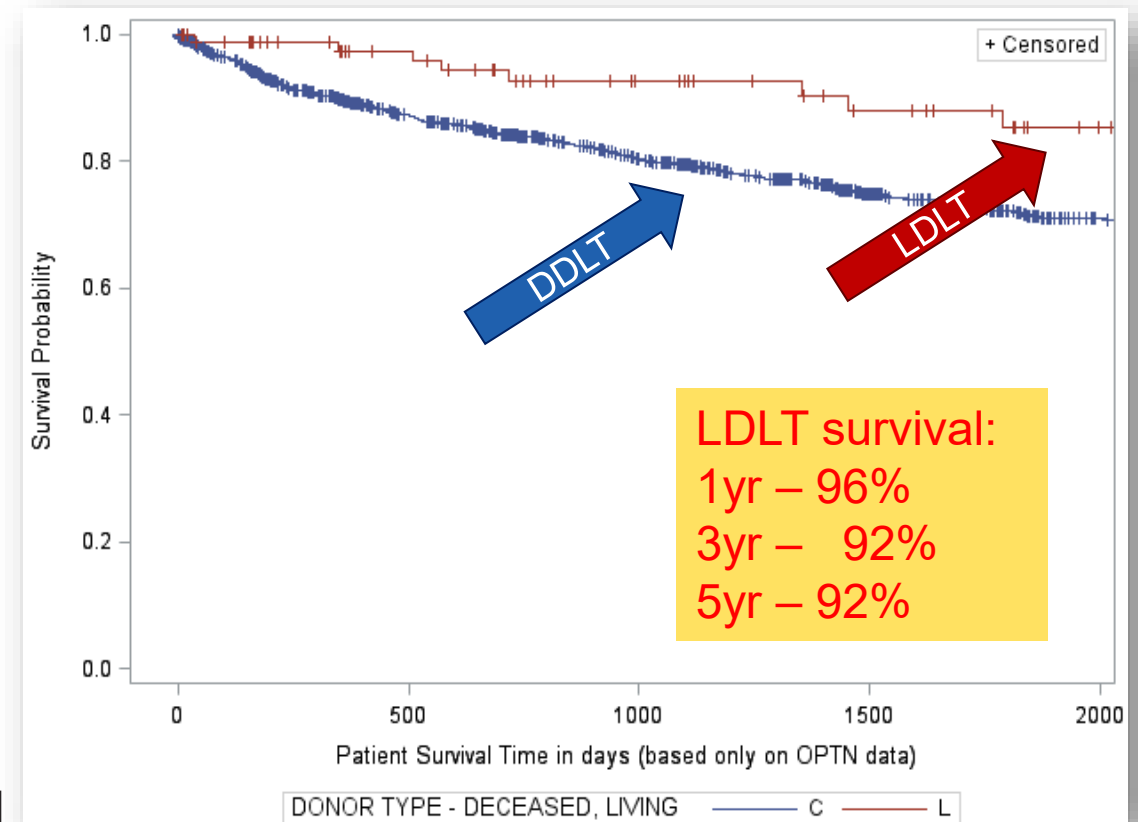
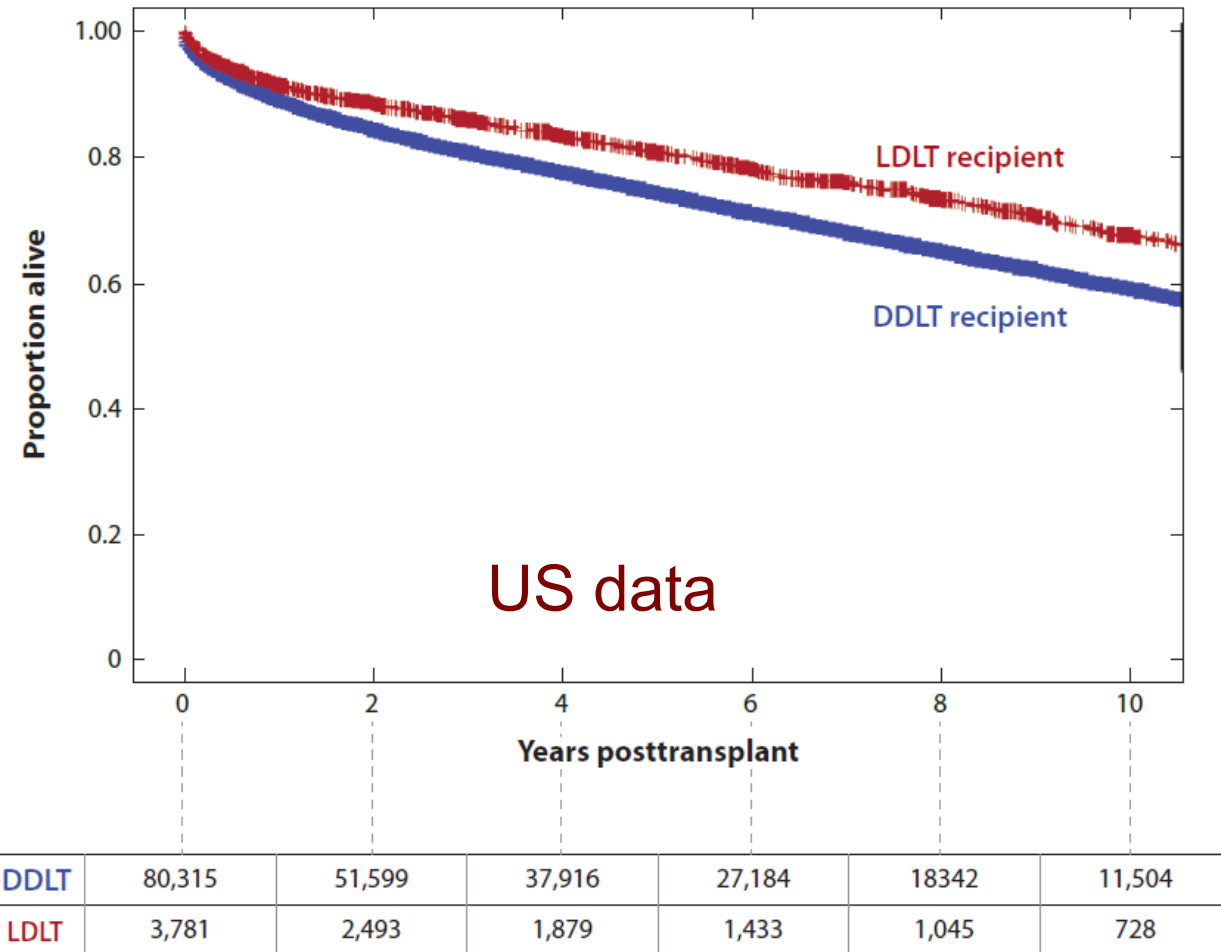


FIGURE 1. The number of LDLT, both adult and pediatric, being done at UPMC on a yearly basis for the last 10 years.

Long-term Survival : LDLT vs DDLT in the US & at Penn



Penn Patients

Cost and Utilization of LDLT vs DDLT

TABLE 4. Cost and Utilization Comparison of LDLT vs DDLT Done in 2017. Includes All Costs and Utilizations From 6 Months Before Transplant to 1-Year Posttransplant

Variable	LDLT N = 60	DDLT N = 52
Pretransplant average number of radiology scans	2.6	3.4
Posttransplant average number of radiology scans	8.6	12.0
Posttransplant average number of emergency room visits	0.5	0.7
Posttransplant average number of GI or other invasive procedures (outpatient)	0.2	0.7
Total Number of outpatient labs	25% Lower	—
Total pretransplant costs (6 mo)	23.5% Lower	—
Total inpatient perioperative costs	31.7% Lower	—
Total posttransplant costs (1 y)	26.0% Lower	—
Total inpatient and outpatient pre and posttransplant costs	29.5% Lower	—

GI indicates gastrointestinal.

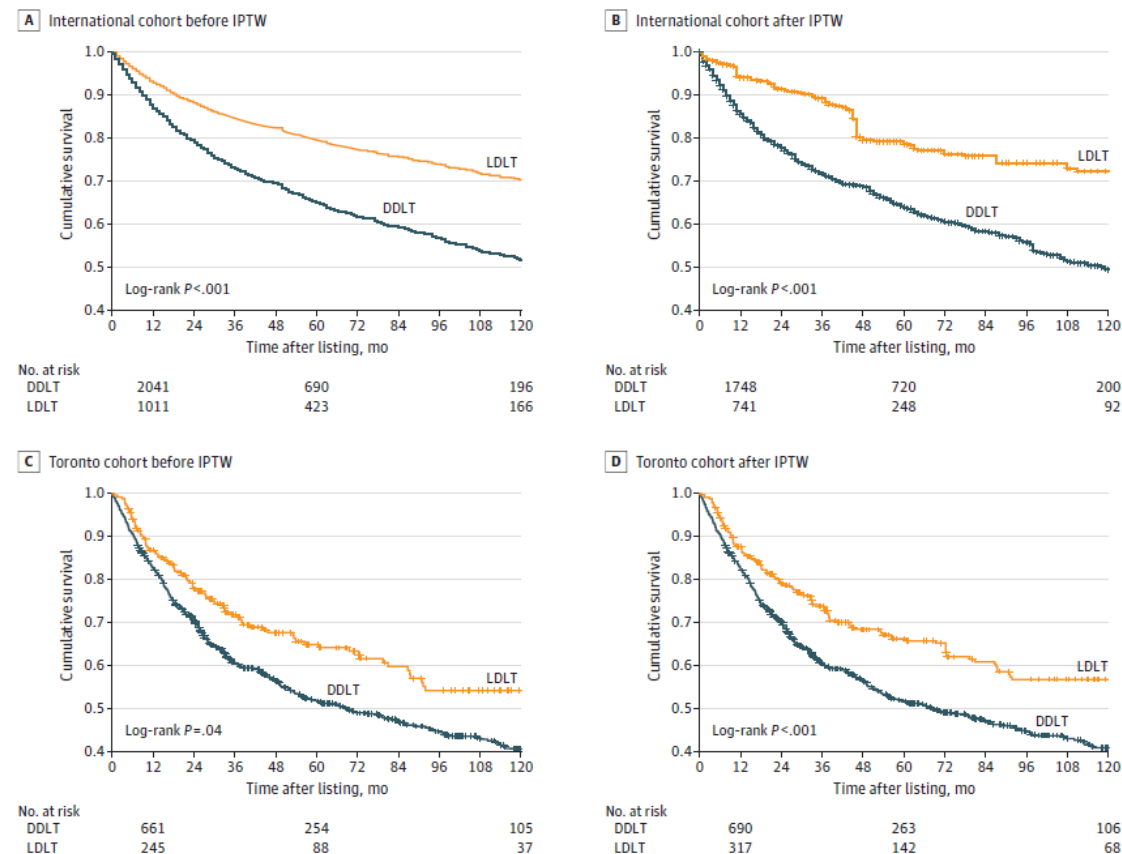
LDLT recipients with lower hospitalization and healthcare burden than DDLT.
Overall→29.5% lower cost associated with LDLT

HCC: LDLT vs DDLT

Evaluation of the Intention-to-Treat Benefit of Living Donation in Patients With Hepatocellular Carcinoma Awaiting a Liver Transplant

- ◆ Having a live donor could decrease risk of death from HCC for patients listed for LT
- ◆ Benefit is related to **elimination of dropout risk** and can be seen in centers where LDLT and DDLT are equally available

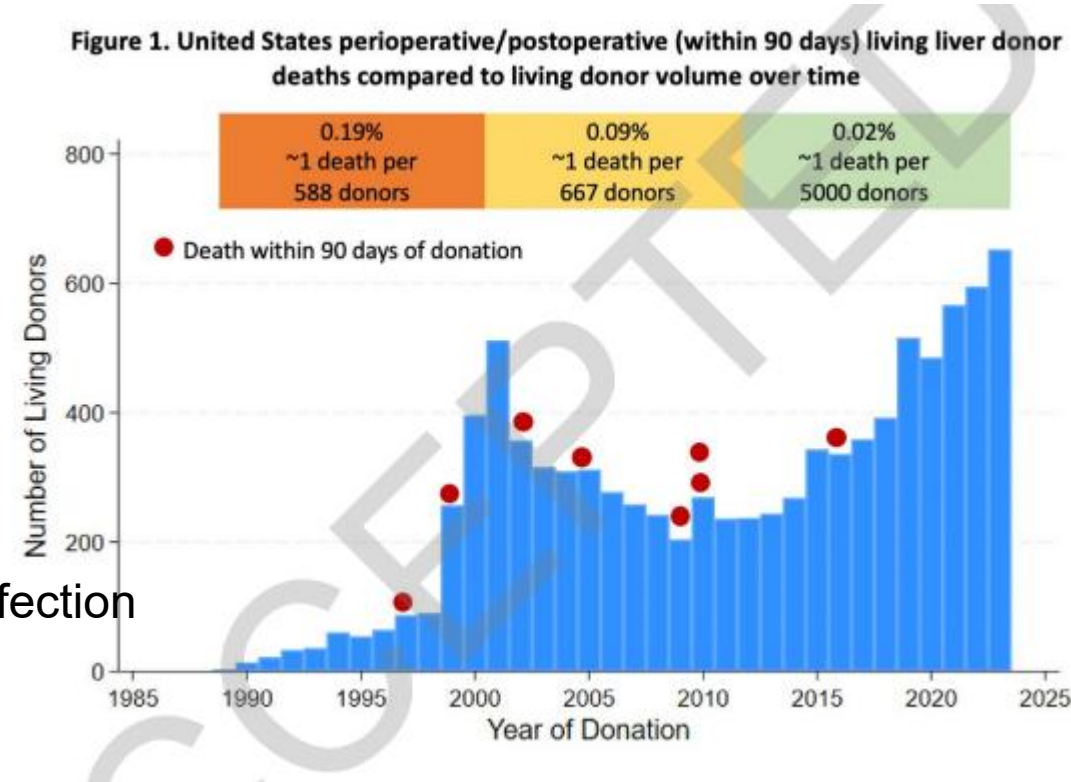
- ◆ International cohort – Asia, Europe, USA
 - LDLT / DDLT
- ◆ Toronto Cohort
 - LDLT and DDLT



Q. Lai, JP Lerut; JAMA Surg. 2021;156(9):e213112

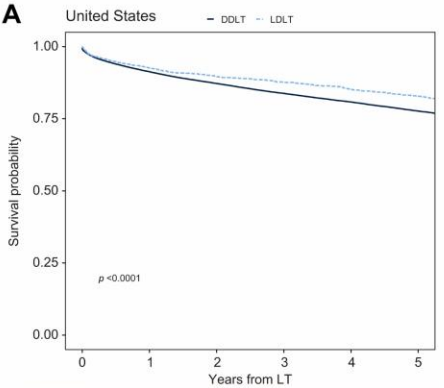
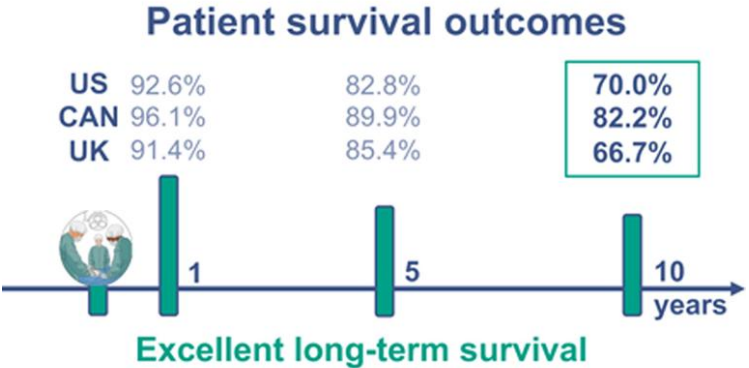
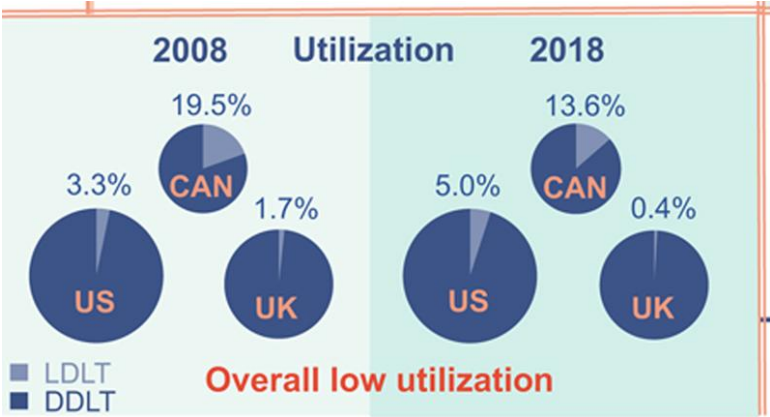
Donor Mortality in North America

- **>11,000 living donors over 30 years (1989-2023)**
- **83 deaths**
 - Peri-operative (<30 days) - 6
 - Post-operative (30-90 days) – 2
 - 90 days – 5 years – 17
 - > 5 years - 53
- **Cause of death –**
 - Peri/post operative : CVS, liver failure, respiratory failure, infection
 - Late deaths – trauma, suicide, drug overdose, cancer
- **Risk of Peri/postoperative death ~1/5000 Rare**
 - Risk decreased over time 0.19%→ 0.02%
 - No deaths since 2016

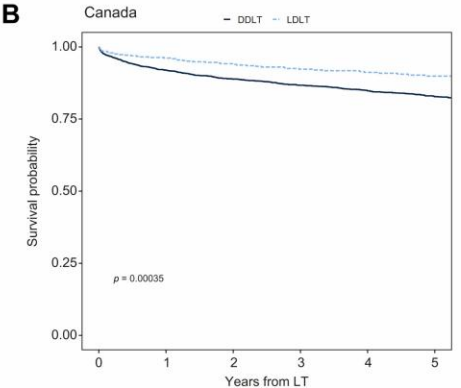


E. King, K. Olthoff, Ann Surgery 8.2025

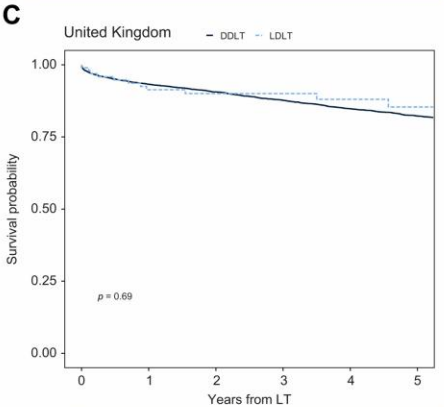
Low utilization of adult-to-adult LDLT in Western countries despite excellent outcomes: International multicenter analysis of the US, the UK, and Canada



N° at risk						
DDLT	54,465	46,646	38,658	31,696	25,917	20,782
LDLT	2,328	1,986	1,606	1,325	1,053	827



N° at risk						
DDLT	2,860	2,354	1,965	1,626	1,361	1,123
LDLT	529	461	413	363	309	253



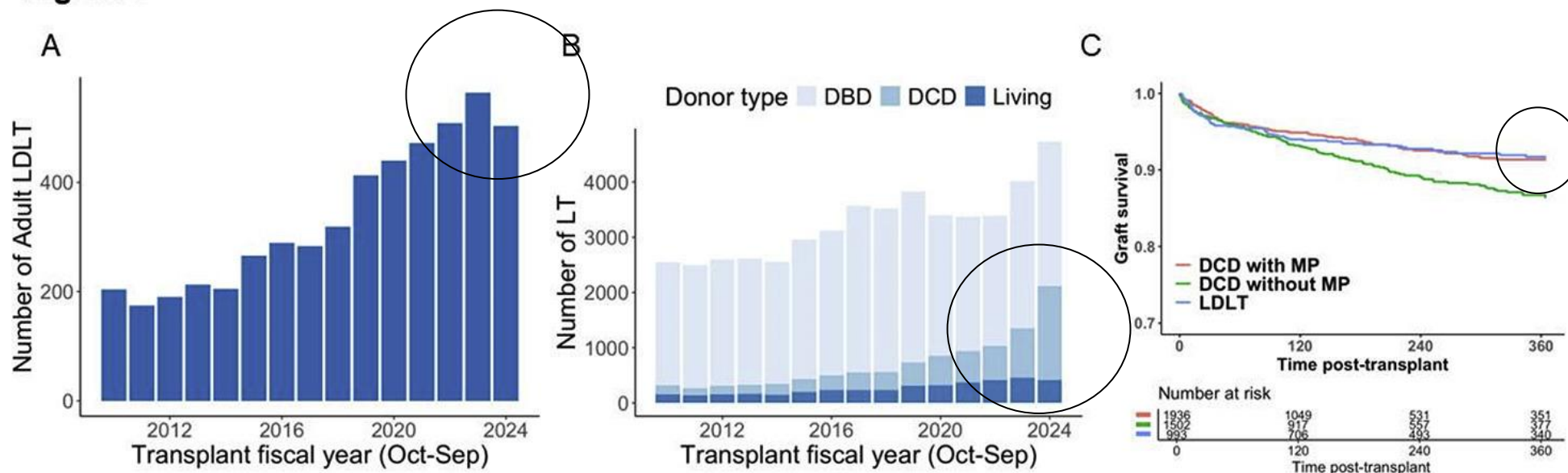
N° at risk						
DDLT	6,486	5,521	4,566	3,743	3,053	2,371
LDLT	97	79	65	50	37	27

However, Similar adjusted Survival LDLT vs DDLT

DCD and LDLT

Shifting Landscape of Adult Liver Transplantation in the United States: Declining Role of Living Donor Transplants?

Figure 1



Decline in LDLT volume with an increase in DCD grafts among patients with MELD < 20 and small body sizes

The New York Times

U.S. Government Cracks Down on Organ Transplant System

Organ donation groups accused of safety lapses are facing multiple investigations, and new policies are underway to protect patients.

Listen to this article · 6:58 min [Learn more](#) [Share full article](#) [104](#)



DCD and LDLT

Opinion

Living Donor Liver Transplant Programs in the United States Need to Be Carefully Nurtured Amidst Expanding Use of Perfusion Technology

Sorabh Kapoor * and Chirag S. Desai

- ◆ **Despite adoption of DCD donation, persistent gap between listing and transplants**
 - Indications – MASLD, ALD, oncology
 - Lower MELD
 - Older recipients
- ◆ **LDLT should still be promoted in the USA along with the new perfusion techniques**



Organ Procurement and Transplantation Network. National Data. Available online: <https://optn.transplant.hrsa.gov/data/view-data-reports/national-data/>

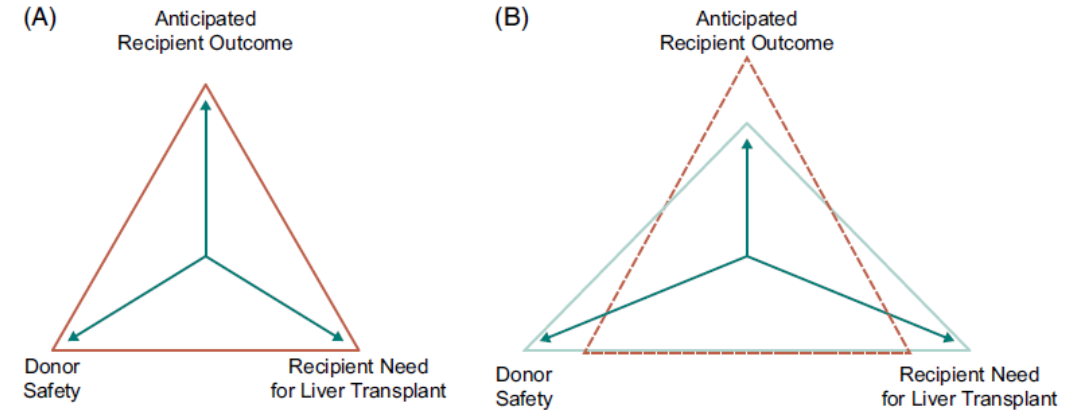
Future of LDLT in the USA

REVIEW



Future of U.S. living donor liver transplant: Donor and recipient criteria, transplant indications, transplant oncology, liver paired exchange, and non-directed donor graft allocation

Kiran Bambha¹ | Scott W. Biggins¹ | Christopher Hughes² |
Abhi Humar² | Swaytha Ganesh¹ | Mark Sturdevant³



◆ Safe expansion of LDLT

- Donor criteria –using donors with more than minimal **steatosis**, **older**
- Recipient criteria- **older**, **low MELD**,
- Broaden indications - **transplant oncology**: advanced HCC, ICC, CRLM, **LD- RAPID**
- **Non-Directed Doors, Paired exchange**- institutional and national

Final Thoughts

- ♦ LDLT should and will grow in the US
- ♦ ALL liver transplant recipients should be considered for LDLT
- ♦ LDLT should be performed in centers with strong infrastructure, administrative support, experienced surgical/medical/ancillary staff
- ♦ Donor safety should always be the priority -
- ♦ **LDLT Should only be performed if risk to the donor is justified by the expectation of an acceptable outcome in the recipient**



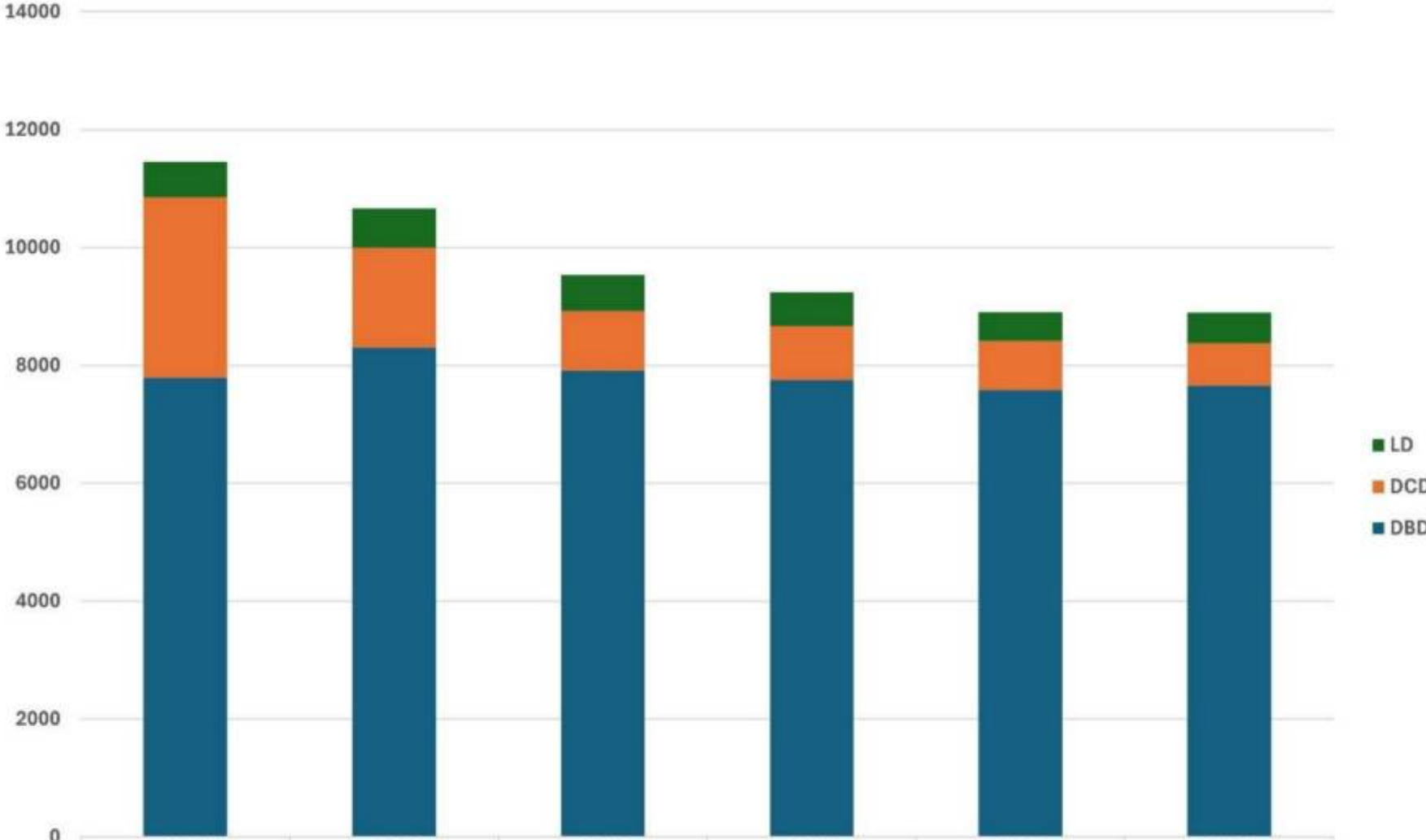
Why we do it



THANK
YOU!



USA Annual Liver Transplants - Last 5 years



	2024	2023	2022	2021	2020	2019
LD	604	658	603	569	491	524
DCD	3057	1695	1014	915	830	713
DBD	7796	8306	7911	7752	7585	7659

DCD and LDLT

A Comparison of Living Donor Liver Transplant (LDLT) and Donor After Cardiac Death (DCD): Is There a Superior Option?
7:10 PM - 7:20 PM EDT
Monday, June 5,
2023Room: Room 2 Upper Level (San Diego

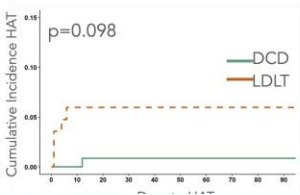


Greg McKenna
Baylor University Medical Center

Table 1: Demographics / Outcomes DCD vs LDLT

		DCD (n= 143)	LDLT (n=94)	p value
Recipient	Age	59	53.5	0.005
	Sex (M:F)	72% : 28%	51% : 49%	0.002
Donor	Age	37	38	0.3

Figure 1: Postoperative Complications DCD vs LDLT



Hepatic Artery Thrombosis

90 Day	DCD	1%
	LDLT	6%
1-Year	DCD	2%
	LDLT	6%



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risks and increased complications in LDLT, and of poor immediate graft

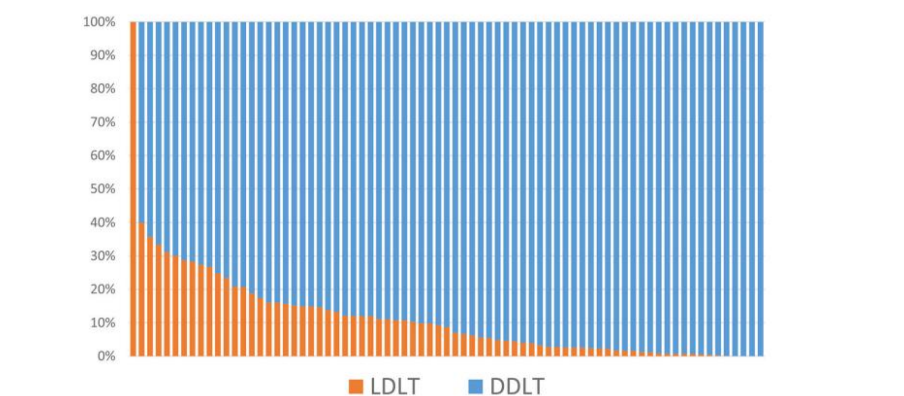


FIGURE 4 Proportion of liver transplants performed using living donors among “potentially eligible” recipients across centers. The “potentially eligible” cohort was defined as liver transplant recipients with a weight, age, and allocation Model-for End-stage Liver Disease score at the time of transplant $\leq$ 95th percentile of all living donor liver transplants (LDLTs). DDLT, deceased donor liver transplant. Each bar represents a center.

Variation in adult living donor liver transplantation in the United States: Identifying opportunities for increased utilization

Krista L. Lentine¹ | Tomohiro Tanaka² | Huiling Xiao¹ | Therese Bittermann³ |
 Mary Amanda Dew⁴ | Mark A. Schnitzler¹ | Kim M. Olthoff³ | Jayme E. Locke⁵ |
 Emre⁶ | Heather F. Hunt⁷ | AnnMarie Liapakis⁸ | David A. Axelrod²

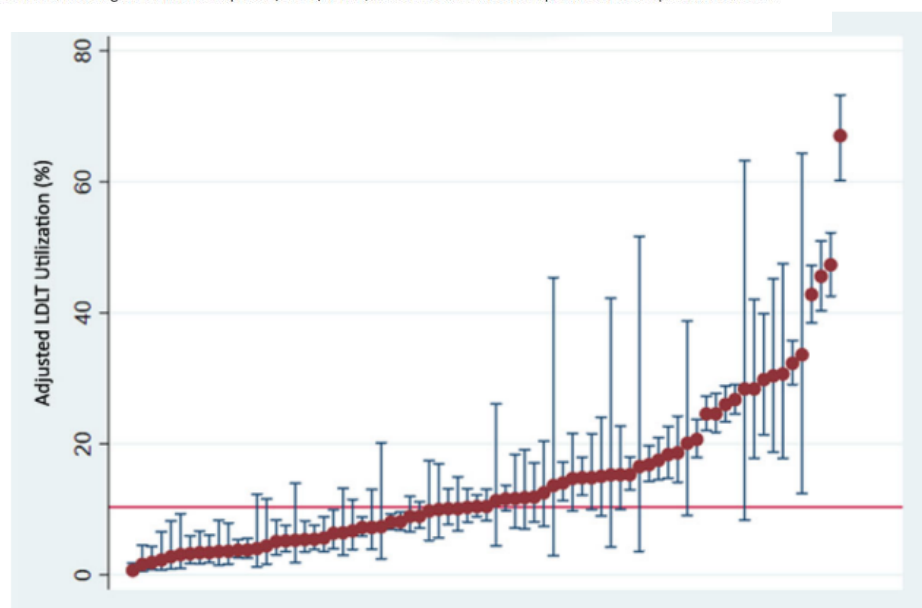


FIGURE 3 Proportion of centers' liver transplant volume performed using living donors, adjusted for recipient characteristics. LDLT, living donor liver transplant.

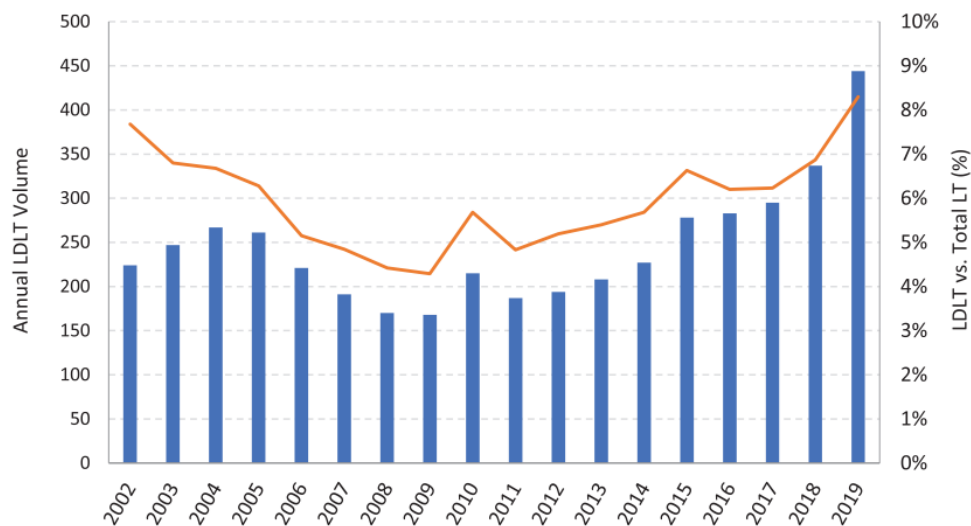


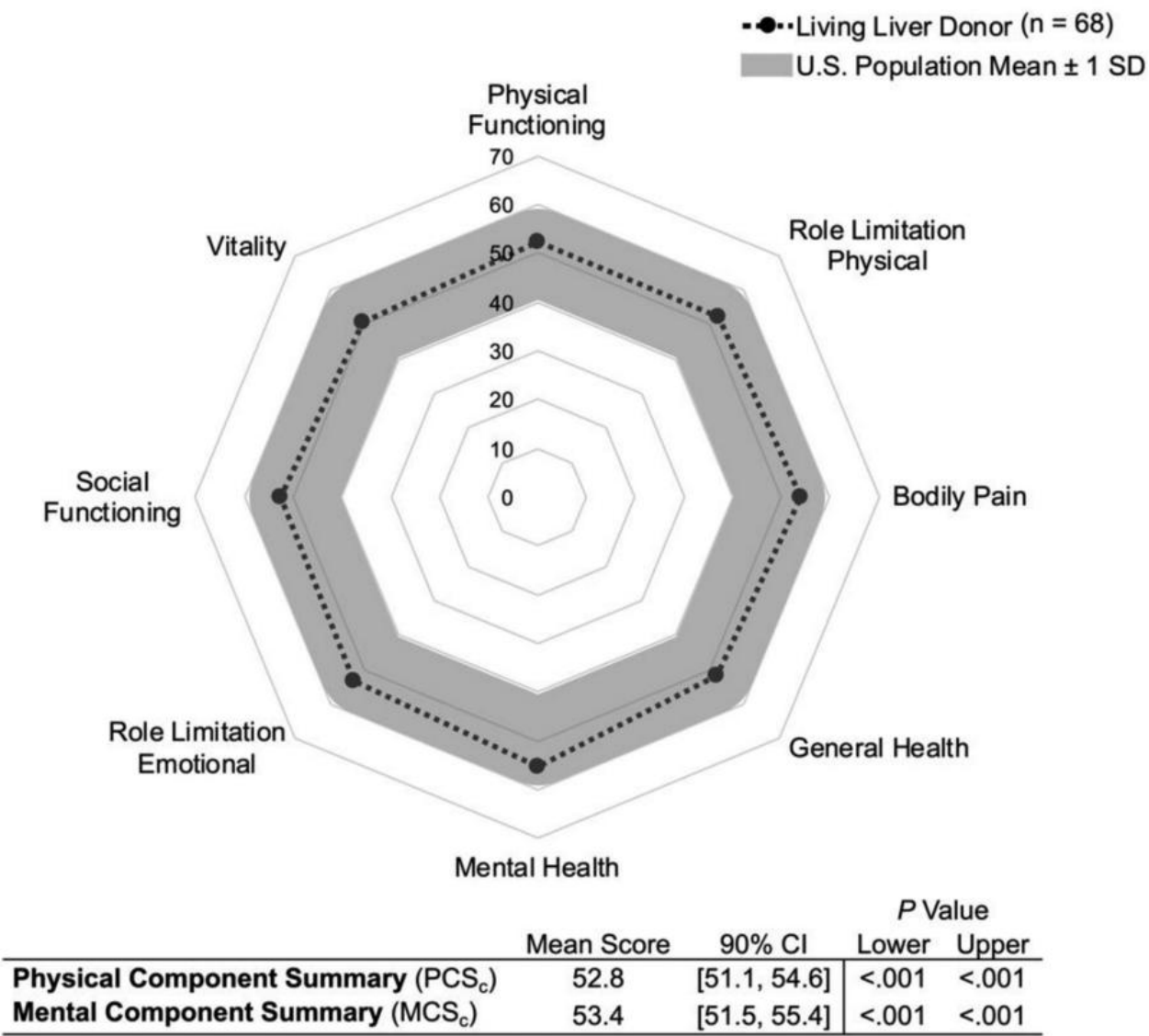
FIGURE 1 Living donor liver transplants performed annually in the United States (2002–2019). Left axis: Annual LDLT volume (bars). Right axis: LDLT as percentage of total LT in the year (orange line).

Long Term Health of Live Donors

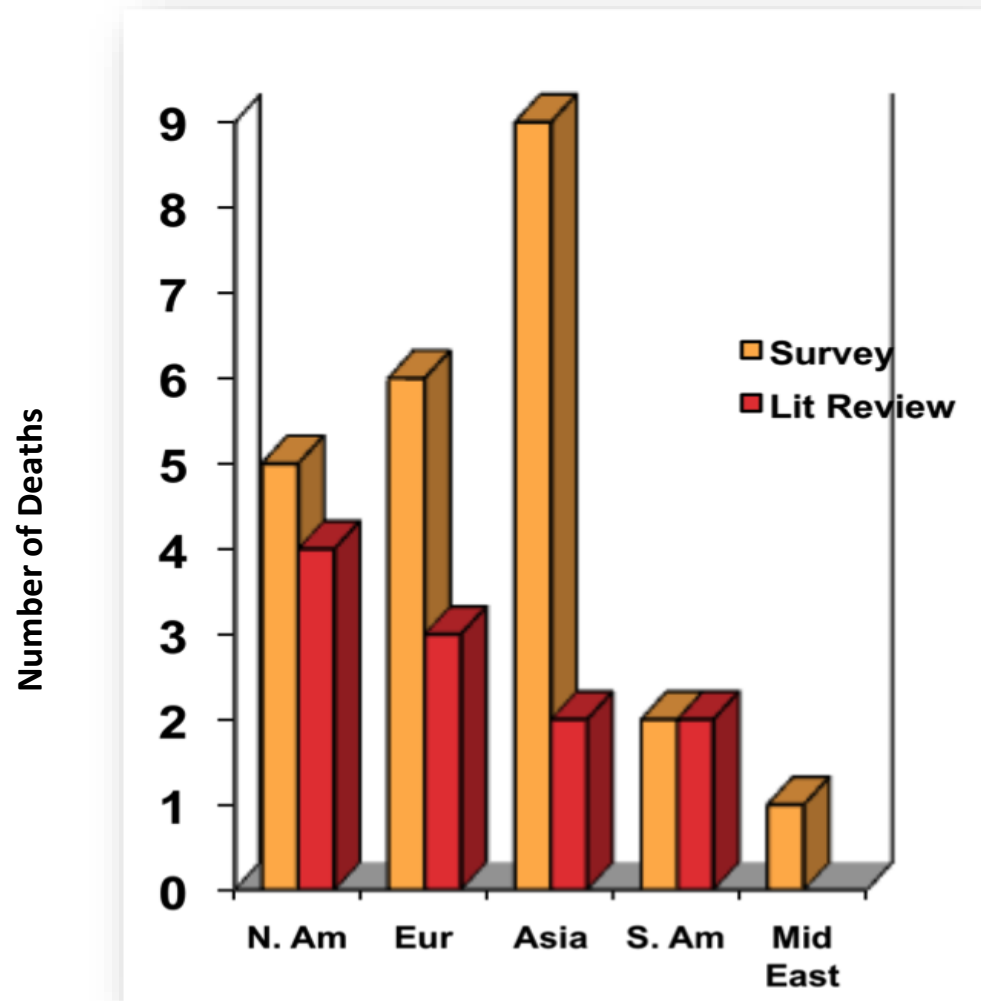
Long-term Financial, Psychosocial, and Overall Health-Related Quality of Life After Living Liver Donation.

Muhammad H. Raza¹, Michelle H. Kim^{1,2}, Li Ding³, Tse-Ling For
Yuri Genyk^{1,2}, Linda Sher^{1,2}, Juliet Emamaullee^{1,2}

- ◆ USC study
- ◆ Mental and Physical health up to 20yrs post donation
- ◆ Excellent HR-QOL



Risk of Donor Death



- **Deaths reported in survey (n=23)**

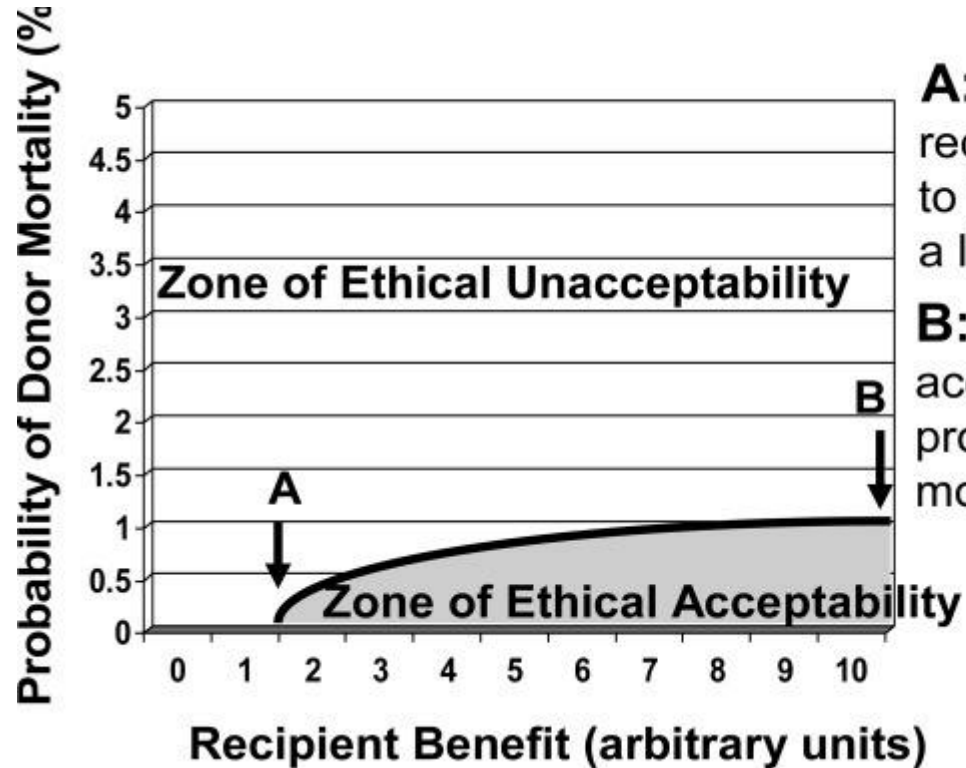
- 15 $\leq$ 60 days Post Op
- 8 > 60 days Post Op

- **Deaths in literature (n=11)**

- 8 in first 60 days
- 3 >60 days

**Donor Mortality quoted
at 0.2%**

The Concept of Double Equipoise



A: point of minimum recipient benefit to justify use of a live donor

B: point of maximum acceptable donor probability of mortality risk

Donor Viewpoint

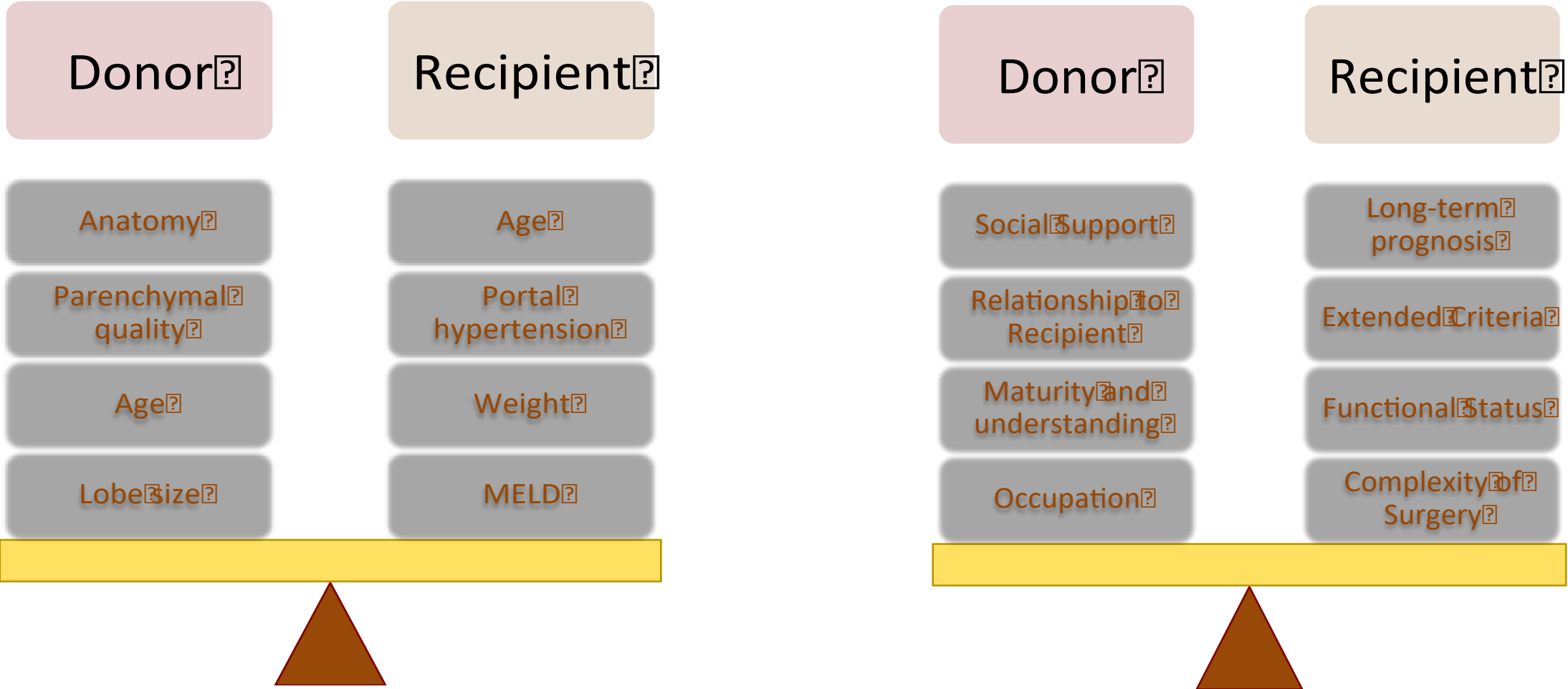
- ♦ Donation risk
- ♦ Recipient may die on waitlist

Need to balance
risk to donor with benefit to recipient

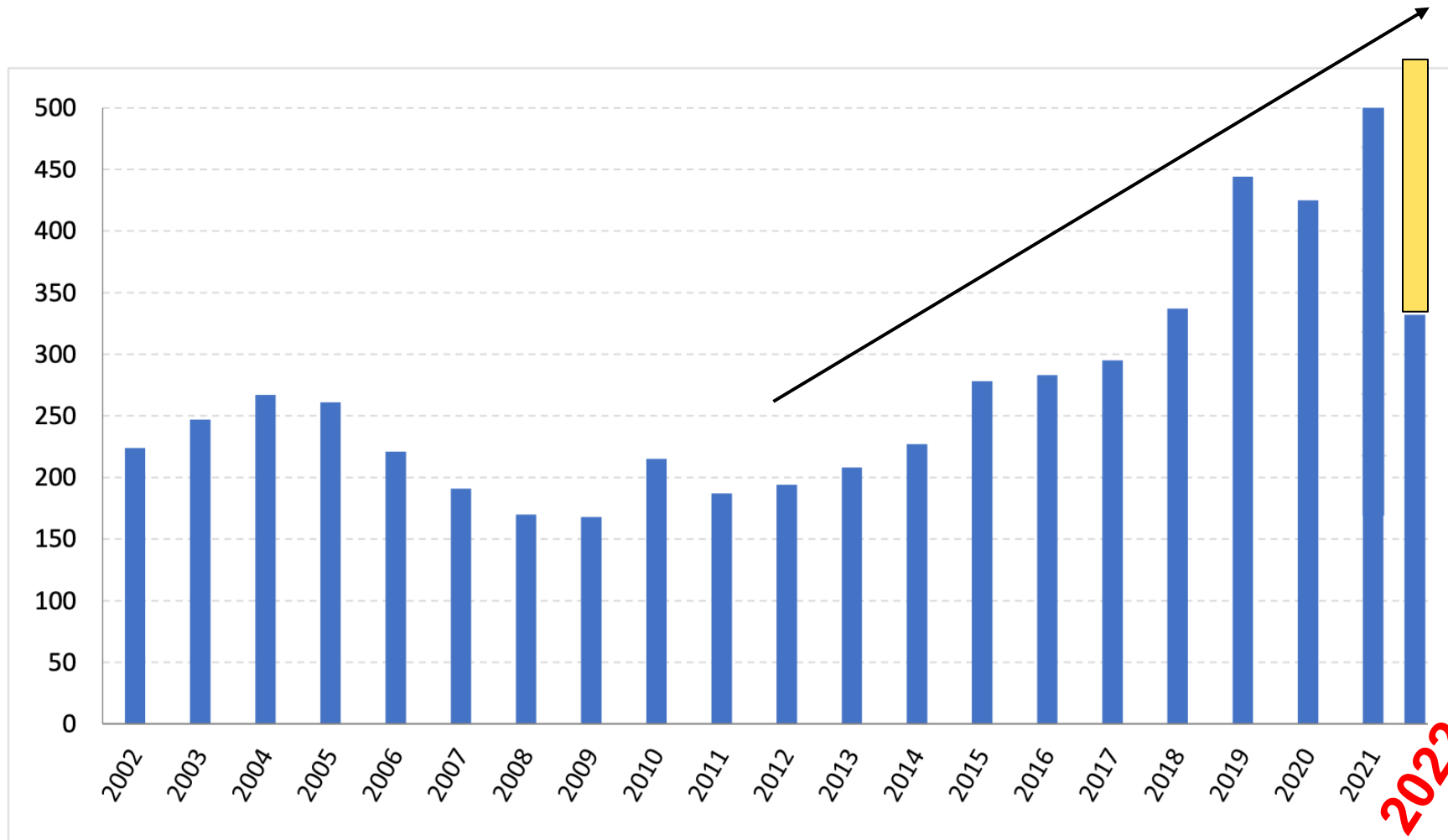


Current Status of Living Donor Liver Transplantation: Who should we transplant?

LDLT: Importance of Donor and Recipient Matching



LDLT cases over time (USA)



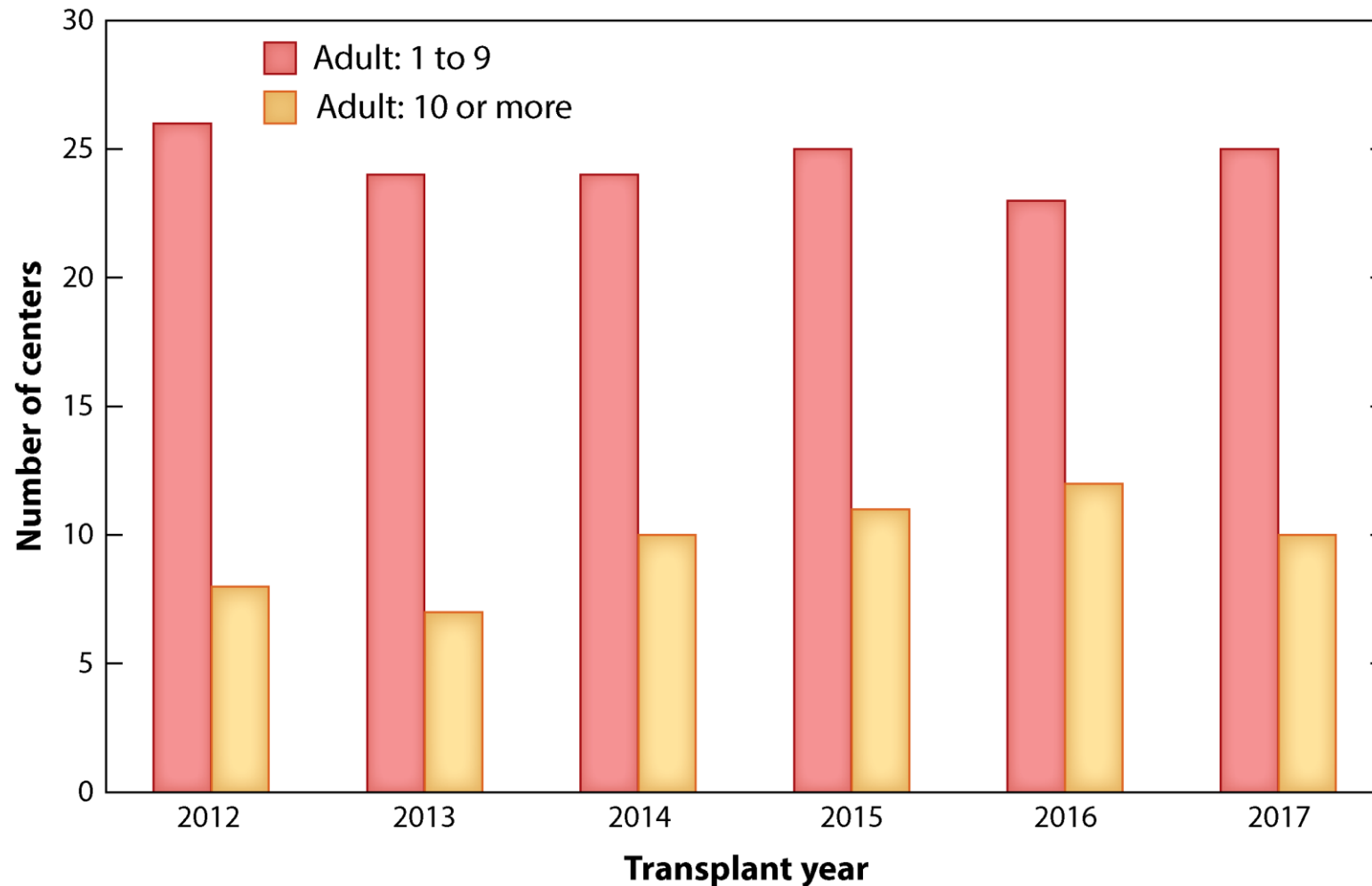
USA LDLT

- Based on OPTN data as of 7/31/2022
- **Adult** - age 18+ at the time of listing

Percentage of Adult LT

- 2008-2013: 3.3%
- 2014-2019: 4.3% (pre-pandemic)
- 2020: 5.5%
- 2021: 6.1% (567 total)

Number of transplant centers performing LDLTs - US



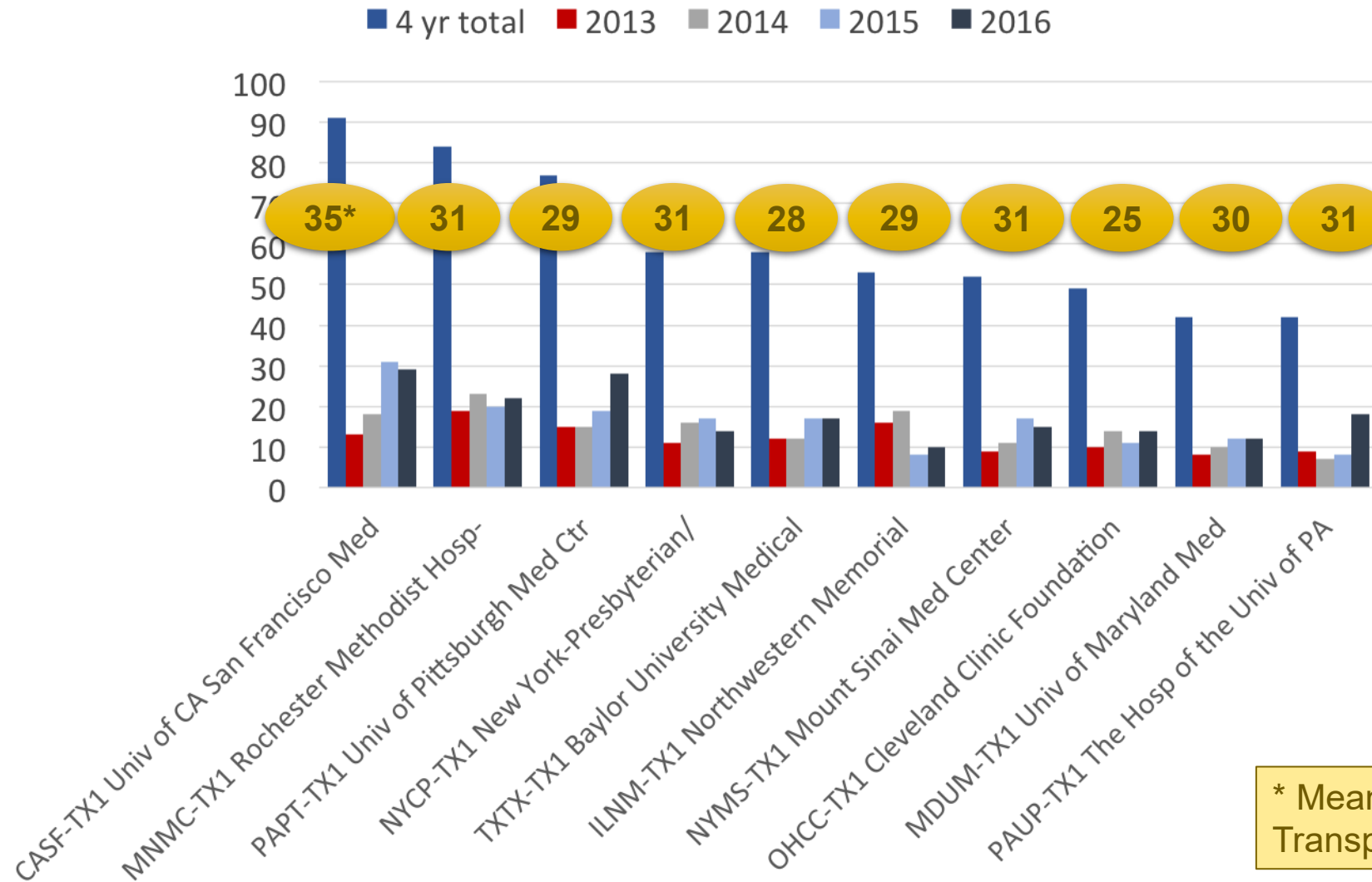
75 centers performed ≥ 1 LDLT over the study period

- **2002-2007** (centers=57 | n=1,411)
- **2008-2013** (centers=54 | n=1,142)
- **2014-2019** (centers=55 | n=1,864)

Center Volume Distributions

- Median: **19**
- 25th | 75th percentiles:
5 | 79
- Maximum: **474**

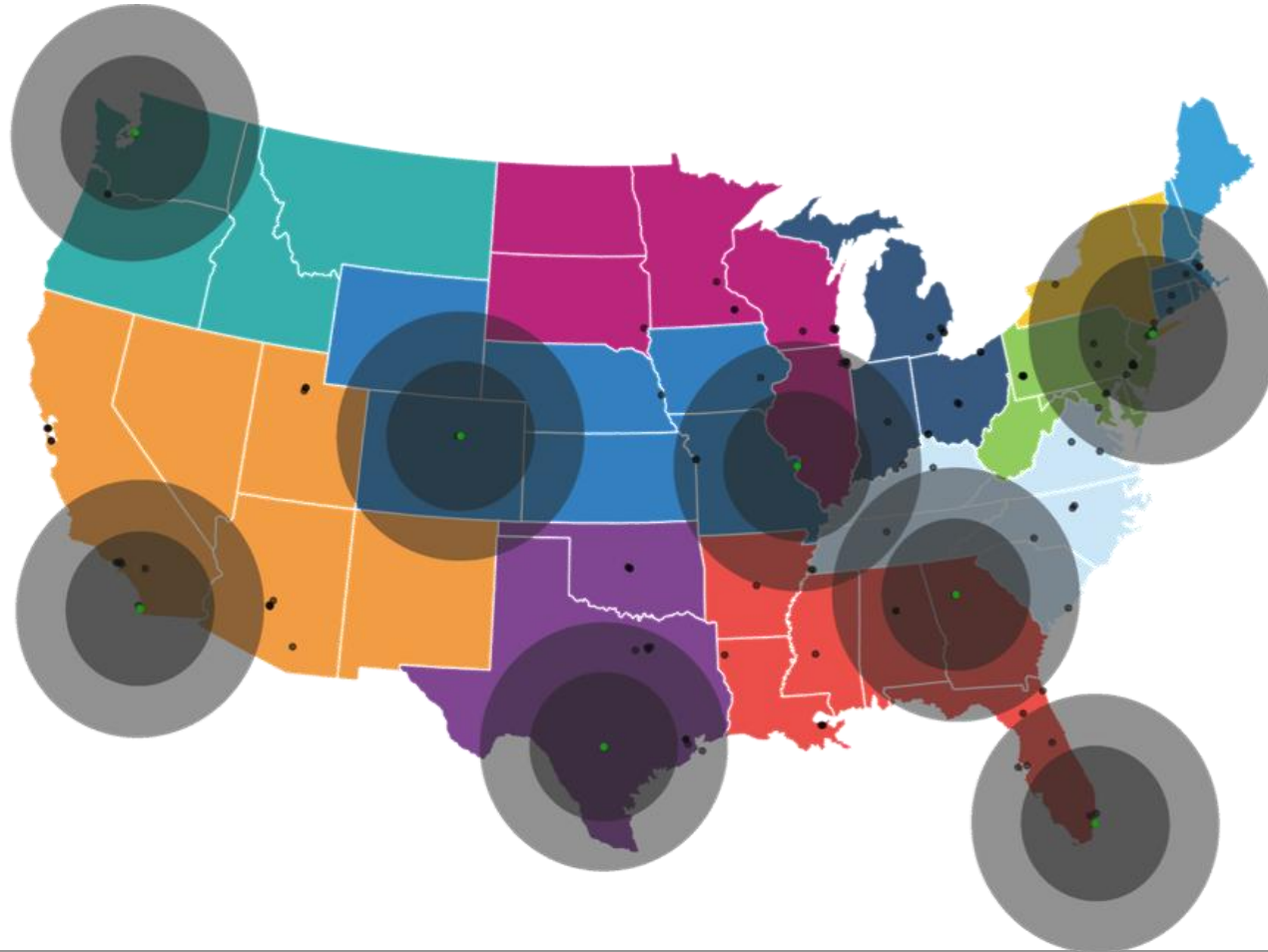
US Activity: Top 10 and mean MELD



Data compliments of A. Thomasson and D. Goldberg

Changing the Current Living Donor Paradigm...

- ◆ Centers should perform LDLT if there is a relative shortage of deceased donors compared to size of waitlist
- ◆ Current liver distribution system makes it harder to get deceased donor organs



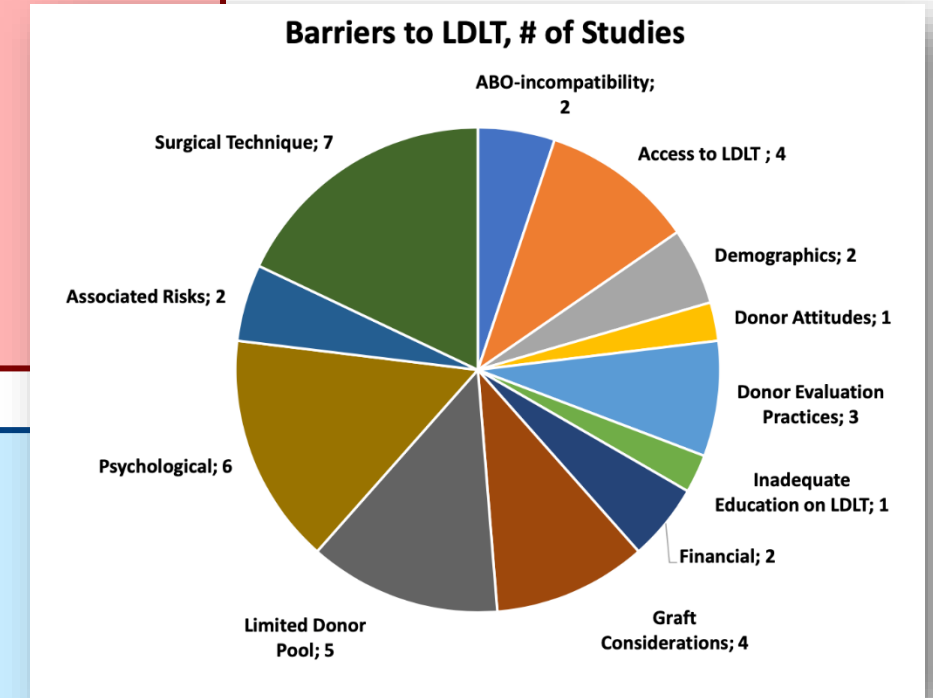
Changing the paradigm of LDLT in the US

♦ Why we don't do more

- Technical complexity/lack of centers
- Requires significant infrastructure and institutional support
- Recipient hesitancy
- Concern for donor morbidity and mortality
- Limited donor pool
- Inadequate public education regarding LDLT

♦ Why we should do more

- **Transplant benefit with better overall survival**
- **Transplanting earlier decreases waitlist mortality**
- Liver allocation changes will greatly affect liver availability
- List is growing larger with higher mean MELDs at transplant
- Better long-term quality of life minimizing effects of chronic liver disease



Based on Lit Search and Systemic Review

Living donor transplantation

Benefits of Living Donor Liver Transplant

There are many important benefits specific to getting a liver from a living donor.



GET TO YOUR TRANSPLANT SOONER

While the wait for a liver is long and uncertain, with the right living donor, you get to transplant sooner.



GET TO YOUR TRANSPLANT HEALTHIER

Eliminating the wait means you are transplanted before you get sicker and your liver disease worsens.



IMPROVE YOUR SURVIVAL

There is a higher survival rate with living donor liver transplantations.



KNOW YOUR BEST OPTION

A thorough evaluation of your donor is performed to ensure this is the best option for you AND a safe procedure for your donor.



REMOVE UNCERTAINTY, SCHEDULE CONVENIENTLY

Living donation removes the uncertainty around wait time for a donor and helps you better prepare for your scheduled transplant day.



EXPANDS THE DONOR POOL

Living donor liver transplant candidate and donor selection and engagement: Meeting report from the living donor liver transplant consensus conference

[Michelle T. Jesse](#), [Whitney E. Jackson](#), [AnnMarie Liapakis](#), [Swaytha Ganesh](#), [Abhinav Humar](#), [Nicolas Goldaracena](#), [Josh Levitsky](#), [David Mulligan](#), [Elizabeth A. Pomfret ...](#) [See all authors](#)

- 2023 Jul;37(7):e14955.

doi: 10.1111/ctr.14955. Epub 2023 Mar 23.

Financial, policy, and ethical barriers to the expansion of living donor liver transplant: Meeting report from a living donor

[Anjana Pillai¹](#), [Elizabeth C Verna²](#), [Neehar D Parikh³](#), [Matthew Cooper⁴](#), [Carrie Thiessen⁵](#), [Julie Heimbach⁶](#), [Elisa J Gordon⁷](#), [Gonzalo Sapisochin⁸](#), [Nazia Selzner⁹](#), [Amit Mathur¹⁰](#), [Emily R Perito¹¹](#), [Michael J...](#)

• 2023 Jul;37(7):e14967.

doi: 10.1111/ctr.14967. Epub 2023 Mar 20.

A survey of transplant providers regarding attitudes, barriers, and facilitators to living donor liver transplantation in th

[AnnMarie Liapakis¹](#), [Uchenna Agbim²](#), [Therese Bittermann³](#), [Mary Amanda Dew⁴](#), [Yanhong Deng⁵](#), [Geliang Gan⁵](#), [Sukru Emre⁶](#), [Heather F Hunt⁷](#), [Kim M Olthoff³](#), [Jayme E Locke⁸](#), [Michelle T Jesse⁹](#), [V](#)

A scoping review of nonmedical barriers to living donor liver transplant

Owen Jones¹  | Zhihao Li¹  | Christian Tibor Josef Magyar^{1,2}  |
Nicolas Goldaracena³  | Blayne A. Sayed^{1,4}  | Anand Ghanekar¹ |
Mark Cattral¹ | Nazia Selzner¹  | Gonzalo Sapisochin¹ 

