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## Long Cold Ischemia Times in Same Hospital Deceased Donor Transplants

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### Abstract

**Background**—Recent changes in deceased donor organ allocation for livers (Share-35) and kidneys (KAS) have resulted in broader sharing of organs and increased cold ischemia time (CIT). Broader organ sharing however is not the only cause of increased CIT.

**Methods**—This was a retrospective registry study of CIT in same-hospital liver transplants (SHLT, n=4,347) and kidney transplants (SHKT, n=9,707) between 2004 and 2014.

**Results**—In SHLT, median (IQR) CIT was 5.0 (3.5–6.5) hours versus 6.6 (5.1–8.4) hours in other-hospital LT. DCD donors, donor biopsy, male recipient, recipient obesity, and previous transplant were associated with increased CIT. MELD at transplant of 29+ or status 1a was associated with decreased CIT. SHLT CIT varied by OPO and transplant-center ( $p<0.01$ ), with center median CIT ranging from 2.0 – 7.8 hours across 118 centers. In SHKT, CIT was 13.0 (8.5–19.0) hours versus 16.5 (11.3–22.6) hours in other-hospital KT. Overweight donors, DCD donors, right-kidney, donor biopsy, recipient obesity, use of mechanical perfusion, additional KT procedures on the same day, and transplant center annual volume were associated with increased CIT. Older donor age, ECD donors, and underweight recipients were associated with decreased CIT. SHKT CIT varied by OPO and transplant-center ( $p<0.001$ ), with center median CIT ranging

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from 3.3 – 29 hours across 206 centers. Transplant centers with longer SHKT also had longer SHLT (p=0.01).

**Conclusion**—Same-hospital transplants already have a significant amount of CIT, even without transporting the organ to another hospital.

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## INTRODUCTION

Cold ischemia time (CIT) is an undesirable, yet inevitable risk factor in deceased donor transplantation. Irish et al previously demonstrated the association between prolonged CIT and delayed graft function (DGF) after kidney transplantation <sup>1</sup>. Other authors have reported associations between prolonged CIT and poor outcomes after transplantation. These include decreased graft survival in deceased donor kidney transplant (DDKT) recipients <sup>2-7</sup>, primary non-function, early allograft dysfunction <sup>8</sup>, and increased recurrence of HCC <sup>9</sup> among deceased donor liver transplant (DDLTL) recipients.

Recent changes in organ allocation for deceased donor livers (Share-35) and kidneys (KAS) in the United States have increased the distances that organs may be transported, as candidates and donors are often geographically separated <sup>10,11</sup>. This trend may be further exacerbated with redistricting efforts aimed at reducing geographic disparities <sup>12</sup>. CIT in particular has come under increased scrutiny with the shift in allocation practices that may increase CIT in organs that are transported further distances.

Increased transport distance is not the only cause of prolonged CIT. There are many logistical concerns that occur within the transplant and donor centers well before the organ is ready for transport. In an English study of logistical factors influencing CIT in the UK, Shresta et al report a variety of factors influencing CIT <sup>13</sup>. These include time for organ allocation, cross-matching, allograft biopsies, recipient-related issues such as transportation or medical comorbidity, or donor hospital issues such as operating room (OR) and surgeon availability. It is possible that these factors have a more profound impact on CIT in comparison to organ transport <sup>14</sup>.

In the context of broader organ sharing, we sought to quantify in-hospital CIT resulting from factors other than organ transport. In this national retrospective study of CIT in the US, we studied DDLTLs and DDKTLs, where the donor and recipient operations occurred at the same hospital. We examined pairs of kidneys from the same donor where one kidney was transplanted at the same hospital as recovery and one was transported to a different hospital for transplant. We also aimed to describe heterogeneity in same-hospital CIT between transplant centers and OPOs, and whether centers with long CIT in LT also had long CIT in KT.

## METHODS

### Study Population

We investigated 4,347 deceased donor liver transplant recipients, and 9,707 deceased donor kidney transplant recipients who underwent transplantation at the same hospital where their organ was recovered between June 1, 2004 and May 31, 2014. We excluded split/partial liver

transplants, liver transplants that were missing CIT (n=231) and those with CIT greater than 16 hours (n=35) as these were likely errors. We excluded en-bloc or sequential kidney transplants, kidney transplants that were missing CIT (n=675) and those with CIT greater than 48 hours (n=68).

### Data Source

This study used data from the Scientific Registry of Transplant Recipients (SRTR). The SRTR data system includes data on all donor, waitlisted candidates, and transplant recipients in the US, submitted by the members of the Organ Procurement and Transplantation Network (OPTN). The Health Resources and Services Administration (HRSA), U.S. Department of Health and Human Services provides oversight to the activities of the OPTN and SRTR contractors. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy of or interpretation by the SRTR or the U.S. Government.

### Identifying Same-Hospital Transplants

Same-hospital liver transplants (SHLT) and kidney transplants (SHKT) were identified by matching the recipient transplant center with the donor provider hospital using the OPO identifier, provider number, and provider type. Other-hospital liver transplants (OHLT) and kidney transplants (OHKT) were identified as transplants where the donor hospital differed from the recipient transplant center. We identified a subpopulation of donors with both a SHKT and OHKT for a subgroup analysis of paired kidneys and their CIT. Differences in demographics between same- and other-hospital transplants were tested using Chi-Squared, Student's t-tests, and Wilcoxon Rank Sum statistics.

### Cold Ischemia Time and Time Ratios

CIT was studied using an accelerated failure time (AFT) model. AFT models are an alternative to the more familiar proportional hazards (PH) models like Cox. AFT models provide time-ratios (TR) instead of hazard ratios. A time-ratio can be interpreted as a percentage increase ( $TR > 1.0$ ) or decrease ( $TR < 1.0$ ) to CIT. For example, if obesity is associated with CIT with a TR of 1.06, CIT is increased by 6% with obesity.

### OPO, Transplant-Center, and Patient Level Associations

We studied whether CIT varied based on OPO, transplant center, or donor and recipient characteristics. We used multilevel (mixed effects) regression to estimate both OPO and center level effects and account for center clustering. We evaluated the effect of competition in DSAs by comparing single-center and multi-center OPOs. We adjusted for the following donor and recipient characteristics: donor and recipient age, ethnicity, BMI, previous (kidney or liver) transplant, and year of transplant. We also adjusted for performing transplant operation on weekend and performing additional KT procedures on same day. We adjusted for organ-specific transplant volume as a center-level characteristic. The LT model was also adjusted for MELD at transplant and receipt of MELD exception points. The KT model was adjusted for laterality (left versus right kidney), donor biopsy, and mechanical reperfusion.

## Center-level correlation of long cold ischemia time

To determine whether hospitals with long CIT in SHLT also had long CIT in SHKT, we correlated the hospital's average CIT for SHLT with the hospital's average CIT for SHKT using a univariate linear regression. Hospitals in the regression were weighted by the hospital's total liver transplant volume.

## Statistical Analysis

Statistical analysis was performed using Stata 14.2 (College Station, Texas). Figures were prepared using R 3.1 (the R Foundation for Statistical Computing, Vienna, Austria). For all analyses,  $p < 0.05$  was considered statistically significant. Multilevel AFT regressions were done using the `mestreg` command in Stata with Gamma (KT) and Log-logistic (LT) distributions.

## RESULTS

### Study Population

Out of 55,629 liver transplants, 4,347 (7.8%) occurred at the same hospital as organ recovery (Figure 1a). SHLT were performed at 118 transplant centers in all 52 OPOs with LT programs. Out of 96,641 kidney transplants, 9,707 (10%) were SHKT (Figure 1b). SHKT were performed at 206 transplant centers in all 58 OPOs with KT programs. A significantly lower proportion of LT were performed in the same hospital (7.8%) than KT (10%) ( $p < 0.001$ ). Donor and recipient characteristics of SHLT and SHKT are summarized in tables 1a and 1b.

### Cold Ischemia Time for Same-Hospital Liver and Kidney Transplants

The distribution of CIT for both LT and KT was right-skewed regardless of recovery location (Figure 1). After excluding livers with CIT >16hrs, the median (IQR) CIT for SHLT was 5.0 (3.5 – 6.5) hours (Figure 1a), versus 6.6 (5.1–8.4) hours for OHLT. After excluding kidneys with CIT >48hrs, the median (IQR) CIT for SHKT was 13.0 (8.5 – 19.0) hours (Figure 1b), versus 16.5 (11.3 – 22.6) hours of CIT in OHKT. CIT was lower in same-hospital transplant versus other-hospital transplants in both LT and KT ( $p < 0.001$ ). In SHLT, the shortest (5<sup>th</sup> percentile) CIT was 2 hours and the longest (95<sup>th</sup> percentile) was 10 hours. In SHKT, the shortest (5<sup>th</sup> percentile) CIT was 4 hours and the longest (95<sup>th</sup> percentile) was 28 hours.

### Donor and Recipient Characteristics Associated with Liver Transplant Cold Ischemia Time

DCD donors were associated with an 8% increase in CIT (TR  $_{1.031.081.13}$ ,  $p < 0.01$ ). Donor biopsy was associated with a 9% increase in CIT (TR  $_{1.061.091.12}$ ,  $p < 0.001$ ). Male LT candidates had a 3% increase in CIT (TR  $_{1.031.031.06}$ ,  $p = 0.02$ ). Obese recipients had a 5% increased CIT compared to normal BMI recipients (TR  $_{1.021.051.09}$ ,  $p < 0.001$ ). Candidates who had a previous LT had an 11% increased CIT (TR  $_{1.051.111.17}$ ,  $p < 0.001$ ). Conversely, candidates with MELD at transplant of 29–34, 35+, or status 1a/b had a decreased CIT by 4% ( $p = 0.04$ ), 9% ( $p < 0.001$ ), and 26% ( $p < 0.001$ ) respectively. Over time, CIT decreased by 3% per year ( $p < 0.001$ ) (Table 2a).

## Donor and Recipient Characteristics Associated with Kidney Transplant Cold Ischemia Time

Overweight donors were associated with an increased CIT by 3% ( $p=0.02$ ) compared to normal BMI donors, DCD donors had a 9% increased CIT ( $p<0.001$ ), donor right kidney was associated with a 5% increased CIT ( $p<0.001$ ), and donor biopsy had a 13% increased CIT ( $p<0.001$ ). Obese recipients were associated with an increased CIT by 3% ( $p=0.02$ ). Transport that involved mechanical perfusion at some point was associated with a 30–41% increased CIT ( $p<0.001$ ). Conversely, older donors were associated with a decreased CIT by 2% per decade of age ( $p<0.01$ ), ECD donors had a 6% decreased CIT ( $p<0.01$ ), underweight recipients had a decreased CIT by 7% ( $p=0.04$ ). Over time, CIT decreased by 2% per year ( $p<0.001$ ) (Table 2b). When evaluating paired kidneys from the same donor, one of which was a SHKT and the other an OHKT, CIT was 20% shorter in SHKTs ( $p<0.001$ ).

## OPO and Transplant-Center Variation in Cold Ischemia Time

For both SHLT and SHKT, CIT varied between transplant centers and between OPOs ( $p<0.01$ ). In SHLT, the median CIT for individual transplant centers ranged from 2 to 7.8 hours with an average center having a median of 4.9 hours of CIT (Figure 2a). In SHKT, the median CIT for individual transplant centers ranged from 3.3 to 29 hours with an average center having a median of 12.8 hours of CIT (Figure 2b). While we did not observe any associations with same-day or annual LT volumes at SHLT transplant centers ( $p=0.2$ ,  $p=0.1$  respectively), we found that each additional KT procedure on the same day as another SHKT increased CIT by 3% ( $p<0.01$ ) and that increased annual KT volume was associated with an increased CIT by 1.2% per 10 transplants ( $p=0.01$ ). Same-hospital transplants occurring on weekends did not have significantly different CIT than those occurring on weekdays ( $p=0.2$ ). For SHLT, there was no significant difference in CIT between OPOs with a single center (low competition) and those with multiple centers (high competition) ( $p=0.5$ ). Similarly, for SHKT, there was no significant difference in CIT between single center and multi-center OPOs ( $p=0.6$ ). Furthermore, in transplant centers that perform both KT and LT, centers that had a high median CIT for SHLT also had a high median CIT for SHKT (Figure 3,  $p=0.01$ ).

## DISCUSSION

In this retrospective study of CIT, we found that same-hospital LT and KT had a median of 5.0 and 13.0 hours of CIT respectively, compared to 6.6 and 16.4 hours in other-hospital CIT. If we consider the association between CIT and DGF reported by Irish et al <sup>1</sup>, the median same-hospital KT would have increased odds of DGF by 69% associated with CIT, while the other-hospital KT would have increased odds of DGF by 93% compared to a KT with no CIT. The 95<sup>th</sup> percentiles of same-hospital CIT were 10hrs and 28hrs for LT and KT respectively. Our findings demonstrate that a major portion of CIT occurred in the hospital and not from transport alone.

For risk factors associated with CIT, we found that SHLT CIT was increased with DCD donors (8%), donor biopsy (9%), male recipients (3%), obese recipients (5%), and candidates with previous LT (11%), and that it was decreased in MELD 29+ and status 1

candidates (4–26%). In SHKT, we found that CIT was increased with overweight donors (3%), DCD donors (9%), donor right kidney (5%), donor biopsy (13%), obese recipients (3%), and any mechanical perfusion (41%). We found that SHKT CIT was decreased with donor age (2% per decade), ECD donors (6%), and in underweight recipients (7%).

Accounting for differences in donor and recipient characteristics, we found that there was significant heterogeneity in CIT between OPOs as well as between transplant centers. This heterogeneity was exemplified in the range of center median CIT from 2.0 – 7.8 hours in SHLT, and 3.3 – 29 hours in SHKT. In SHKT but not in SHLT, we found that additional KT procedures being performed on the same day at a center would increase CIT, and that annual center transplant volume also increased CIT. We saw evidence that centers with long CIT in LT also had long CIT in KT. This association along with our findings that hospitals were capable of reducing CIT for LT candidates with greater perceived urgency (MELD 20+, Status 1A) suggests that transplant centers might be able to improve in-hospital efficiency to reduce CIT.

There were similarities as well as some notable differences in our findings compared to the English study by Shrestha et al regarding CIT in KT. Our reported median CIT was 13 hours for same-hospital KT, and 16.4 hours when transport was involved. These values are comparable to the overall mean CIT of 13.8 hours in the Shrestha study. Both studies found significant heterogeneity in CIT between centers. While their study considered virtual versus pre-transplant crossmatch policies at transplant centers, we did not ascertain whether these policies were in place for the transplant centers in the US and could not study their associations with CIT. In both studies, we observed increased CIT with transport (aka reallocated), and with pumping to kidney on ice. While Shrestha et al found that DCD donors were associated with reduced CIT, we found that DCD donors were associated with an increased CIT. These conflicting findings could be a result of differences in unmeasured confounding in either study, or by the allocation and geographic differences between the English and American systems.

Echoing this difference, we found same-hospital KTs to have 20% lower CIT than other-hospital KTs when comparing paired kidneys from the same donor. In prior work, our group created an extensively detailed model to estimate transport times for livers, and we found that estimated transport time comprised only 21% of CIT in liver transplant<sup>14</sup>. These 2 separate results lead us to conclude that 80% of CIT is due to non-transport factors. Reducing allocation delays or reducing hospital delays are the only avenues to decreasing this largest fraction of CIT.

Unfortunately, organ procurement organizations are not required to record the time of acceptance of an organ offer, so the length of allocation delays is unknowable. Either center-driven events, or allocation delays, or both, could contribute to longer CIT. We cannot separate CIT into that which is attributable to allocation delays vs center-driven delays. Our study did not find any difference in same-hospital CIT in liver or kidney comparing single to multi-center OPOs. Presumably, the greater complexity of allocation in multi-center OPOs would make allocation delays longer, so this counter-intuitive finding suggests that allocation delays might not be the primary driver of differences in same-hospital CIT.

Further data from UNOS specifying time of final offer acceptance would allow for an improved understanding of CIT.

There are limitations of this study that warrant discussion. First, all registry studies are limited by self-reporting error, missing data, and reporting bias. The effect of missing CIT on inferences is likely minimal, as only 5–7% of CIT were missing. We did not describe mechanical perfusion among deceased donor liver transplants as this relatively new practice was not captured in the registry data. A second limitation in our design is that we did not account for changes in CIT due to secular trends or changes in allocation policy; however, we selected a study period that ended before the start of the new KAS in December 2014, and only captured a short period of Share-35 starting in June of 2013. The results of our study would mostly reflect a prepolicy state of allocation and might under-estimate the CIT that we would expect to see in other-hospital transplants under the current KAS and Share35 allocation systems.

We have shown that there is significant in-hospital CIT *without transport*. Furthermore, our findings suggest that motivated transplant centers were able to reduce CIT for candidates who urgently needed a transplant – those with MELD 35+ or Status 1A. A better understanding of what in-hospital factors are mechanistically related to long CIT may provide more effective avenues to reduce long CIT. Identifying modifiable factors that influence CIT is a necessary next step to reducing in-hospital CIT. Our findings are most relevant in the context of allocation policy where increased transportation from broader sharing would increase CIT for some recipients. The perceived detriments of longer CIT may be assuaged however by increasing in-hospital efficiency rather than fixating on transport time. While broader sharing may contribute additional CIT, much more CIT is being accumulated for other reasons.

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## ABBREVIATIONS

<b>CIT</b>	Cold Ischemia Time
<b>DGF</b>	Delayed Graft Function
<b>DDKT</b>	Deceased Donor Kidney Transplant
<b>HCC</b>	Hepatocellular Carcinoma
<b>DDLT</b>	Deceased Donor Liver Transplant
<b>KAS</b>	Kidney Allocation System

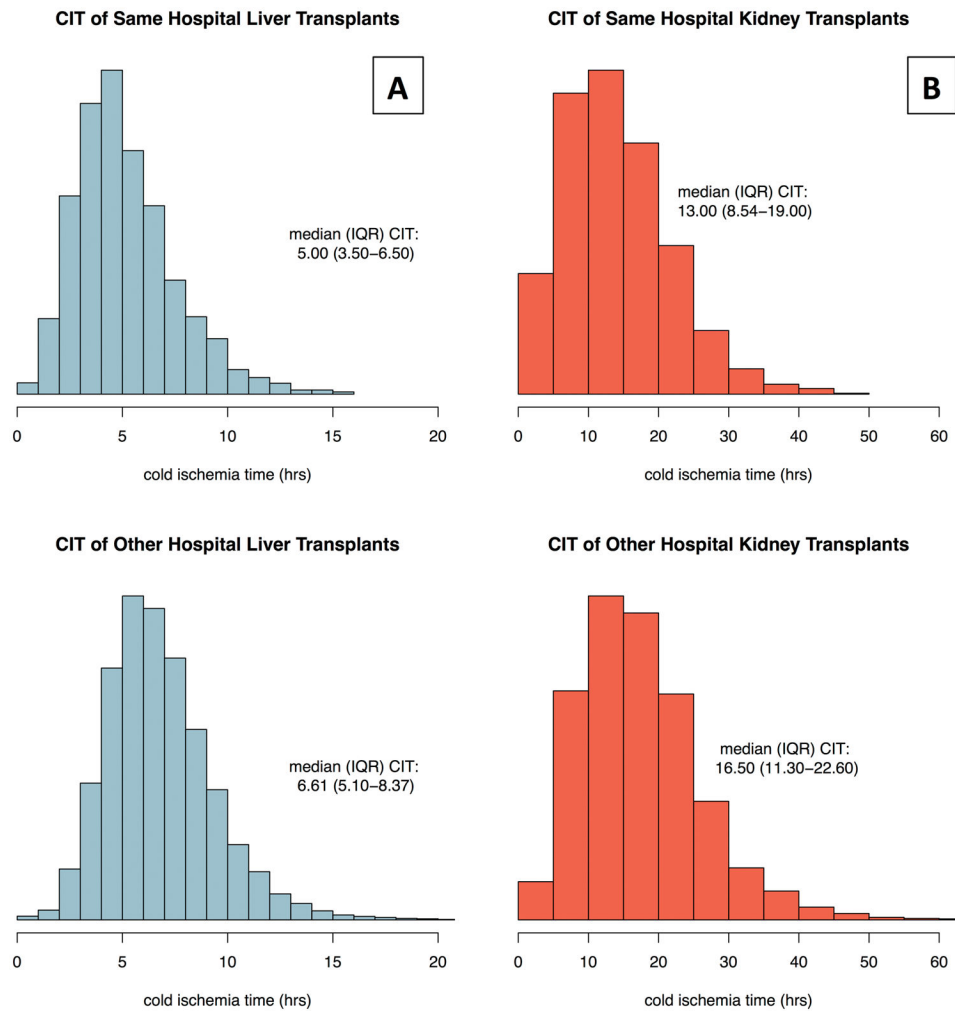
<b>OR</b>	Operating Room
<b>OPO</b>	Organ Procurement Organization
<b>LT</b>	Liver Transplant
<b>KT</b>	Kidney Transplant
<b>SRTR</b>	Scientific Registry of Transplant Recipients
<b>OPTN</b>	Organ Procurement and Transplantation Network
<b>HRSA</b>	Health Resources and Services Administration
<b>SHLT</b>	Same-Hospital Liver Transplant
<b>SHKT</b>	Same-Hospital Kidney Transplant
<b>OHLT</b>	Other-Hospital Liver Transplant
<b>OHKT</b>	Other-Hospital Kidney Transplant
<b>AFT</b>	Accelerated Failure Time
<b>PH</b>	Proportional Hazards
<b>TR</b>	Time Ratio
<b>BMI</b>	Body Mass Index
<b>MELD</b>	Model for End-Stage Liver Disease
<b>IQR</b>	Inter-Quartile Range
<b>DCD</b>	Donation after Cardiac Death
<b>ECD</b>	extended criteria donors

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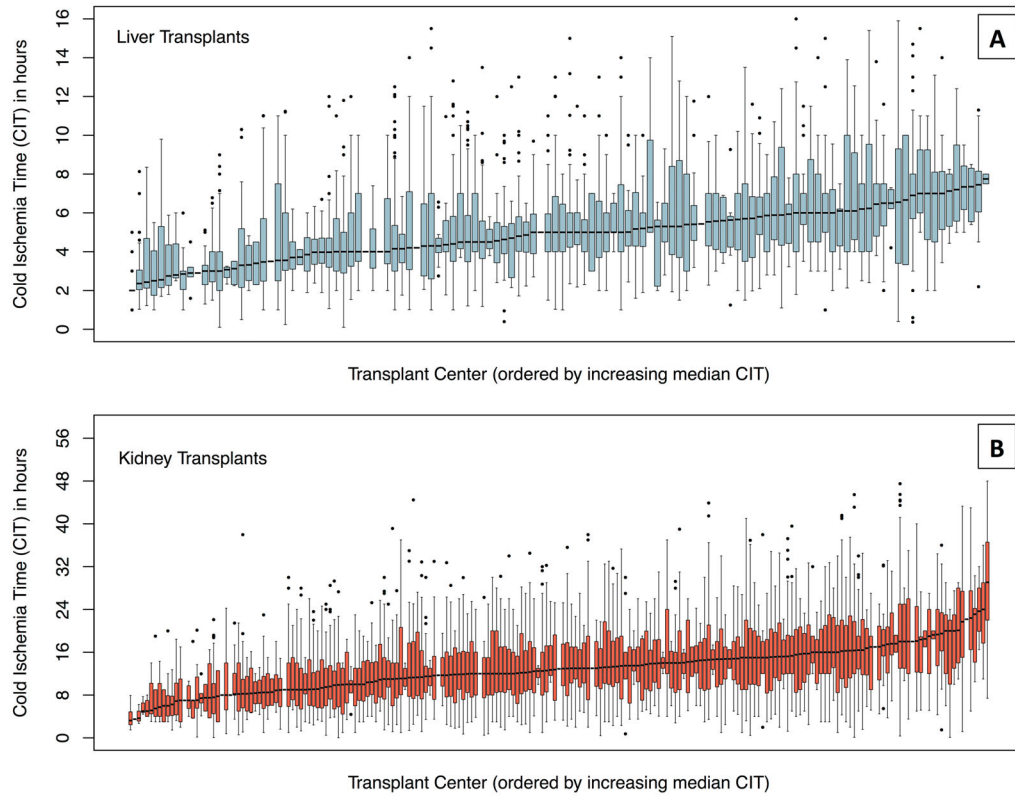
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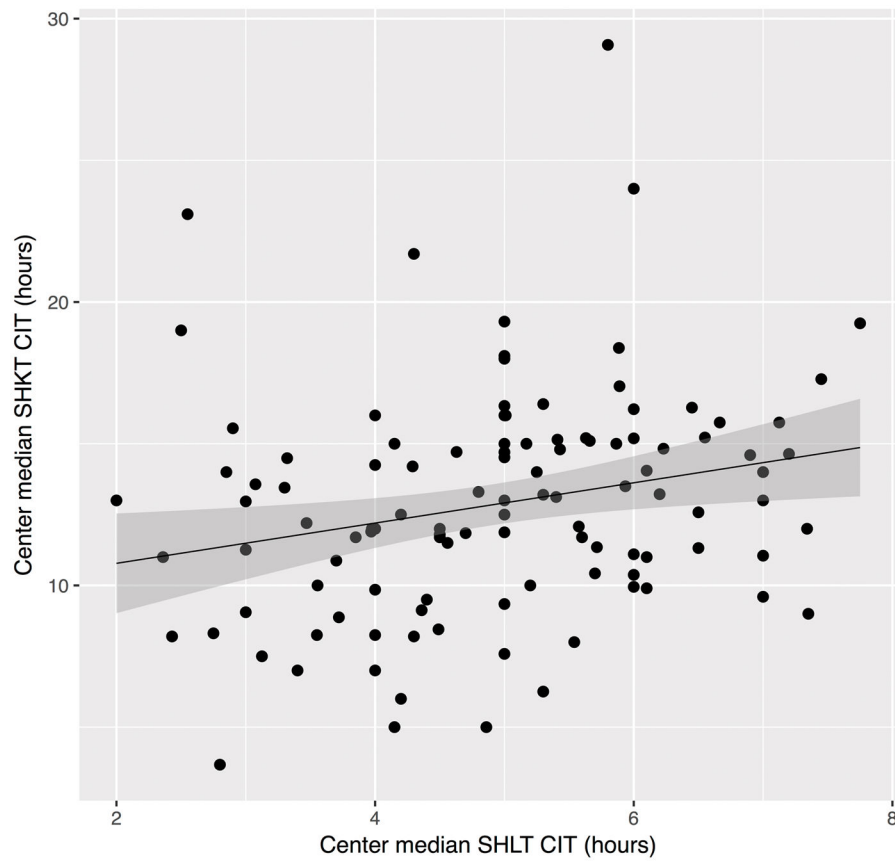
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**Figure 1. Figure 1a/b: Cold Ischemia Time of Liver and Kidney Transplants**  
 Same-hospital transplants are when the transplant and recovery procedures occur in the same center. Other-hospital transplants are when the transplant and recovery procedures occur at difference centers.



**Figure 2. Figure 2a/b: Range of Cold Ischemia Time by Transplant Center for Same-Hospital Liver and Kidney Transplants**  
The median for each center is shown as the dark line, IQR as grey bars, and outliers as points.



**Figure 3. Median CIT of Centers that Perform both Liver and Kidney Transplants**  
SHKT: Same-hospital Kidney Transplant, SHLT: Same-hospital Liver Transplant, CIT: Cold Ischemia Time. Each point represents a transplant center that performs both liver and kidney transplants. Centers that had a high median CIT for SHLT also had a high median CIT for SHKT ( $p=0.01$ ).

**Table 1a**

## Liver Transplant Deceased Donor and Recipient Characteristics

	Same-Hospital Liver Transplants	Other-Hospital Liver Transplants
Transplants, n *	4347	51282
Cold Ischemia Time hours, median (IQR)	5.0 (3.5–6.5)	6.6 (5.1–8.3)
Donor Characteristics:		
Age in years, mean (SD)	39 (23–52)	41 (24–54)
Female, n (%)	1700 (39)	21008 (41)
Ethnicity, n (%)		
White	2857 (66)	33758 (66)
Black	921 (21)	9085 (18)
Hispanic	492 (11)	6792 (13)
Other	77 (1.8)	1647 (3.2)
BMI, n (%)		
Underweight	157 (3.6)	1781 (3.5)
Normal	1583 (36)	18641 (36)
Overweight	1412 (32)	16194 (32)
Obese	1195 (27)	14666 (29)
DCD, n (%)	304 (7.0)	2323 (4.5)
Biopsy, n (%)	1372 (32)	17065 (33)
Recipient Characteristics:		
Age at transplant, mean (SD)	55 (48–61)	55 (47–60)
Female, n (%)	1412 (32)	17192 (34)
Ethnicity, n (%)		
Caucasian	3320 (76)	35770 (70)
African American	422 (9.7)	5437 (11)
Hispanic	442 (10)	7058 (14)
Other	163 (3.8)	3017 (5.9)
BMI, n (%)		
underweight	182 (4.3)	2573 (5.0)
normal	1218 (28)	14353 (28)
Overweight	147 (33)	16415 (32)
obese	1497 (34)	17941 (35)
Received HCC exception points, n(%)	965 (22)	12545 (25)
MELD at transplant, n (%)		
6–14	125 (2.9)	1880 (3.7)
15–21	1080 (25)	8742 (17)
22–28	2023 (47)	20506 (41)
29–34	509 (12)	8381 (17)
35+	468 (11)	8123 (16)
Status 1a/b	100 (2.3)	2791 (5.5)

	<b>Same-Hospital Liver Transplants</b>	<b>Other-Hospital Liver Transplants</b>
Previous LT, n (%)	253 (5.8)	3645 (7.1)
>1 transplants on same day, n (%)	290 (6.7)	4158 (8.1)

\* Livers with CIT >16hrs excluded (n=35)

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**Table 1b**

## Kidney Transplant Deceased Donor and Recipient Characteristics

	Same-Hospital Kidney Transplants	Other-Hospital Kidney Transplants
Transplants, n*	9707	86934
Cold Ischemia Time, median (IQR)	13.0 (8.53–19.0)	16.4 (11.3–22.4)
Donor Characteristics:		
Age, mean (SD)	39 (23–51)	40 (24–51)
Female, n (%)	3835 (40)	34386 (40)
Ethnicity, n (%)		
White	6880 (71)	59468 (68)
Black	1523 (16)	11989 (14)
Hispanic	1069 (11)	12582 (14)
Other	235 (2.4)	2895 (3.3)
BMI, n (%)		
underweight	386 (4)	3256 (3.8)
Normal	3405 (35)	31042 (36)
Overweight	3154 (32)	27255 (31)
obese	2762 (28)	25381 (29)
DCD, n (%)	1842 (19)	10115 (12)
ECD, n (%)	1487 (15)	14004 (16)
Right Kidney, n (%)	4954 (51)	45353 (52)
Biopsy, n (%)	3923 (40)	36156 (41)
Recipient Characteristics:		
Age at transplant, mean (SD)	52 (41–61)	53 (42–62)
Female, n (%)	3711 (38)	34153 (39)
Ethnicity, n (%)		
White	4745 (49)	39448 (45)
Black	3266 (34)	27012 (31)
Hispanic	1034 (11)	13774 (16)
Other	662 (6.8)	6700 (7.7)
BMI, n (%)		
underweight	306 (3.2)	3157 (3.6)
Normal	2666 (27)	24882 (29)
Overweight	2938 (30)	27091 (31)
obese	3797 (39)	31804 (37)
Previous KT, n (%)	1075 (11)	11027 (13)
Pre-Transplant Biopsy, n (%)	1617 (22)	12196 (17)
Ice and Mechanical perfusion, n (%)		
Received and kept on ice	6218 (64)	62356 (72)
Received on ice, put on pump	1120 (12)	6993 (8.1)
Received on pump, put on ice	636 (6.6)	5065 (5.8)
Received and kept on pump	1721 (18)	12380 (14)

\* Kidneys with CIT >48hrs excluded (n=68)

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**Table 2a****Patient Factors Associated with Cold Ischemia Time in Same-Hospital Liver Transplantation**

	<b>Time Ratio (95% CI)</b>	<b>p-value</b>
Donor Age (centered at 40, per decade)	1.00 (0.99 – 1.01)	>0.9
Donor Male Gender	0.99 (0.96 – 1.01)	0.3
Donor Race		
White	REF	
Black	0.99 (0.95 – 1.02)	0.4
Hispanic	0.99 (0.95 – 1.03)	0.7
Other	1.08 (0.99 – 1.18)	0.1
Donor BMI		
Normal	REF	
Underweight	1.03 (0.96 – 1.10)	0.4
Overweight	1.01 (0.98 – 1.04)	0.6
Obese	1.00 (0.97 – 1.03)	>0.9
DCD	1.08 (1.03 – 1.13)	<0.01
Donor Biopsy	1.09 (1.06 – 1.12)	<0.001
Recipient Age (centered at 55, per decade)	0.99 (0.98 – 1.00)	0.1
Recipient Male Gender	1.03 (1.00 – 1.06)	0.02
Recipient Race		
White	REF	
Black	1.00 (0.96 – 1.04)	>0.9
Hispanic	0.97 (0.93 – 1.02)	0.3
Other	0.96 (0.90 – 1.02)	0.2
Recipient BMI		
Normal	REF	
Underweight	0.96 (0.88 – 1.03)	0.2
Overweight	1.02 (0.99 – 1.06)	0.1
Obese	1.05 (1.02 – 1.09)	0.001
HCC points	0.98 (0.95 – 1.02)	0.3
MELD (allocation)		
6–14	1.03 (0.95 – 1.11)	0.5
15–21	0.99 (0.96 – 1.02)	0.508
22–28	REF	-
29–34	0.96 (0.92 – 1.00)	0.04
35+	0.91 (0.87 – 0.96)	<0.001
status 1a	0.74 (0.68 – 0.81)	<0.001
Previous Liver Transplant	1.11 (1.05 – 1.17)	<0.001
Year of transplant (centered at 2014)	0.97 (0.97 – 0.98)	<0.001
Additional LT procedures on same day	0.97 (0.92 – 1.01)	0.2
Transplant Center Annual Volume	1.00 (1.00 – 1.00)	0.1
Weekend Transplant	0.97 (0.95 – 1.01)	0.3

	<b>Time Ratio (95% CI)</b>	<b>p-value</b>
Single-center OPO (low competition)	1.03 (0.90 – 1.18)	0.5

Multilevel Accelerated Failure Time Model with OPO-level and Hospital-level variance ( $p < 0.01$ ).

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**Table 2b**

## Patient Factors Associated with Cold Ischemia Time in Same-Hospital Kidney Transplants

	Time Ratio (95% CI)	p-value
Donor Age (centered at 40, per decade)	0.98 (0.98 – 1.00)	<0.01
Donor male gender	1.00 (0.98 – 1.03)	0.7
Donor Race		
White	REF	
Black	0.98 (0.95 – 1.01)	0.3
Hispanic	1.00 (0.96 – 1.04)	>0.9
Other	1.06 (0.98 – 1.14)	0.2
Donor BMI		
Normal	REF	
Underweight	0.98 (0.92 – 1.04)	0.5
Overweight	1.03 (1.00 – 1.06)	0.02
Obese	1.02 (0.99 – 1.05)	0.3
DCD	1.09 (1.05 – 1.12)	<0.001
ECD	0.94 (0.90 – 0.98)	<0.01
Donor Right Kidney	1.05 (1.03 – 1.07)	<0.001
Donor Biopsy	1.13 (1.09 – 1.16)	<0.001
Recipient Age (centered at 50, per decade)	1.01 (1.00 – 1.02)	0.1
Recipient male gender	0.99 (0.97 – 1.01)	0.3
Recipient Race		
White	REF	
Black	1.01 (0.98 – 1.03)	0.7
Hispanic	1.01 (0.97 – 1.06)	0.5
Other	1.05 (1.00 – 1.10)	0.06
Recipient BMI		
Normal	REF	
Underweight	0.93 (0.87 – 1.00)	0.04
Overweight	1.03 (1.00 – 1.06)	0.09
Obese	1.03 (1.00 – 1.06)	0.02
Recipient Previous Transplant	1.02 (0.98 – 1.06)	0.3
Pre-Transplant Biopsy	1.00 (0.97 – 1.03)	>0.9
Ice and Mechanical Perfusion		
Received and kept on ice	REF	
Received on ice, put on pump	1.41 (1.33 – 1.49)	<0.001
Received on pump, put on ice	1.30 (1.23 – 1.38)	<0.001
Received and kept on pump	1.40 (1.34 – 1.45)	<0.001
Year of Transplant (centered on 2014)	0.98 (0.98 – 0.99)	<0.001
Additional KT procedures on same day	1.03 (1.01 – 1.05)	<0.01
Transplant Center Annual Volume	1.00 (1.00 – 1.00)	0.01
Single-center OPO (low competition)	0.95 (0.76 – 1.18)	0.6

	<b>Time Ratio (95% CI)</b>	<b>p-value</b>
Weekend Transplant	0.98 (0.96 – 1.01)	0.2
Same Donor SHKT vs OHKT	0.80 (0.79 – 0.81)	<0.001

Multilevel Accelerated Failure Time Model with OPO-level and Hospital-level variance ( $p < 0.001$ ).

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