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The Incremental Cost of Incompatible Living Donor Kidney Transplantation: A National Cohort Analysis

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Incompatible living donor kidney transplantation (ILDKT) has been established as an effective option for end-stage renal disease patients with willing but HLA-incompatible living donors, reducing mortality and improving quality of life. Depending on antibody titer, ILDKT can require highly resource-intensive procedures, including intravenous immunoglobulin, plasma exchange, and/or cell-depleting antibody treatment, as well as protocol biopsies and donor-specific antibody testing. This study sought to compare the cost and Medicare reimbursement, exclusive of organ acquisition payment, for ILDKT (n = 926) with varying antibody titers to matched compatible transplants (n = 2762) performed between 2002 and 2011. Data were assembled from a national cohort study of ILDKT and a unique data set linking hospital cost accounting data and Medicare claims. ILDKT was more expensive than matched compatible transplantation, ranging from 20% higher adjusted costs for positive on Luminex assay but negative flow cytometric crossmatch, 26% higher for positive flow cytometric crossmatch but negative cytotoxic crossmatch, and 39% higher for positive cytotoxic crossmatch ($p < 0.0001$ for all). ILDKT was associated with longer median length of stay (12.9 vs. 7.8 days), higher Medicare payments ($91 330 vs. $63 782 $p < 0.0001$), and greater outlier payments. In conclusion, ILDKT increases the cost of and payments for kidney transplantation.

Abbreviations: DRG, diagnosis-related group; DSA, donor-specific antibody; ESRD, end-stage renal

disease; HRSA, Health Resources and Services Administration; ILDKT, incompatible living donor kidney transplantation; IVIG, intravenous immunoglobulin; KAS, kidney allocation system; KPD, kidney paired donation; OAC, organ acquisition cost; OPTN, Organ Procurement and Transplantation Network; PCC, positive cytotoxic crossmatch; PFNC, positive flow cytometric crossmatch but negative cytotoxic crossmatch; PLEX, plasmapheresis/plasma exchange; PLNF, positive on Luminex assay but negative flow cytometric crossmatch; UHC, University HealthSystem Consortium

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Introduction

During the past 60 years, kidney transplantation has been established as the optimal therapy for the majority of patients with end-stage renal failure, offering improved quality and quantity of life at lower cost compared to chronic dialysis (1,2). In particular, living donor transplantation offers patients with renal failure the best chance of dialysis-free survival. While access to deceased donor kidney transplantation is limited by the shortage of donor organs, patients with high titers of anti-HLA antibodies from sensitizing events (e.g. blood transfusions, pregnancies, prior transplants) face the additional challenge of identifying compatible donated organs (3–6). Highly sensitized patients have traditionally faced very low transplantation rates and long waiting times on the deceased donor waitlist (3). Even with extra priority for highly sensitized patients under the new kidney allocation system (KAS), the only patients to benefit from this priority are those with a calculated PRA of 98% or higher (7).

The use of peritransplantation treatments to reduce the level of preformed alloantibodies has been established as a clinically viable option to improve access for highly sensitized patients to living donor transplantation (8–10). Desensitization protocols for incompatible living donor kidney transplantation (ILDKT) use resource-intensive treatments to lower antibody titers to safe levels, which minimizes the risk of hyperacute rejection (5,6,8,11). High-titer patients require intervention to abrogate the impact of circulating antibody, by reducing the amount in circulation and/or neutralizing its impact, while low-titer patients may require little to no additional treatment. Regimens incorporating intravenous immunoglobulin (IVIG), plasmapheresis/plasma exchange (PLEX), rituximab, and other agents result in acceptable allograft survival, albeit less than HLA-compatible transplantation (12,13). In addition, these patients are at a significantly higher risk of antibody-mediated rejection and may require more aggressive and costly therapies, such as splenectomy and eculizumab treatment, as well as heightened post-transplantation monitoring. (14,15)

Living kidney donation offers the best option to increase the supply of donor organs for renal transplantation and eliminates the need to wait for a compatible deceased donor. Unfortunately, sensitized patients may identify a willing donor who is biologically incompatible due to the presence of donor-specific antibodies (DSA) (3,8,16). While kidney paired donation (KPD) programs may identify a compatible kidney for fortunate patients, the likelihood of success is limited for the most highly sensitized patients. For these patients, ILDKT is associated with a twofold to fivefold reduction in mortality compared with the relevant options (waiting for a compatible deceased donor or remaining on dialysis) (3).

Despite the marked benefit of ILDKT, use of desensitization remains limited nationally, due in part to the concern about the high cost of the procedure and uneven reimbursement for necessary pretransplantation and post transplantation therapies. The purpose of this study was to examine the relative cost of ILDKT and compatible living donor kidney transplantation in a nationally representative, risk-adjusted cohort. We also examined the impact of DSA titer on ILDKT cost and payments.

Materials and Methods

Data sources and study samples

Study patients were drawn from patients undergoing ILDKT and matched controls from data collected for two national cohort studies. The first study was a multicenter retrospective analysis of adults undergoing ILDKT at one of 22 transplant programs in the United States between 1997 and 2011 (3). ILDKT recipients were further classified by the level of DSA: positive on Luminex assay but negative flow cytometric *and cytotoxic* crossmatch (PLNF), positive flow cytometric crossmatch but negative cytotoxic crossmatch (PFNC), and positive cytotoxic crossmatch (PCC). Patients who were both HLA and ABO blood group incompatible were classified based on the DSA titer. No patients who were only ABO incompatible were included.

The second study was a retrospective analysis of cost and payment for kidney transplantations performed at centers within the University HealthSystem Consortium (UHC) between 2002 and 2013 with available cost data (17). UHC is an alliance of 107 academic medical centers and 234 of their affiliated hospitals (approximately 90% of the nation's nonprofit academic medical centers, including approximately 50% of US transplant centers). UHC cost records are based on data submitted from the UB-04 billing forms. UHC patient records were linked to records from the national Organ Procurement and Transplantation Network (OPTN) registry by using date of transplantation, age, and sex, as previously described (17). The OPTN data system includes data on all donors, waitlisted candidates, and transplant recipients in the United States, submitted by the members of the OPTN, and has been described elsewhere. The Health Resources and Services Administration (HRSA), US Department of Health and Human Services, provides oversight to the activities of the OPTN contractor. (17) The UHC

population is similar to the overall US kidney transplant population as described in previous publications.

A secondary analysis of transplant payments for inpatient and outpatient care used Medicare payment data for patients with Medicare fee-for-service coverage. Medicare payment data were integrated with the national transplant registry by linking beneficiary identifiers from Medicare files to OPTN-IDs using Social Security number, sex, and date of birth as described in previous publications (17). We required a minimum payment of $10,000 for the transplant hospitalization to eliminate nontransplantation admissions. The final analytic cohort consisted of ILDKT recipients and controls undergoing transplantation between 2002 and 2011.

Matched compatible controls

To identify appropriate compatible controls, each ILDKT recipient in the UHC cohort was matched with up to three compatible living donor transplant recipients from UHC centers using a previously described algorithm (3). Matched controls were drawn from the pool of US transplant recipients who were not included in the ILDKT cohort study and had linked UHC cost records. Matched controls were identified by an iterative, expanding-radius matching algorithm, based on characteristics that included age, panel reactive antibody (PRA), prior transplantation, and blood group as previously described (3). Briefly, this is a matching algorithm that progressively loosens restrictions on variables within predetermined ranges until a match is identified and allows for prioritizing variables based on their clinical importance. An additional match was performed among Medicare-insured incompatible transplant recipients in the cohort and compatible transplant recipients with Medicare payments. Residual differences in cohort characteristics were addressed with multivariate modeling.

Cost and payment measures

UHC data include patient-level claims data from administrative billing claims submissions, adjusted to costs based on the transplant hospital's general Medicare cost:charge ratio and adjusted for geographic differential in wages. The primary outcome was cost of the hospitalization for transplantation, including organ acquisition cost (OAC). Costs were adjusted to 2013 dollars using the healthcare Consumer Price Index. Because Medicare payments do not include OAC (which is paid via the institutional cost report), Medicare payments reflect only the reimbursement obtained through the transplant Diagnosis Related Group (DRG) and any outlier payments that are provided when the charges for the admission exceed predetermined thresholds. In this case, the center receives additional payments that partially offset the cost of exceptional expensive cases. Direct calculation of hospital margin is not possible using these data because cost accounting systems and allocation of costs to the OAC may vary over time and between institutions. Medicare payment estimates were also adjusted to account for differential payments by Medicare to transplant programs in Maryland due to that state's Medicare payment waiver by removing payments recorded as related to OAC for these centers.

Cost regression analysis

Initial financial analysis compared the total cost of transplantation inclusive of OAC for ILDKT and compatible living donor transplantations. Log transformation yielded a normally distributed cost outcome and was examined in linear regression analyses of the impact of ILDKT on costs of care compared with matched controls. The varied association of ILDKT and costs of care across DSA levels were also examined by interactions. We used clustered sandwich estimator to account for correlation of ILDKT and matched compatible transplants.

Medicare payment analysis

Medicare payment data were evaluated for the subset of UHC patients with fee-for-service Medicare. Total payments for hospitalization for transplantation (Part A) were examined. In addition, Medicare outlier payments were examined to assess the prevalence and amount paid comparing ILDKT patients with controls as well as differences by antibody strength. Medicare payments for posttransplantation care (months 1–36) were analyzed for patients with continuous coverage and Medicare primary insurance (N = 1629 cases and controls). These costs include all Part A and B claims but do not include medications that were reimbursed under Part D, supplemental private insurance, or Medicaid.

Statistical analysis

Cost data linkage and management were performed by using SAS 9.4 software (SAS Institute, Cary, NC). Cohort matching and cost analyses were performed with STATA 14 (Stata, College Station, TX). Multivariate models used log transformed cost data to address the substantial right skew of cost data, and the resulting beta estimates were reported after transformation.

Approvals

This study was approved by the institutional review boards at Saint Louis University and Johns Hopkins University. The project was also approved by the OPTN, HRSA, and UHC.

Results

Among the full cohort of 1025 ILDKT recipients, 926 had linked UHC cost data; 2762 matched controls were identified among compatible living donor transplant recipients with UHC records, representing patients who underwent transplantation at 16 transplant centers. Overall demographic characteristics were similar for the two groups, although recipients of ILDKT more commonly were women (67.4% vs. 54.3%) and had blood type O (49.2% vs. 42.6%) (Table 1). There was a modestly higher number of patients with diabetes (23.6% vs. 20.5%) among the controls. By antibody titer level, 171 PLNF ILDKT recipients were matched to 511 controls, 495 PFNC ILDKT patients were matched to 1479 controls, and 260 PCC ILDKT recipients were matched to 772 controls.

Overall, ILDKT was associated with an increase in the cost of the transplant procedure compared with transplantation costs for matched compatible controls. The average cost of ILDKT, including OACs, was 41.6 higher than that for matched controls ($151 024 vs. $106,636 $p < 0.001$). The differential in cost between ILDKT and compatible transplantation increased with antibody titer levels. PLNF ILDKT was associated with a mean cost of $152 949 vs. $117 342 for compatible transplantations with similar characteristics ($p < 0.001$). PFNC ILDKT ($146 667 vs. $105,939 $p < 0.001$) and PCC ILDKT ($161 269 vs. $102 319 $p < 0.001$) were associated with even greater differential in costs compared with compatible transplantations. Similar patterns were seen for median costs (Figure 1A).

Regression analysis of log-transformed costs adjusted for residual differences in ILDKT and control populations demonstrated that the total transplantation cost was 20% higher for PLNF ILDKT, 26% higher for PFNC

Table 1: Baseline demographic and clinical characteristics of the sample of ILDKT patients with UHC cost records and matched compatible living donor transplant controls

	ILDKT (n = 926)	Matched controls (n = 2,762)	p value
Age, mean (SD)	45.1 (12.9)	45.6 (12.4)	0.20
Female (%)	624 (67.4)	1499 (54.3)	<0.001
Black race (%)	144 (15.5)	467 (16.9)	0.3
ABO blood type (%)			<0.001
O	456 (49.2)	1178 (42.6)	
A	318 (34.4)	1052 (38.1)	
B	115 (12.4)	447 (16.2)	
AB	37 (4.0)	85 (3.1)	
No of previous transplantations (%)			0.6
0	547 (59.1)	1661 (60.1)	
1	321 (34.7)	951 (34.4)	
2	54 (5.8)	140 (5.1)	
≥3	4 (0.4)	10 (0.4)	
Diabetes (%)	190 (20.5)	653 (23.6)	0.03
ESRD duration (%)			0.2
Preemptive	108 (11.7)	315 (11.4)	
0–1 years	122 (13.2)	400 (14.5)	
1–4 years	230 (24.8)	686 (24.8)	
4–10 years	175 (18.9)	490 (17.7)	
10 + years	291 (31.4)	871 (31.6)	
PRA (%)			0.07
0–19	223 (24.1)	678 (24.6)	
20–79	318 (34.3)	926 (33.5)	
80–100	385 (41.6)	1158 (41.9)	

ILDKT, incompatible living donor kidney transplantation; UHC, University HealthSystem Consortium; ESRD, end-stage renal disease; PRA, panel reactive antibody.

Table 2: Comparison of log-transformed costs in ILDKT recipients versus matched compatible controls, by DSA strength

	Log cost ratio versus matched controls (95% CI)	p value
DSA strength		
PLNF	1.20 (1.13–1.28)	<0.0001
PFNC	1.26 (1.21–1.31)	<0.0001
PCC	1.39 (1.30–1.49)	<0.0001

DSA, donor-specific antibody; PLNF, positive on Luminex assay but negative flow cytometric crossmatch; PFNC, positive flow cytometric crossmatch but negative cytotoxic crossmatch; PCC, positive cytotoxic crossmatch.

ILDKT, and 39% higher for PCC ILDKT compared with cost for compatible donors (Table 2). Interaction analysis demonstrated that the incremental cost attributable to ILDKT was not significantly different between PLNF and PFNC ILDKT (p = 0.22). However, PCC ILDKT was significantly more expensive than PLNF ILDKT (p = 0.001) and PFNC ILDKT (p = 0.009) after adjustment for donor and recipient characteristics.

Costs were further analyzed to determine the differences in cost by category of expenditure (Figure 2 A–D). ILDKT was associated with dramatic increases in the cost of blood products ($9196 vs. $2908 p < 0.0001), pharmaceuticals ($32 485 vs. $17 399, p < 0.0001), dialysis ($1524 vs. $617, p < 0001), and room and board (including both intensive care unit and ward, $21 681 vs. $14 008 p < 0.0001) during the transplantation episode. Operating room cost was marginality higher for ILDKT patients ($7132 vs $6757 p = 0.02). Similar trends were noted when cost was assessed based antibody strength, although the greatest differences were noted in the PCC group.

Medicare payment data were available for a subset of the 526 ILDKT recipients, for whom matched controls were identified among recipients of living donor transplantation with linked Medicare data (Table 3). ILDKT was associated with increasing Medicare payments per transplantation from $70 161 to $101 202 across DSA levels. The payment was not significantly higher in patients who were PLNF compared to their controls (p = 0.69). However, PFNC ILDKT ($93 481 vs. $57 258, p < 0.0001) and PCC ILDKT ($101 202 vs. $54 309, p < 0.0001) were associated with greater Medicare payments compared to matched controls.

Analysis of Medicare outlier payments to hospitals in addition to the standard DRG-based reimbursement demonstrated that a greater percentage of PLNF patients than controls received an outlier payment (15.7 vs. 5.7%), although the mean outlier payment received per patient was higher in the controls ($70,597 vs. $28,674). (Table 3). Substantially more PFNC patients than controls received outlier payments (22.6% vs. 7.7%), and mean value was nearly $15,500 greater ($42,094 vs $26,594) per outlier case overall. Among PCC ILDKT, 24.4% received outlier payments (vs. 4.7% of controls), with a mean value of $40 631 (vs. $35 361) per case. The higher rate of outlier payments in ILDKT may reflect an incremental length of stay of 4 days. Although the difference in length of stay among PLNF ILDKT and compatible transplantations was modest (9.5 vs. 8.1 p < 0.0001), the increase in length of stay was more pronounced in PFNC ILDKT (12.6 vs. 7.9, p < 0.0001) and PCC ILDKT (15.0 vs. 7.5 p < 0.0001).

Post transplantation payments were analyzed for 437 ILDKT transplants and 1318 controls with at least 1 year of post transplantation follow-up and continuous Medicare coverage. Overall, the unadjusted median Medicare payments for ILDKT ($32 422 vs. $27 018 p = 0.008) were higher for the first posttransplantation year. In multivariate modeling, adjusting for donor and recipient characteristics including antibody strength, there was no increase in the expected payment under Medicare at 12 months. In multivariate analyses, there were no significant differences in posttransplantion costs associated

Table 3: Comparison of Medicare payments for ILDKT recipients versus matched compatible controls for the cohort overall and by DSA strength

	N	Total payment (mean US$)	LOS (median days)	Outlier (% of cases)	Outlier payment (mean US$ per case)
Overall					
Control	1562	58 084	7.8	6.6	34 603
Case	526	92 150	12.9	22.1	40 098
PLNF					
Control	244	68 237	8.1	5.7	70 597
Case	83	70 161	9.5	15.7	28 674
PFNC					
Control	847	57 258	7.9	7.7	26 594
Case	283	93 481	12.6	22.6	42 094
PCC					
Control	471	54 309	7.5	4.7	35 361
Case	160	101 202	15.0	24.4	40 631

Mean payments include payments (US$) for inpatient stay exclusive of organ acquisition cost. Outlier payments summarize the percentage of cases receiving outlier payments and the value (US$) of such payments when received. Length of stay (LOS) includes the day of transplant to discharge from the transplant hospitalization. All differences between cases and controls are statistically significant ($P < 0.0001$). DSA, donor-specific antibody; PLNF, positive on Luminex assay but negative flow cytometric crossmatch; PFNC, positive flow cytometric crossmatch but negative cytotoxic crossmatch; PCC, positive cytotoxic crossmatch.

with PLNF, PFNC, PCP transplantation after adjustment for donor and recipient characteristics (data not shown).

Discussion

Living donor kidney transplantation has been clearly established as the preferred therapy for patients with ESRD who have a compatible living donor. Successful transplantation results in longer expected survival, improved quality of life, and lower cost compared with chronic dialysis. For patients with a willing but HLA-incompatible donor, KPD is the optimal solution when identification of a compatible donor is feasible, allowing transplantation without the need for the resource-intensive desensitization therapy required for ILDKT. However, for patients with a willing donor who are unable to identify a compatible donor through KPD, ILDKT reduces mortality and improves patient outcomes (3). In the current study, we performed a novel linkage of records from a large, multicenter ILDKT cohort with cost data from an academic hospital consortium and Medicare claims. We found that ILDKT was 20–39% more expensive than compatible transplantation for the transplantation episode and that differential expense increased with higher pretransplantation DSA titer. Importantly, although Medicare payments were significantly higher, the average increase in payments does not appear sufficient to cover the difference in costs.

Although this national cohort analysis did not specify the method of desensitization treatment used by each center, most use either the combination of high-dose IVIG/rituximab protocol initially by developed Jordan and colleagues or PLEX/low-dose IVIG pioneered at Johns Hopkins by Montgomery and colleagues (6,18). The Jordan approach requires the administration of high-dose IVIG (2 g/kg) twice, 1 month apart before transplantation, with rituximab administered between doses. Alemtuzimab is given at the time of transplantation with an additional dose of IVIG. PLEX is selectively used in cases with persistent elevation of DSA titers. In a prospective evaluation comparing 66 ILDKT with 111 low-risk (compatible) patients, this protocol resulted in equivalent death-censored graft survival (ILDKT 87.9% vs. control 88.3%) at 5 years. However, rates of rejection and graft loss were higher in the 19 patients who required PLEX due to persistently elevated DSA titers (8). The Hopkins approach to desensitization combines plasmapheresis every other day for a number of pretransplantation and posttransplantation treatments depending on initial antibody titers and rebound. Patients also receive low-dose IVIG, thymoglobulin, and triple maintenance immunosuppression therapy. Patients then undergo five additional treatments after transplantation to prevent antibody rebound. Prospective evaluation of a cohort of 211 patients transplanted between 1998 and 2009 demonstrated improved survival compared with a matched group of waitlisted patients. Recent trials with the addition the anti–plasma cell agent bortezomib have not demonstrated beneficial effects (19).

Effective desensitization requires clinically complex regimens including expensive pharmaceuticals in addition to the cost of PLEX treatments (19). The cost of high-dose IVIG alone exceeds $20 000 per dose (based on the average wholesale price for a 70-kg man). In addition to the cost of the pretransplantation desensitization treatment itself, patients are generally given thymoglobulin or alemtuzimab as induction to reduce the risk of

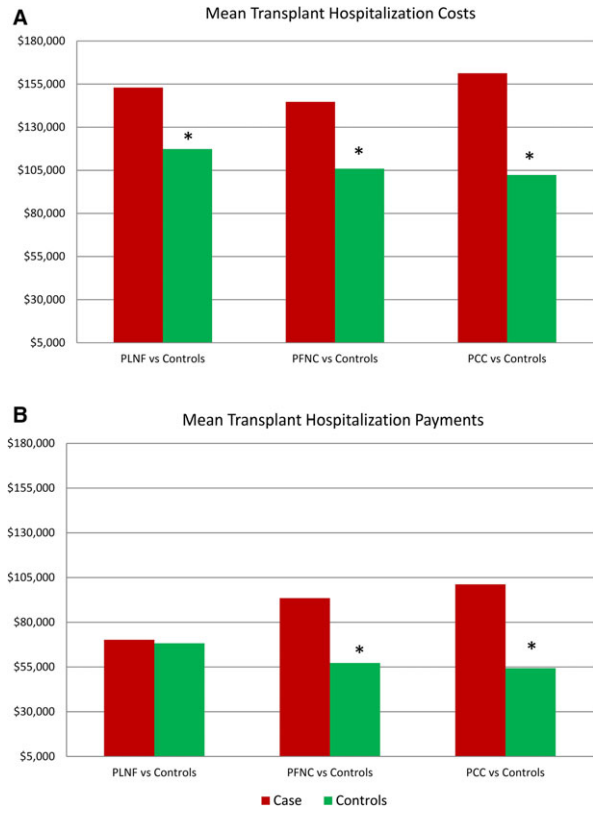

Figure 1: Comparison of mean costs (A) and Medicare payments (B) for the transplant hospitalization in ILDKT recipients versus matched compatible controls, by donor-specific antibody strength. Cost data capture all inpatient costs including organ acquisition cost. Payment data (Medicare Part A) do not include organ acquisition cost (which is paid via the institutional cost report). ILDKT, incompatible living donor kidney transplantation. PLNF, positive on Luminex assay but negative flow cytometric crossmatch; PFNC, positive flow cytometric crossmatch but negative cytotoxic crossmatch; PCC, positive cytotoxic crossmatch. *$p < 0.001$. [Color figure can be viewed at wileyonlinelibrary.com]

cellular rejection. As a consequence of the administration of cell- and antibody-depleting treatments, ILDKT transplantation has been associated with a higher incidence of medical and surgical complications. PLEX treatment can contribute to coagulopathy in the operating room or afterward. In addition, there is the potential for early antibody rebound requiring additional therapies such as urgent splenectomy, splenic irradiation, eculizumab, or transplant nephrectomy. Although the routine use of eculizumab has not been shown to affect outcomes, more-widespread use of bortezomib may follow successful pilot data (20). While there are no multicenter reports addressing the incidence of infectious or cardiovascular complications in ILDKT, rates of these complications in ABO-incompatible transplantation (which uses similar conditioning regimens), compared with ABO compatible transplants, demonstrate marked increases in pneumonia, urinary tract infections, and hemorrhage (21).

Accurate assessment of the incremental cost of ILDKT should be considered in the context of the alternative treatment of long-term dialysis therapy given the low rate of transplantation for highly sensitized patients (3,5,6). In a single-center evaluation of the cost effectiveness of high-dose IVIG-based desensitization in patients awaiting deceased donor transplant, Vo and colleagues demonstrated that ILDKT resulted in break-even costs at 2.5 years posttransplantation, with an estimated overall cost savings of $34 000 compared with chronic dialysis until compatible transplantation (9,10). Care for broadly sensitized patients represents a significant financial burden for US transplant programs, as payment under the Medicare program is not adjusted for donor or recipient characteristics (17). In a recent analysis of 36 715 living donor transplantations, we demonstrated that PRA levels of 98 or greater increased cost by nearly $10 000 per transplantation (17). The current study demonstrates that the cost of PFNC and PCC ILDKT was $35 000–$60 000 more expensive than compatible living donor transplantation. The cost of compatible transplantation varied across the DSA titers as patient and donor characteristics differ. Overall, Medicare payments were also higher for these patients; however, it is difficult to determine overall profit and loss given accounting differences in the treatment of OAC between transplant programs. Furthermore, several programs benefit from unique payer arrangements, such as the Medicare waiver in Maryland, under which the statewide single-payer system provides additional funds for transplantation of higher-risk kidneys.

The results of this study are limited by the nature of the available data. First, despite linkage with the largest cohort study of ILDKT in the world and UHC data that include the majority of academic medical centers in the United States, ILDKT remains an uncommon procedure. In this study, only 16 transplant programs were represented. However, given the magnitude of the effect of ILDKT on costs, it is unlikely that a larger cohort would alter these findings. Second, the UHC data lack information on the exact regimen used for desensitization and detailed data on categorization of antibody titer. Thus, these data may not capture the full cost of the ILDKT treatment if study medications were included or treatments were administered outside of the transplant period. While some centers may treat PLNF patients as similar to compatible patients, all ILDKT patients in this study received additional therapy by study definition. The data, however, provide the best estimate of the cost of the transplantation episode and incremental resources needed to support ILDKT given real world practice. Third, payment data include patients with Medicare fee-for-service payment data only. These data may not reflect case rates and negotiations arranged

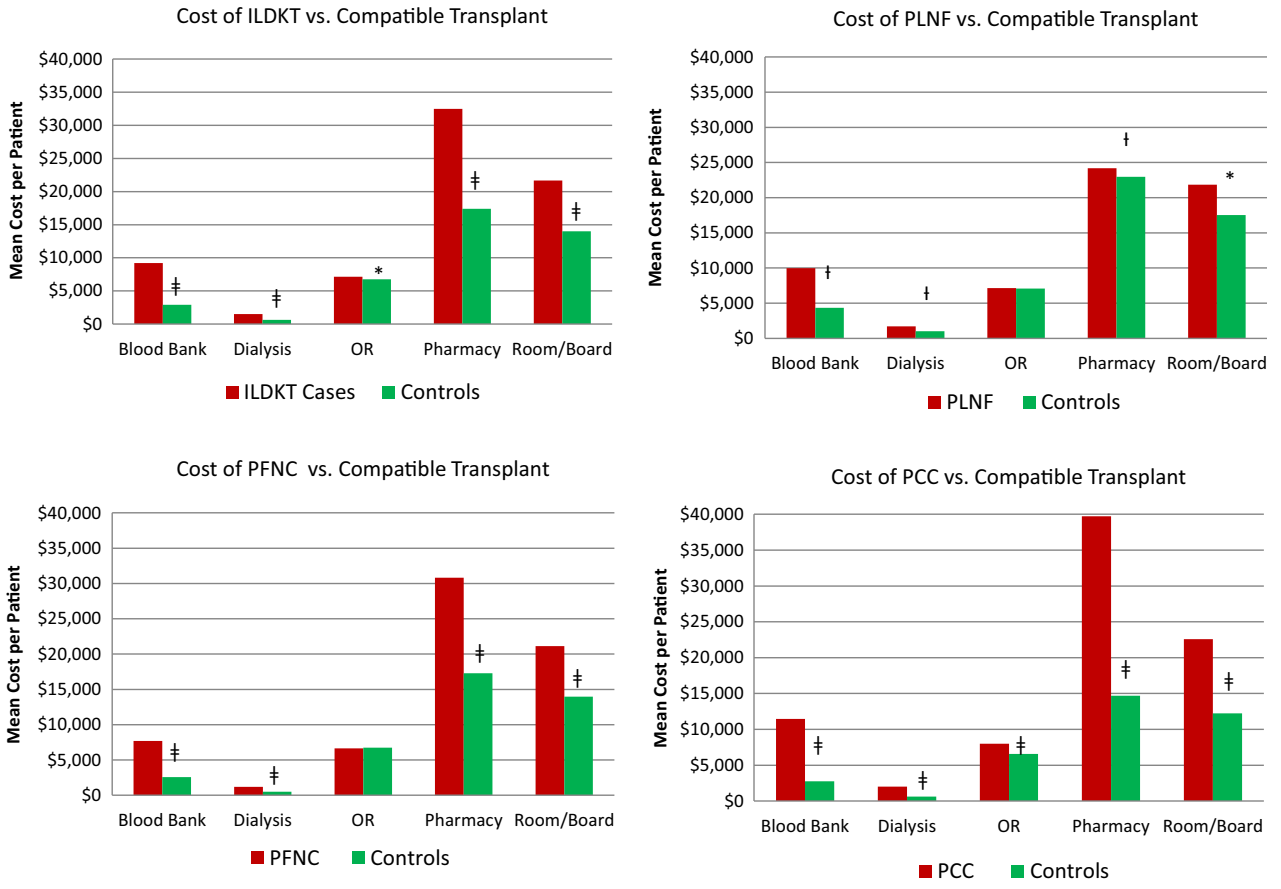

Figure 2: Comparison of costs of blood, pharmacy, room and board, and operating room services during the transplant episode for ILDKT recipients versus matched compatible controls, by donor-specific antibody strength. *$p < 0.001$, †p 0.001 to < 0.05. ILDKT, incompatible living donor kidney transplantation; OR, operating room; PCC, positive cytotoxic crossmatch; PFNC, positive flow cytometric crossmatch but negative cytotoxic crossmatch; PLNF, positive on Luminex assay but negative flow cytometric crossmatch. [Color figure can be viewed at wileyonlinelibrary.com]

with private payers to facilitate these transplants. Finally, this analysis was not designed to estimate the relative cost of ILDKT compared with long-term dialysis. Expected waiting time for and likelihood of compatible transplantation (whether deceased or living) are needed to assess the cost effectiveness of this treatment. These values differ by geography, ethnicity, and degree of all sensitization.

In summary, integration of data from large, national clinical and economic sources enable quantification of the marked increase in cost associated with ILDKT in a contemporary, national practice. Costs increased with DSA titer reflecting the increased use of posttransplantation therapies including PLEX as well as possible increases in complications with more-intensive desensitization regimens. The incremental cost of ILDKT compounds fear of regulatory citation for poor outcomes and lack of clinical experience, and limits broader adoption of this lifesaving procedure. (3,14) Broader adoption of ILDKT may improve patient survival and, potentially, reduce healthcare expenditures for patients with willing but incompatible donors who are unable to find a compatible match within KPD programs. Furthermore, it is likely the novel treatment strategies and new pharmaceutical agents will affect the cost differential observed in this study.

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Disclosure

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