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Combined liver–kidney and liver transplantation in patients with renal failure outcomes in the MELD era

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Summary

With the implementation of the Model for End-Stage Liver Disease (MELD) scoring system, the number of combined liver–kidney transplants (CLKT) has increased dramatically. The United Network for Organ Sharing (UNOS) dataset was analysed for adult recipients with renal failure for the period between February 2002 and April 2006. This group was subdivided into patients on hemodialysis (HD) and to those not on HD prior to transplantation. All recipients in renal failure (serum creatinine ≥2.5 mg/dl) at the time of transplantation were included. A total of 1397 subjects were in renal failure but not on HD (18% received a CLKT, 82% underwent LT alone). Another 1740 subjects were on HD prior to transplantation (41% received a CLKT while 59% received a LT). In dialysis-dependent recipients, Cox regression analysis demonstrated CLKT had an independent protective effect. In subjects on HD, CLKT had improved survival at 1 year (79.4 vs. 73.7%, $P = 0.004$). In patients in renal failure without HD, CLKT was not protective. CLKT subjects had a nonsignificant difference in survival as compared with patients who had undergone liver transplantation alone, at 1 year (81.0% vs. 78.8%, $P > 0.10$). In subjects undergoing CLKT, there was improved survival at 1 year as compared with LT-alone patients on hemodialysis; however, in patients with renal failure, but not on hemodialysis, there was no difference in survival when comparing CLKT to LT-alone.

Introduction

The Model for End-Stage Liver Disease (MELD) scoring system was implemented in February 2002 to improve the allocation of deceased-donor livers to those patients with renal failure and the highest waiting-list mortality. Creatinine concentration weighs heavily in the MELD score and thus gave significant priority for transplantation to patients with abnormal renal function. This system has led to an increase in liver transplants performed in renal insufficiency patients. However, the concern is that renal insufficiency before liver transplantation has been known to be associated with increased wait-list mortality as well as mortality after transplantation [1,2]. Patients requiring preoperative hemodialysis (HD) had worse outcomes as compared with those not requiring HD [3,4]. It can be used to predict not only the need for postoperative HD but also the risk of postoperative infection [5]. Thus, we have seen with the increase of pretransplant renal dysfunction and associated decreasing 5-year survival rates following liver transplantation [6]. Furthermore, the development of renal insufficiency or the persistence of renal insufficiency following liver transplantation are both associated with diminished patient survival [7]. Since the introduction of the MELD score, the number of combined liver–kidney transplants (CLKT) has increased dramatically. Utilizing Organ Procurement and Transplantation Network (OPTN)/UNOS data, it has been

previously shown that patients receiving CLKT had better outcomes than patients with preoperative serum creatinine >2 mg/dl who received a liver transplant alone (LTA) [8]. Since 1990, over 1790 patients in the United States have received a CLKT with a patient survival somewhat less than that for patients receiving either organ alone. Patients with renal failure because of acute injury or to the hepatorenal syndrome (HRS) have classically not been included as candidates for combined transplantation because of the reversibility of the renal dysfunction following liver transplantation. However, the rate and duration of renal failure prior to liver transplantation continues to be prolonged even with the new allocation scheme prioritizing liver transplants to those with renal failure. Thus, the issue of when kidney transplantation should be offered to ESLD patients and what evaluation is necessary prior to this decision continues to confront the transplant community. With the continued increase in demand, organ allocation remains an important consideration as the supply continues to remain the same with a concomitant decrease in quality. This study compares the outcomes of CLKT with isolated LT for patients in renal failure who either require HD or not. This analysis includes patients during the MELD era to help determine the optimal strategy for donor allocation.

Methods

The UNOS liver transplant dataset was analysed for all adult, non status-1, liver transplants occurring in recipients with renal failure in the U.S. during the period from February 2002 to April 2006. This group was subdivided into subjects undergoing transplantation while on HD and to those in renal failure not on HD prior to transplantation. Subjects receiving CLKT were compared with those receiving LT-alone (Fig. 1). Univariate analyses (chi-square, Student's *t*-test, Kaplan–Meier survival) and multivariate survival models (Cox proportional hazard models) were constructed to analyse independent predictors of death or re-transplantation. Survival models for both 1-year survival and overall survival were constructed. All recipients in renal failure at the time of transplantation were included (creatinine >2.5 mg/dl or on HD at the time of transplantation). While creatinine is generally a poor measure of renal function, the MDRD and Cockcroft–Gault equations are not applicable to the patient with decompensated liver disease. Because of the massive fluctuations in body weight with accumulation of ascites and variable amounts of muscle mass, these equations are not predictive of GFR and cannot be used in the pre-transplant population. This has been shown by several authors [9–11]. Also, all transplant organ allocation in this study and the definition of HRS are based on serum creatinine measurements [12]. Therefore, despite its inherent weakness, we used creatinine measurements to define renal dysfunction. We chose a Cr of 2.5 as the lower aspect of renal function as this is the level on which the diagnosis of HRS is based. All data manipulation and analysis were performed using SAS© (Cary, NC, USA). A value ≤0.05 was used as the upper limit for type 1 error to be deemed statistically significant and all statistical tests were two-sided. Because the dataset was deidentified, institutional review board permission was not required for this analysis (Fig. 2).

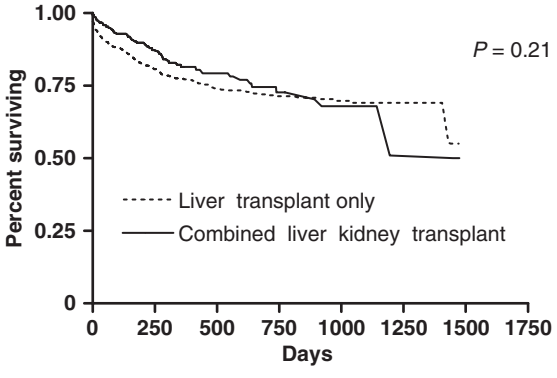

Figure 1 One-year survival for patients in renal failure but not on hemodialysis after LT-alone or combined LKT.

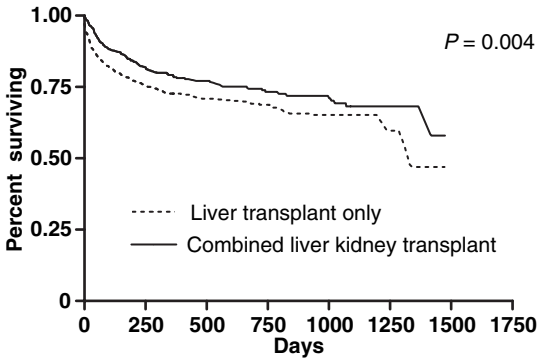

Figure 2 One-year survival for patients on hemodialysis at the time of transplant after LT-alone or combined LKT.

Results

We analysed 1397 subjects who were in renal failure but not requiring HD. A further subdivision of this group revealed that 18% received a CLKT while 82% of patients underwent LT. We found 1740 subjects who required HD prior to transplantation. Further subdivision of this group who required HD at the time of transplant revealed 41% of the patients received a CLKT while 59% of the patients

received a LT. Table 1 demonstrates renal failure patients undergoing a CLKT versus the LT group. For the recipients with renal failure not on HD the mean age, diagnosis of hepatitis C, body mass index, calculated MELD at transplant and creatinine at the time of transplant was not significantly different from recipients on HD at the time of transplant. Donor age and BMI of the donor for recipients with renal failure was similar in both groups. There was a significantly higher incidence of patients receiving a CLKT in the hemodialysis group as compared with the renal failure group that was not on HD (41% vs. 17.5%). There was also a statistically different incidence of liver graft failure in the hemodialysis cohort with 313 (30.5%) of those receiving isolated liver transplantation suffering graft failure versus 173 (24.2%) of those receiving CKLT ($P = 0.003$). This difference was not seen in those not on hemodialysis (graft failure in 25.0% of isolated liver transplant versus 20.0% in CKLT, $P = 0.10$).

Hemodialysis cohort (Table 2)

For the recipients with renal failure on HD, the mean age and hepatitis C positivity was similar for those patients receiving CLKT as compared with LT-alone. In recipients

Table 1. Demographics of study population.

	Recipients with renal failure but NOT on hemodialysis (creatinine >2.5 mg/dl; *n* = 1397)	Recipients ON hemodialysis (*n* = 1740)	*P*-value
Recipient factors			
Age, mean years (SD)	52.7 (9.4)	51.7 (9.6)	0.005
Hepatitis C positive, *n* (%)	495 (35.4)	619 (35.6)	0.53
Diabetes mellitus, *n* (%)	348 (24.9)	474 (27.2)	0.04
Body mass index, mean (SD)	28.4 (8.5)	27.8 (8.9)	0.03
Calculated MELD at transplant, mean (SD)	32.8 (7.8)	33.9 (8.7)	0.01
Creatinine at the time of transplantation, mean mg/dl (SD)	3.8 (1.4)	3.9 (2.4)	0.009
Donor factors			
Donor age, mean years (SD)	39.5 (16.8)	37.8 (16.5)	0.01
Body mass index, mean (SD)	26.1 (5.5)	26.0 (5.6)	0.85
Transplant factors			
Received combined liver–kidney grafts, *n* (%)	245 (17.5)	714 (41.0)	<0.0001
Age difference between recipient and donor, mean years (SD)	13.2 (18.7)	13.9 (18.2)	0.04
Waitlist time, mean days (SD)	206 (411)	207 (415)	0.39
One year post-transplant survival	79.2%	76.1%	0.29
Retransplantation, *n* (%)	184 (13.2)	200 (11.5)	0.21

Table 2. Characteristics of recipients *on hemodialysis* who received liver transplant alone (LTA) versus combined liver kidney transplant (CLKT).

Hemodialysis cohort	Liver graft alone (*n* = 1026)	Combined liver and kidney grafts (*n* = 714)	*P*-value
Recipient factors			
Age, mean years (95% CI)	51.5 (50.9–52.1)	51.9 (51.2–52.6)	0.37
Hepatitis C positive, n (%)	357 (34.8)	262 (36.7)	0.42
Diabetes mellitus, *n* (%)	225 (21.9)	249 (34.9)	<0.0001
Body mass index, mean (95% CI)	28.3 (27.8–28.8)	27.2 (26.3–28.0)	0.02
Calculated MELD at transplant, mean (95% CI)	35.9 (35.4–36.4)	31.1 (30.5–31.7)	<0.0001
Creatinine at the time of transplantation, mean mg/dl (95% CI)	3.22 (3.11–3.35)	4.75 (4.56–4.94)	<0.0001
Donor factors			
Donor age, mean years (95% CI)	39.4 (38.3–40.4)	35.5 (34.4–36.7)	<0.0001
Body mass index, mean (95% CI)	28.3 (27.8–28.8)	27.1 (26.3–28.0)	0.01
Transplant factors			
Age difference between recipient and donor, mean years (95% CI)	12.1 (11.0–13.3)	16.4 (15.2–17.7)	<0.0001
Waitlist time, mean days (95% CI)	187 (162–211)	236 (204–268)	0.01
One year post-transplant survival	73.7%	79.4%	0.004
Liver graft failure after transplant, *n* (%)	313 (30.5)	173 (24.2)	0.003

Table 3. Characteristics of recipients in renal failure (creatinine >2.5 mg/dl) but *NOT on hemodialysis* who received liver transplant alone (LTA) versus combined liver kidney transplant (CLKT).

Non hemodialysis cohort	Liver graft alone (n = 1152)	Combined liver and kidney grafts (n = 245)	P-value
Recipient factors			
Age, mean years (95% CI)	52.6 (52.1–53.2)	53.1 (51.8–54.3)	0.52
Hepatitis C positive, n (%)	406 (35.2)	89 (36.3)	0.75
Diabetes mellitus, *n* (%)	256 (22.2)	92 (37.6)	<0.0001
Body mass index, mean (95% CI)	28.6 (28.0–29.2)	27.5 (26.7–28.2)	0.02
Calculated MELD at transplant, mean (95% CI)	33.8 (33.4–34.3)	28.1 (27.2–29.0)	<0.0001
Creatinine at the time of transplantation, mean mg/dl (95% CI)	3.67 (3.59–3.74)	4.20 (3.96–4.44)	<0.0001
Donor factors			
Donor age, mean years (95% CI)	40.3 (39.3–41.3)	36.1 (34.2–38.0)	0.0002
Body mass index, mean (95% CI)	26.2 (25.9–26.5)	25.7 (25.0–26.5)	0.23
Transplant factors			
Age difference between recipient and donor, mean years (95% CI)	12.4 (11.3–13.4)	16.9 (14.7–19.2)	0.0005
Waitlist time, mean days (95% CI)	200 (176–224)	233 (183–283)	0.25
One-year post-transplant survival	78.8	81.0	0.20
Liver graft failure after transplant, *n* (%)	288 (25.0)	49 (20.0)	0.10

on HD, those receiving CLKT as compared with LT-alone had longer waiting times (236 days vs. 187 days, $P < 0.02$), significantly lower MELD scores (31 vs. 36, $P < 0.0001$), lower bilirubin levels (8.5 mg/dl vs. 10.9 mg/dl, $P < 0.0001$), and lower INR levels (1.8 vs. 2.2, $P < 0.0001$). Donor characteristics in the CLKT were more favorable as compared with LT-alone: including donor age (34 years vs. 38 years, $P < 0.0001$) and donor creatinine (1.0 mg/dl vs. 1.3 mg/dl, $P < 0.0001$). Cox regression analysis demonstrated CLKT had an independent protective effect in the HD patients: HR 0.775 (CI 0.604–0.995, $P < 0.045$). In this cohort, mean follow-up times for those patients receiving LT-alone was 937 days (±21 SE) vs. 1070 days (26 ± SE) in the CLKT group. In subjects on HD, CLKT had improved survival at 1 year (79.4% vs. 73.7%, $P = 0.004$; Graph 1). The CLKT group also had a higher incidence of diabetes as compared with the LT-alone group suggesting more chronicity to their renal failure.

Renal failure nondialysis cohort (Table 3)

For the recipients with renal failure but not on hemodialysis, the mean age and diagnosis of hepatitis C was similar to those patients receiving CLKT as compared with those undergoing LT-alone. For subjects in renal failure without HD, CLKT waiting time on the list was not significantly different than the same for LT. CLKT had significantly lower MELD scores (28 vs. 34, $P < 0.0001$), lower bilirubin levels (8.5 mg/dl vs. 16.1 mg/dl, $P < 0.0001$), and lower INR levels (1.7 vs. 2.2, $P < 0.0001$). CLKT subjects had greater mean serum creatinine (4.2 mg/dl vs. 3.7 mg/dl, $P < 0.0001$). All these factors suggest that patients receiving a CLKT had less severe liver failure than the LT-alone group. Donor characteristics in the CLKT were more favorable as compared with LT: donor age (36 years vs. 40 years, $P < 0.0004$), donor creatinine (1.1 mg/dl vs. 1.4 mg/dl, $P < 0.0008$). CLKT was not protective in the non-HD cohort using Cox regression analysis. In this cohort, mean follow-up

Table 4. Multivariate Cox proportional hazards survival analysis showing independent predictors of mortality after transplantation.

	P-value	Hazard ratio (HR)	95% CI
Combined kidney–liver transplantation	0.018	0.753	0.596–0.952
Hemodialysis at transplantation	0.035	1.249	1.016–1.536
Donor diabetes mellitus	0.380	1.185	0.811–1.732
Recipient diabetes mellitus (pretransplant)	<0.0001	1.582	1.297–1.931
Hepatitis C	0.192	1.135	0.938–1.374
Donor age	<0.0001	1.012	1.006–1.018
Recipient BMI	0.307	0.991	0.975–1.008
Recipient age	0.235	1.007	0.996–1.017
Recipient bilirubin at transplant	0.947	1.000	0.994–1.006
Recipient INR at transplant	0.892	0.996	0.945–1.050
Recipient creatinine at transplant	0.793	0.992	0.938–1.050
Donor creatinine at transplant	0.709	1.012	0.949–1.081
Days spent on the waiting list	0.946	1.000	0.999–1.001
Retransplantation	<0.0001	1.787	1.368–2.334

For dichotomous variables, the reference group for each hazard ratio is the group without the risk factor. For continuous variables, each hazard ratio is per unit increase in the variable.

times for those patients receiving LT-alone was 1067 days (±21 SE) vs. 937 days (±35 SE) in the CLKT group. CLKT subjects had no significant difference in survival as compared with LT at 1 year (81.0% vs. 78.8%, $P > 0.10$; Graph 2).

Table 4 shows the results of a multivariate proportional hazards survival analysis. This model adjusted for the above stated risk factors for post-transplant, all cause mortality. After adjustment for multiple other factors, the presence of HD ($P = 0.035$, HR = 1.249, 95% CI 1.016–1.536) at the time of transplantation and CKLT ($P = 0.018$, HR = 0.753, 95% CI 0.596–0.952) were both statistically significant independent predictors of mortality after transplantation. The independent effect of CKLT on post-transplant survival did not persist when analysing only the patients not on HD at the time of transplantation ($P = 0.369$, HR = 0.846, 95% CI 0.586–1.220). A separate analysis of graft survival with the same cofactors was not fundamentally different from the overall survival analysis.

Discussion

Renal dysfunction is well-documented to be associated with adverse outcomes in patients with liver failure on the waiting list for liver transplant as also following liver transplantation. Liver transplant candidates with advanced renal dysfunction have increased waitlist mortality if they are dialysis-dependent or if they are listed for CLKT. Waiting-list mortality has also been directly correlated with the degree of reduced renal function [13]. Wong *et al.* [14] demonstrated in a single-center study that in those patients awaiting liver transplant who developed acute kidney injury requiring HD that only 35% of survived to transplantation or discharge.

In a review of the UNOS database, Ojo *et al.* [7] found that the development of chronic renal failure (GFR <29 ml/min) after a nonrenal organ transplantation had a relative risk of death of 4.55. Factors that would accurately predict post liver transplant renal failure could become essential in the allocation of deceased donor kidneys to liver transplant recipients. Others have demonstrated that pretransplant renal failure is a significant independent predictor of short-term mortality following liver transplantation [6]. With the implementation of the MELD system, it was expected that patients with renal dysfunction would have improved outcomes following liver transplantation as the priority was given to creatinine concentration/clearance. One-year mortality of patients requiring pretransplant HD was 30% as compared with 9.7% for all other liver recipients without renal dysfunction [14]. An unintended consequence of the MELD system resulted in an increase in CLKT as higher priority was given to those patients with renal insufficiency. As seen in our data (Tables 2 and 3), those patients receiving CLKT had a lower MELD whether in the hemodialysis or non hemodialysis cohorts. This implies that the CLKT patients' liver disease was not as advanced or decompensated as those patients undergoing LTA. This is a difficult issue to address as the specifics of each transplant center's policies and the average MELD at which patients are transplanted vary greatly from center to center.

More recent analysis of the impact of renal dysfunction on post liver transplant outcomes in the MELD era indicates that patients with renal dysfunction continue to have inferior outcomes, although they show steady improvement as our study indicated. Nonetheless, it is clear that the post liver transplant requirement for HD connotes decreased allograft and patient survival. Gonwa *et al.* [15] recently demonstrated a positive correlation of worsening renal function pretransplantation on post-transplant patient survival. Their data highlighted that patients stratified for renal function (creatinine of <1.0, 1–1.99 and ≥2.0 mg/dl, and requiring HD) who received a LT-alone had 5-year patient survivals of 79.1%, 72.2%, 63.1%, and 63.9% respectively. Even in the MELD era, considering those factors influencing patient survival after liver transplantation, pretransplant renal function remains a significant independent predictor of post-transplant survival. Even more significant is the development of post-transplant renal failure. Two recent studies [16,17] demonstrated that acute renal failure following liver transplantation requiring HD was a mortality risk factor. Bozorgzadeh *et al.* [17] found no significant difference in survival when comparing patients on HD <14 days to those on HD >14 days prior to transplant ($P = 0.52$). However, a duration of post-transplant HD >30 days correlated with poor outcome ($P = 0.0019$). Appropriate deceased donor kidney allocation to those liver transplant patients who would require long-term post-transplant dialysis is of paramount importance in the era of organ shortage.

The number of CLKTs has nearly tripled since the implementation of the MELD system from 134 in 2001 to 399 in 2006. CLKTs represented approximately 6.5% of all liver transplants and 2.3% of all kidney transplants performed in the USA in 2006. Given the current shortage of both kidneys and livers available for transplantation, these trends raise a number of issues. What degree of acute or chronic renal dysfunction prior to transplant justifies CLKT? How can one reliably and safely determine the degree of irreversible renal injury that has occurred in patients with advanced liver disease and the likely course of renal function after transplantation? How do patient survival rates for CLKT compare with LT-alone in the MELD era for patients with equal degrees of renal insufficiency? Our data suggests that only ESLD

patients on dialysis benefit from CLKT. All other ESLD patients should receive a LTA. An accurate way to predict post-transplant renal failure as well as determine the reversibility of pretransplant renal dysfunction would help allocate deceased donor kidneys to the select group of patients with renal failure requiring dialysis. Complicating this issue is the obvious increased prevalence of diabetes-induced end-stage renal disease (ESRD) in the hemodialysis cohort relative to the non hemodialysis cohort receiving CLKT. In such a large database study such as presented here, it is difficult to explain. Nonetheless, it is not unreasonable to postulate that diabetics have accelerated ESRD relative to non diabetics with ESLD. As a result, they will receive higher MELD scores and will be transplanted more quickly.

Patients with ESLD who are candidates for liver transplant should be evaluated for renal insufficiency during their pretransplant evaluation as sudden changes in renal function are common. It is critical to establish an accurate diagnosis of the etiology and chronicity of the renal dysfunction during the liver pretransplant evaluation. A formal renal evaluation should be pursued if the creatinine is near or above the upper limit of normal, or if there is evidence of proteinuria or hematuria [13]. Reversible etiologies of acute renal failure and features suggestive of chronic kidney disease should be the focus of the clinical assessment. Pre-existing abnormalities and results of previous serum and urine tests of renal function should be reviewed to help determine the chronicity of the kidney dysfunction. In patients with abnormal renal function, radiologic imaging of the kidneys should be considered. Importantly from our review, we noticed a significantly higher incidence of diabetes in patients receiving CLKT, suggesting a more chronic disease state in this group of patients. There may be a subset of ESLD patients that may benefit from CLKT even when not requiring dialysis.

Patients without urinary abnormalities or clinical features suggestive of another etiology of acute renal failure may have HRS, which remains a diagnosis of exclusion. Renal function may recover following a successful LTA and remains the treatment of choice for patients with HRS. Historically, the length of time that creatinine is elevated pretransplant is the main determinant of renal function following liver transplant. There may be a difference in those patients undergoing temporary HD for decompensated HRS as opposed to those patients with known and chronic ESRD etiologies. This may introduce a bias in the results; however, this study suggests that the UNOS database alongside the United States Renal Data System registry may provide greater insight into the solution to this dilemma. Furthermore, the duration of acute renal failure and length of HD prior to liver transplant may have a role in determining the need for CLKT. Ruiz *et al.* [18] recently demonstrated increased patient survival in a single center report in 98 patients receiving CLKT. They found an advantage in patients with HRS who underwent dialysis for >8 weeks prior to receiving a CLKT. No survival advantage was demonstrated in patients with <8 week of dialysis. Furthermore, Locke *et al.* [19] conclude that despite the fact that higher quality allografts are utilized for CLKT relative to LTA there was no benefit observed. However, a more detailed analysis of the CLKT cohort highlighted an increase in 1-year patient and liver graft survival in those patients on HD ≥3 months. It has also been demonstrated that some patients were able to discontinue dialysis prior to receiving a transplant since the MELD allocation system was initiated (15% of candidates on dialysis at listing for LTA and 6.5% listed for CLKT; 9). Liver transplant candidates with acute renal failure not requiring dialysis are likely to recover renal function following LTA, with 81.5% survival at 1 year. A recent national consensus conference suggested that patients requiring HD for >6 weeks of HRS is an indication for CLKT [13].

In a recent review of the UNOS database by Gonwa *et al.* [20] demonstrated that when considering all patients with a preoperative serum creatinine of 2 mg/dl or greater (including those requiring HD), patient outcomes were inferior for LTA compared with CLKT. As observed in our data from the MELD era, they also demonstrated that for those patients with creatinine of more than 2 mg/dl but not requiring HD, there was no survival benefit to CLKT compared with LTA. For patients requiring HD, better outcomes were obtained with CLKT [11]. Aberg *et al.* [21] highlight that different etiologies of liver failure have altered outcomes with respect to ESRD. They observed that those patients with chronic ESLD, fulminant failure, and tumor had GFR ≤29 ml/min in 4%, 15%, and 0% of the cases respectively. The percentage with GFR <60 ml/min increased steadily in the chronic ESLD group (46% at 5 years) but decreased in the fulminant group from the day of transplant (26% at 5 years). Of patients with moderately or severely decreased GFR at listing, 73% of the ESLD and 35% of fulminant patients continued to exhibit renal dysfunction at 1 year. The cumulative incidence of ESRD was 16% at 10 years. MELD scores did not correlate with post-transplant GFR. Renal dysfunction prior to transplantation often improved post-transplant in fulminant liver patients, but was mostly unchanged in chronic ESLD patients or often steadily deteriorated.

Factors that determine renal recovery following transplantation still remain to be elucidated. Analysis of the number of patients who are listed for renal transplantation within the first year following liver transplantation

may help to determine the allocation of deceased donor kidneys. Thirty-eight patients were listed for kidney transplant in the first year following LTA between the beginning of the MELD era and the end of 2005. Interestingly, only 31.8% of these patients were receiving HD at LTA. The mean estimated GFR of the remaining was 39 ml/min [13]. Important data on those who developed ESRD but were not listed for kidney transplantation, or those who developed ESRD more than 1 year following liver transplantation, and their overall outcomes, is not available. We believe this type of data would guide allocation of kidneys in patients with renal insufficiency listed for liver transplantation. It has been noted that for those who develop ESRD after liver transplantation, survival is far superior for those receiving concomitant renal transplants compared with those remaining on dialysis [20]. The overall consensus was that local or regional review should adjudicate the decisions with regards to listing for CLKT as they do for other MELD exceptions. They concluded that systematic and continued approval should be granted for those patients (i) with ESRD with cirrhosis and symptomatic portal hypertension or hepatic vein wedge pressure gradient ≥10 mmHg, (ii) ESLD with renal insufficiency (GFR ≤30 ml/min), (iii) acute renal injury or HRS with creatinine ≥2.0 mg/dl and dialysis ≥8 weeks, and (iv) ESLD and renal insufficiency and biopsy demonstrating >30% glomerulosclerosis or 30% fibrosis [22].

Conclusion

In subjects undergoing combined liver–kidney transplantation in the recent MELD era, there was improved survival at 1 year as compared with liver transplantation alone if the subjects were on hemodialysis at the time of transplantation; however, in the cohort in renal failure, but not on hemodialysis, there was no difference in survival when comparing combined liver–kidney transplant to liver transplantation alone. This data suggests subjects in renal failure but not on hemodialysis should not be considered for combined liver–kidney transplantation given the current organ shortage. One potential limitation in this analysis is the lack of further definition of the severity of renal disease. We lack precise diagnosis and no data are available on an important determinant of renal disease. Finding a more accurate way of determining which of the patients will develop long-term renal failure after liver transplantation and allocation of kidneys in this select group of patients is of profound importance.

Authorship

TMS: wrote paper, analysed data and designed study. SCK: analysed data and critical review. TLP: analysed data. AA-O: analysed data. NS: analysed data. CKA: analysed data. CB: analysed data. PGN: collected data; analysed data and wrote paper.

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