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Advances in liver transplantation allocation systems

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Abstract

With the growing number of patients in need of liver transplantation, there is a need for adopting new and modifying existing allocation policies that prioritize patients for liver transplantation. Policy should ensure fair allocation that is reproducible and strongly predictive of best pre and post transplant outcomes while taking into account the natural history of the potential recipients liver disease and its complications. There is wide acceptance for allocation policies based on urgency in which the sickest patients on the waiting list with the highest risk of mortality receive priority. Model for end-stage liver disease and Child-Turcotte-Pugh scoring system, the two most universally applicable systems are used in urgency-based prioritization. However, other factors must be considered to achieve optimal allocation. Factors affecting pre-transplant patient survival and the quality of the donor organ also affect outcome. The optimal system should have allocation prioritization that accounts for both urgency and transplant outcome. We reviewed past and current liver allocation systems with the aim of generating further discussion about improvement of current policies.

Key words: Liver; Transplantation; Allocation; Model for end-stage liver disease

Core tip: This manuscript is a review on the different allocation systems developed in the field of liver transplantation. The review includes an overview of the past and current policies with critical discussion. It also reviews specific studies and suggested allocation models developed with the aim of improving current systems.

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INTRODUCTION

Liver transplantation is accepted as the curative treatment for end-stage liver diseases (ESLDs), acute liver failure, for metabolic disease where the liver is affected or affects other organs and for selected cases of hepatocellular carcinoma (HCC). Other indications for liver transplant included selected malignancies such as hepatoblastoma and neuroendocrine tumors. As outcomes have improved for graft and patient survival post liver transplant and the numbers of patients with liver disease and liver cancer grows, there is an increasing demand for donor organs. Policies for allocation and organ sharing have developed world-wide as demand has exceeded supply of donor livers. Allocation policies vary among different regions of the world, in specific countries and even between centers in one area when policy allows.

The most important aim of current allocation systems is prioritization of patients with the highest need for transplantation (based on mortality) while not sacrificing transplant outcome. Systems have been developed to predict the mortality of patients on the waiting list for liver transplantation. The Child-Turcotte-Pugh (CTP) score was the first prognostic system used to prioritize cirrhotic patients for liver transplantation by the United Network for Organ Sharing (UNOS) in the United States. Today, model for end-stage liver disease (MELD) scoring and its modifications has been succeeded CTP as the standard for use in allocation policy by many liver transplantation centers worldwide. In this manuscript we will review the previous and current accepted allocation policies and discuss potential modifications aimed at improving overall outcomes for liver transplantation.

PAST LIVER ALLOCATION POLICIES (PRE-MELD ERA)

Prior to 1997, the patient's need for liver transplantation was determined by the hospital status (intensive care *vs* standard care) and also by time on the wait list. Patients admitted to the intensive care unit (ICU) received the highest priority, next were non-ICU hospitalized patients followed by those who were outpatients. After 1998 UNOS adopted the CTP scoring system for prioritization of patients in need of liver transplantation.

CTP scoring system

The CTP scoring system was first introduced by Child and Turcotte as a pre-operative risk assessment tool for cirrhotic patients with variceal bleeding who were candidates for portosystemic shunt surgery[1]. Five variables were utilized: ascites, encephalopathy, nutritional status, serum bilirubin and albumin levels for scoring and divided the scores into 3 classes of A-C for prognosis levels. A later modification by Pugh *et al*[2] in 1973 substituted prothrombin time for nutritional status. This grading system was used to predict the post operation survival of cirrhotic patients undergoing emergency trans-section of esophagus for ligation of bleeding varices[2]. Based on 5 variables, each scored from 1-3 with total score range of 5-15 (Table 1), the CTP scoring was found to be a valuable tool to estimate the prognosis in cirrhotic patients, and had good specificity, high sensitivity, low cost and was simple to apply for individual patients[3]. Based on the prognostic validity of CTP scoring system, UNOS incorporated CTP score into the classification of candidates on the wait list for liver transplantation to help prioritize organ offers (Table 2). CTP score was used in the classification of UNOS status 2A, 2B and 3, while status 1 was applied for patients with acute fulminant hepatic failure at high risk of death without liver transplantation.

Table 1 Child-Turcotte-Pugh scoring system used as prognostic tool in cirrhosis

Parameter	Score		
	1	2	3
Encephalopathy	None	Grade Ⅰ-Ⅱ	Grade Ⅲ-Ⅳ
Ascites	Absent	Mild	Moderate to Severe
Albumin	> 3.5 g/dL	2.8-3.5 g/dL	< 2.8 g/dL
Prothrombin time prolongation over control (in seconds) or INR	< 4 < 1.7	4-6 1.7-2.3	> 6 > 2.3
Total Bilirubin	< 2 mg/dL	2-3 mg/dL	> 3 mg/dL

INR: International normalized ratio.

In 1997 the American Society of Transplant Physicians and American Association for the Study of Liver Diseases released a report on minimal criteria for placement of adults on the waiting list for liver transplantation. These included non-disease specific criteria for cirrhotic patients requiring a minimal CTP score of 7, and listing irrespective of CTP score for those who experienced gastrointestinal bleeding caused by portal hypertension or a single episode of spontaneous bacterial peritonitis. Disease-specific criteria included fulminant hepatic failure regardless of etiology. It was also suggested that specific risk scores for primary biliary cirrhosis and primary sclerosing cholangitis (PSC) would replace Child's classification[4].

There were several limitations of the allocation system based on CTP score. Grading of encephalopathy and the amount of ascites, subjectively determined variables, may be affected by inter-observer variability and also by medical treatment. The status of renal function was not directly accounted for in CTP scoring. Renal dysfunction has a negative impact on the survival of patients with ESLD[5] and specially for the rapidly progressive type of renal failure that occurs in the setting of advanced portal hypertension in cirrhotics, hepatorenal syndrome type 1, where mortality is very

Table 2 Old United Network for Organ Sharing classification for of candidates for liver transplantation

Status	Characteristics
1[1]	Patients with fulminant liver failure or those who their newly transplanted liver does not function
2A	Patients with chronic liver disease, in critical care unit and with life expectancy of < 7 d. They have a CTP score ⩾ 10 and meet other medical criteria.
2B	Patients with chronic liver disease becoming more urgently in need of a liver transplantation but do not meet the criteria of status 2A. They have a CTP score ⩾ 10, or a CTP score of ⩾ 7 and at least one of the other medical criteria.
3	Patients with chronic liver disease under medical care but not admitted in the hospital and do not meet the criteria for status 2B.

[1]These most critical patients include patients with fulminant hepatic failure; Primary non-function within 7-d of transplant; hepatic artery thrombosis (HAT) within 7-d of transplant and acute decompensated Wilson's disease. CTP: Child-Turcotte-Pugh.

high[6]. Another problem with this classification was the extremely broad categorization of class 2B. The system had only 3 categories of disease severity and many patients in class 2B category had low mortality risk, and the number of patients in this group expanded and became very large. This led to long wait time for transplantation as time on the list within a particular category determined which patients received organ offers. There also was no priority for patients with HCC, leading many of these patients to be removed from the list due to tumor progression or spread beyond the liver.

CURRENT STANDARD ALLOCATION SYSTEM (MODEL FOR END-STAGE LIVER DISEASE ERA)

In April 2000, Malinchoc *et al*[7] published the result of their multicenter study leading to development of a survival model in cirrhotic patients undergoing trans-jugular intrahepatic protosystemic shunt (TIPS) procedure. The model, introduced as Mayo TIPS model, was shown to be valid in prediction of early death following elective TIPS insertion for refractory ascites or prevention of variceal bleeding. In 2001 the same group released their study result showing reliability of this model with minor modification for the prediction of early mortality in patients with end stage liver disease[8]. The new scoring system was introduced as model for end-stage liver disease (MELD) and utilized the variables serum bilirubin and creatinine level, International Normalized Ratio (INR), and the etiology of liver disease. The impact of the etiology of liver disease on the predictive ability of MELD was revealed to be minimal in further analysis, so it was later deleted from the MELD[9].

MELD was superior to CTP scoring in several aspects. It relied on only a few objective parameters. The parameters were simple, reproducible and measurable by standard tests and offered a continuous and broad spectrum of scoring.

Table 3 Current United Network for Organ Sharing status and score assignment for liver transplant candidates

Status 1A: adult or pediatric patient with fulminant hepatic failure
Status 1B: severely ill pediatric patient (⩽ 18 yr) with MELD or PELD ⩾ 25, in ICU
Calculated MELD/PELD score
Exceptional MELD or PELD score
Status 7: inactive status, temporarily unsuitable for transplant

ICU: Intensive care unit; MELD: Model for end-stage liver disease; PELD: Pediatric end-stage liver disease.

MELD development was based on adult data and was not entirely applicable for pediatric groups where patient growth and development are real concerns. Therefore, another model, Pediatric end-stage liver disease (PELD) was developed using data from the Studies of Pediatric Liver Transplantation (SPLIT)[10]. This model utilizes 5 parameters of bilirubin, INR, albumin, growth failure, and age was shown to be accurate in the prediction of 3 mo mortality for pediatric patients waiting on the liver transplant list.

Since 2002, MELD was adopted by UNOS for prioritization of patients on the wait list for liver transplantation in the United States. The previously defined status I was maintained and MELD replaced status 2A, 2B and C (Table 3). The new system had gone through multiple analyses in different groups of patients with various causes of liver disease on the waiting lists for liver transplantation. As a result of these analyses, some modifications were made. The maximum serum creatinine level was set as 4 mg/dL for patients on hemodialysis (and other forms of renal replacement therapy) were given a serum creatinine level of 4 mg/dL even if treatment reduced their laboratory values. MELD score was given a cap of 40 and higher levels did not receive additional priority as all patients at this level have a very high mortality. Waiting time was applied only for patients with equal MELD/PELD score, and those with longer wait time on the list received priority[11].

In this new era, other indications for prioritization for liver transplantation not addressed by MELD/PELD scoring were considered. Patient with HCC stage Ⅰ and Ⅱ received a MELD score of 24 and 29, respectively and would receive additional points every three months, granted by UNOS Regional Review Boards (RRB) for the 11 regions, after re-evaluation of their tumor status while on the waiting list. It was also possible to grant higher priority (MELD exception scores) after review by individual RRB. Exceptions were granted and eventually standardized with respect to criteria for conditions such as hepatopulmonary and portopulmonary syndrome, and other metabolic

disorders including familial amyloidosis[11]. Other exceptions for treatment failures for complications of liver disease were considered on a case by case basis by the local RRB whose membership voted to approve or disapprove exceptions submitted for review (discussed below).

The first year impact of the new MELD/PELD allocation prioritization system was impressive. Fewer candidates were added to the wait list for liver transplantation, there was a significant increase in deceased donor liver transplantation and fewer (but non-significant) removals from the list because of death or being too sick without changing post-transplant outcomes. The application of MELD predictably led to an increase in the rate of transplantation for HCC, but also to a less desirable effect of increasing the numbers of combined liver and kidney transplantation[12].

An important concept was introduced into practice following the analysis of the survival benefit of patients receiving liver transplantation for patients stratified by pre-transplant MELD score. One-year survival of patients with MELD scores of less than 15 was adversely affected by liver transplantation when compared with patients who remained on the list. This effect was highest among patients with MELD score of 6-11[13]. This finding altered the practice of many transplant centers in that they no longer actively placed patients on the wait list if their MELD score was < 15 unless they had other complications of their liver disease or HCC that increased the urgency for transplantation.

To facilitate prioritization of the most urgent patients and reduce the waiting list mortality, a new policy called "Share 35" was adopted by UNOS in 2013. Increasing MELD increment correlates with increased wait list mortality, but patients with MELD scores over 35 are at the highest risk of mortality, similar to that for patients with Status 1-A[14]. According to Share 35 policy, patients with MELD scores over 35 on waiting lists within a region get the highest priority for organ receiving after Status 1-A patients. The first 12 mo analysis after adoption of Share 35 policy showed an increase in transplant rate, less drop outs due to medically too ill to transplant, lower wait list mortality and no change in early post transplant outcomes[15]. These data suggest that "share 35" achieved its initial goals of helping those most ill on the United States national wait list for liver transplant, but further analysis of long-term outcomes will be important to determine if true survival benefit was achieved by transplanting these very ill patients.

Although the MELD system has many advantages over other scoring systems for organ prioritization, it is not a perfect system. MELD does not account for laboratory variability in the measurement of parameters utilized or the effect of medical therapy to alter them, an example being the effect of warfarin on INR[16]. Serum creatinine is not a perfect indicator of renal function, especially in patients with ESLD due to their low muscle mass and also falsely low estimate of creatinine measurement in icteric serum when levels of bilirubin are very elevated[17].

The role of clinical judgment in the MELD system is limited to not listing a patient, or inactivating or removing patients from the wait list. Complications of ESLD such as ascites or hepatic encephalopathy are not considered by the system. Ascites without or with low serum sodium as a sign of hemodynamic derangement in the setting of advanced disease was shown to be associated with increased mortality, even in patients with low MELD scores[18]. For this reason new UNOS policy to modify the MELD score is being implemented (see below). Hepatic encephalopathy, another complication of liver cirrhosis was associated with poor outcomes[19,20]. Even after adjustment for MELD, hepatic encephalopathy grade 2 and higher was shown to be associated with poor survival in patients with cirrhosis, suggesting that encephalopathy grade provides additional prognostic information independent of MELD[21]. In another study, poorer outcomes were also observed with lower grades of hepatic encephalopathy (covert hepatic encephalopathy) in patients with cirrhosis. An increased rate of death, hospitalization and progression to higher grades of encephalopathy occurred despite controlling for MELD[22]. However judgement of encephalopathy grade is subjective, and influenced by patient medication adherence, so there has been little traction for bringing back this parameter of the former CTP allocation system.

The MELD system is also defective in not considering the impact on quality of life of the cirrhotic patient. Severe disabling pruritus, recurrent cholangitis and recurrent variceal bleeding poorly responsive to accepted medical and interventional management are among these complications[23]. For patients with these complications, it is left to the judgment of the center and RRB as to whether to appeal for and grant a MELD exception to these individuals.

In early phase of implementation of the MELD allocation system, the exception points offered to HCC patients led to a marked advantage for these patients to receive liver transplants in comparison with non HCC patients on the waiting list[12]. The potential negative impact of HCC priority on non HCC patients and low risk of progression to the advanced forms in stage I HCC[24] warranted further modification of MELD priority for HCC. According to the adjustment made in 2003 and 2005, patients with T1 tumors did not receive exception points anymore and those with T2 lesions were awarded a score of 22 that was increased every 3 mo by an amount based on predicted 10% increase in 3 mo mortality[25]. Further refinement of the system included adoption of very specific radiologic criteria for HCC beyond the prior presence of "arterial enhancement" that all centers needed to document in liu of direct histological demonstration of HCC.

MELD exceptions

There are several conditions for which liver transplantation is curative that are not addressed by MELD score alone. To compensate for these limitations of MELD based allocation for these conditions, a system of granting exception points was developed. MELD exceptions fall within two categories: (1) standardized exceptions; and (2) non-standard exceptions[26]. For standardized exceptions such as HCC, hepatopulmonary and portopulmonary syndrome, due to the presence of sufficient supporting data, exception points are granted to patients either automatically with RRB approval or by RRB discretion. Increases in exception priority scoring are reviewed by RRB every 3 mo. Non-standardized exceptions are those conditions considered important by the transplant team; however, there is no general agreement for their increased risk of mortality. These conditions could include cholangitis, recurrent pruritus and complications of portal hypertension[26,27].

Standardized MELD exceptions

Hepatocellular carcinoma is the most common condition for which standardized MELD exception is utilized. In the final revision of eligibility of patients with HCC for MELD exception, T2 tumors within Milan criteria (one single tumor no more than 5 cm in diameter or up to 3 tumors each $\leqslant$ 3 cm) without evidence of extra hepatic or vascular involvement (UNOS criteria) are automatically granted a MELD score of 22, and no priority was given to T1 patients. In addition, rules for radiologic criteria for tumor were adopted, (OPTN criteria, http://optn.transplant.hrsa.gov/publiccomment/pubcommentpropsub_273.pdf) and arterial enhancement or "tumor blush" alone was no longer accepted in isolation. However, even after implementation of this last policy revision, there was concern about the advantage of HCC patients over patients with other indications for liver transplantation with lower drop out from the list[28,29].

In order to prevent the negative impact of HCC prioritization on other patients on the transplant waiting list, UNOS policy is to cap the score given to patients with HCC exceptions at 34 points so as to not compete with the most ill patients on the transplant list being offered organs under Share 35. In addition, a delay in granting the exception points for all HCC patients for up to 6 mo was also implemented in order to weed out those with high risk for rapid tumor growth and metastatic potential. In a recently published study a MELD equivalent score ($MELD_{EQ}$) was introduced to evaluate the effect of this delay on HCC patients' list drop out and post transplantation survival[25]. $MELD_{EQ}$ was developed based on the laboratory MELD score, alpha fetoprotein levels, maximum tumor size, and number of tumors. The study result supported the 6 mo delay for exception points being granted in patients with $MELD_{EQ} \leqslant 15$ given the low risk of waiting list dropout. However, the patients with $MELD_{EQ}$ of 16-21 would possibly be negatively affected by this delay and authors suggested $MELD_{EQ}$ based prioritization of these patients. For those with higher MELD scores, further evaluation has been suggested before a conclusion is reached[25].

Other standardized MELD exception conditions include hepatopulmonary syndrome, portopulmonary hypertension, familial amyloid polyneuropathy, cystic fibrosis and cholangiocarcinoma.

Non-standardized MELD exceptions

HCC beyond Milan criteria is the most common indication for non-standardized MELD exceptions for RRB review. There is no standard guideline for offering exception points to these patients at this time, and regions are free to establish local policy. One suggestion published as a consensus recommendation is to consider only tumors within University of California-San Francisco (UCSF) criteria that are down-staged by ablative or alternative therapies to within UNOS criteria (Milan criteria) for exception points[26]. Consideration is also being given to holding transplantation for those with elevated AFP above 1000 ng/mL and for not prioritizing patients with low MELD scores who had a single small T2 lesion that was successfully ablated who remain without evidence of tumor recurrence. Adoption of this AFP cap would reduce transplantation of patients with high rates of tumor recurrence, and delay or exclude transplant for those with stable liver disease in whom there is low probability of death related to their HCC. Adoption of both criteria would reduce transplantation of patients with HCC and make more livers available for others on the list. Current UNOS requirements for data collection and reporting for patients transplanted for HCC will help provide evidence to support either or both of these potential policy modifications.

Other categories of non-standardized exception may include hyponatremia, ascites, recurrent bacterial cholangitis in the setting of PSC and polycystic liver and kidney disease.

There is a current mandate for UNOS to adopt a more uniform policy for MELD exceptions so that allocation remains and even across regions. Whether there will be creation of a national review board (as some countries such as the United Kingdom have adopted) or larger regional review boards that combine several existing UNOS regions to provide broader representation is under discussion. However there are already in place mandated standardized training for RRB membership and plans to study some of the issues that have been included in non-standardized exceptions to determine if there is an adequate evidence base to consider making nationally standardized exceptions for these other conditions.

The limitations and imperfect nature of the MELD allocation system has been an attractive subject for many studies that have generated suggestions for

system improvement. Some of the suggested models are based on urgency and consider the highest priority for the sickest patients similar to CTP and MELD systems. Others are designed to obtain the best post-transplant outcomes for graft and long-term patient survival, and take into consideration pre-transplant mortality and post transplant outcomes[17]. In the following section several of these models are presented.

SUGGESTED MODIFICATIONS FOR CURRENT LIVER ALLOCATION POLICY

MELD-Na

Hemodynamic derangements seen in advanced cirrhosis usually parallel the severity of disease and degree of portal hypertension[30]. Activation of the renin-angiotensin system and sympathetic nervous system and secretion of antidiuretic hormone are the compensatory mechanisms evoked by splanchnic and systemic vasodilation, with a resulting decrease in arterial pressure[31-33]. The sodium and water retention that result from these mechanisms are responsible for ascites formation and in the more advanced form, dilutional hyponatremia. In addition to reflecting the severity of hemodynamic derangement, development of hyponatremia in the setting of liver cirrhosis could be a predictor of hepatorenal syndrome with its very poor prognosis[34,35].

Hyponatremia was shown to correlate with a poor outcome in patients with cirrhosis even after adjusting for MELD score[18,36-38] and incorporation of serum sodium level to MELD was shown to increase the predictive ability of MELD for short term survival[39,40]. Using serum sodium level in addition to the bilirubin, creatinine and INR in a new scoring system named United Kingdom End-stage Liver Disease was shown to be superior to MELD score for predicting liver transplant wait list mortality[41]. Even in acute decompensated liver disease the two sodium adjusted MELD models provided higher prognostic accuracy in comparison with MELD[42].

Although addition of serum sodium to MELD could increase its predictive ability, it should be considered that the serum sodium level is not a constant. Serum sodium may vary by time, treatment and even the laboratory[43]. In the United States, one region had adopted the policy of granting priority exceptions for MELD-Na, and published their results[44]. Their data and the aggregate published data worldwide led to a policy change whereby MELD-Na will be adopted by UNOS for allocation. This will be implemented in the United States in 2016.

Delta MELD

Rapid MELD increment in patients was proposed to be associated with a worse prognosis. Although it was shown that MELD increment within 30 d (Delta MELD/month) was superior to initial MELD score for prediction of intermediate term outcome in these patients in some studies[45,46], this predictive ability has been also questioned[47].

However, a national survey on nearly 70000 patients on the waiting list for liver transplantation demonstrated that registrants with a sudden increase in their MELD scores defined as "MELD spike" with more than 30% increment in the MELD over 7 d have risk for a higher short term mortality but no increased post transplant mortality. In this study incorporating "spikes" and MELD scores to a model, the predictive ability was superior to MELD alone[48].

Donor factors

Current organ allocation systems based on prioritizing the sickest patients first are not as perfect in their prediction of post transplant outcomes given the dependence of outcome on other factors, the most important being donor organ quality.

Donor age is one of the most important factors affecting both patient and graft survival[49]. This factor was reported to be particularly important for the transplant outcome of recipients with hepatitis C, and the association of older donor age with more rapidly progressive disease recurrence in the graft and lower graft and patient survival has been reported[50-52]. In one study, a simple statistic, D-MELD was introduced for predicting the post-transplant survival. D-MELD was developed using both pre-transplantation recipient's MELD and the donor age, and could be applied for the both HCV (+) and HCV (-) recipients. In this study authors concluded that a cut-off level of 1600 could be used to predict the poor short and long term outcome[53].

However, waiting for the best matched donors may adversely affect patients on the list due to dropout. Despite the accepted importance of donor age effect on post transplant outcome, there are some studies showing good results even with very old donors, supporting the possibility of expanding the donor criteria in the era of organ shortage. Furthermore, for those with HCV, newer therapies with direct acting antiviral agents offering very high cure rates without graft or patient injury may counter the effects on post transplant survival of older donor age with active HCV. The effect of factors independent of the recipient's condition other than the donor age alone has been discussed for careful older donor selection, including favorable graft biopsies and short ischemia time[54].

Other aspects of the role of age, both for the donor and recipient in organ allocation have been addressed in studies. To achieve the best post-transplant outcome, the kidney allocation system tries to match donors and recipients' characteristics (including their ages) called longevity matching[55]. Age matching between donor and recipient has been also addressed in liver allocation[56,57]. Related studies have shown superior post transplant outcomes for age matched transplants.

The negative impact of age mismatch on transplant outcome was observed even among recipients of living donor livers[58]. In a recently published study, the age mapping allocation model was introduced by Cucchetti *et al*[59] and was shown to be effective in decreasing the life lost years, mostly for the younger recipients, achieving an overall 14% reduction. Age mapping is different from age matching in several aspects. Age mapping is in keeping with the ethical principal of justice in that all candidates in any age have the same chance of receiving an organ. The system also considers that transplant outcome is not only defined as post transplant survival rates; but also takes into account the total life expectancy according to the expected mortality rate of the general for each recipient. This model is limited in not addressing other complexities of liver allocation, particularly status 1 recipients and using only 3 covariates of MELD score > 30, HCV status, and donor age in the final model[60].

Several indices using different donor factors have been developed to help for selecting the best-matched donors. Donor risk score (DRI) included seven donor factors and two transplant factors in calculation and was shown to be useful for prediction of both early and late graft failure[61]. In a recently published study, donor factors found to be independent predictors of one year graft failure in HCV (+) recipients were transformed to donor age scales to develop a model of corrected donor age[62]. However the use of these indices in practice has been very limited and center and patient judgment in offering and accepting organs remains common practice. Future models that will help centers and patients calculate the benefit and risk of accepting or declining an organ will be helpful in offering a better informed consent to the patient and may help better match donor organs with recipients.

CONCLUSION

Current liver allocation systems (MELD/PELD) are based on prioritization of the sickest patients in need of transplantation. Studies of specific factors related to complications of liver disease provided an evidence base that supported policy changes that has improved the ability of allocation models to recognize and help prioritize patients with the most urgent conditions. Further insights towards understanding factors, recipient and donor related, that improve post transplant outcomes should be factored into future changes in allocation policy. Changes in current allocation policies for liver transplantation must continue to strive to achieve optimal fairness while accomplishing the best utilization of organs.

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