possible. Prospective validation of mathematical models using waiting liver transplant candidates should be performed before implementing any change in liver allocation policy. Consideration for how the mathematical models correlate with the ethical principals of justice and utility should be an important part of any organ allocation policy development. Finally, open constant re-examination of models, principals, and new developments are essential to continuous improvement of organ allocation overall.

MELD has not proven to be the Holy Grail of liver allocation. But the journey starting with the development of MELD has, like the medieval expeditions looking for the Holy Grail, has taught us new ways of communicating and opened many new areas for research and development, all of which have helped to improve the human condition.

References

[1] Freeman RB, Weisner RH, Harper A, McDairmid SV, Lake J, Edwards EB, et al. The New Liver Allocation System: moving towards evidence-based transplantation policy. Liver Transpl 2002;8:851–858.

[2] Child II CG, Turcotte JG. Surgery and portal hypertension. In: Child II CG, editor. The liver and portal hypertension. Philadelphia, PA: Saunders; 1964. p. 50–58.

[3] Freeman RB, Edwards EB. Liver transplant waiting time does not correlate with waiting list mortality: implications for liver allocation policy. Liver Transpl 2000;6:543–552.

[4] Organ procurement and transplantation: assessing current policies and the potential impact of the DHHS final rule. National Academy Press: Washington, DC; 1999, p 6.

[5] Malinchoc M, Kamath PS, Gordon FD, Peine CJ, Rank J, ter-Borg PL. A model to predict poor survival in patients undergoing transjugular intrahepatic portosystemic shunts. Hepatology 2000;31:864–871.

[6] Kamath PS, Wiesner RH, Malinchoc M, Kremers W, Therneau TM, Kosberg CL, et al. A model to predict survival in patients with end-stage liver disease. Hepatology 2001;33:464–470.

[7] Wiesner RH, Edwards EB, Freeman RB, Harper A, Kim R, Kamath P, et al. Model for end stage liver disease (MELD) and allocation of donor livers. Gastroenterology 2003;124:91–96.

[8] Wiesner RH, McDairmid SV, Kamath PS, Edwards B, Malinchoc M, Kremers WK, et al. MELD and PELD: application of survival models to liver allocation. Liver Transpl 2001;7:567–580.

[9] Stell DA, McAlistair VC, Thorburn D. A comparison of disease severity and survival rates after liver transplantation in the United Kingdom, Canada, and the United States. Liver Transpl 2004;10: 898–902.

[10] Freeman RB. Waiting list mortality risk (and/or other measures) as the basis for allocation: MELD and PELD in liver allocation. Plenary Presentation Am Transpl Congr 2004.

[11] Wolfe RA. Efficient liver allocation. Am J Transpl 2004 [in press].

[12] Merion RM, Wolfe RB, Weisner RH, Freeman RB, Port F, Dykstra DM, et al. Lifetime benefit for liver transplantation. Am J Transpl 2004; in press.

[13] Freeman RB. MELD/PELD: where are we and where are we going? Am J Transpl 2004 [in press].

[14] Freeman RB. MELD and liver allocation: continuous quality improvement. Hepatology 2004;40:787–789.

[15] Hanley JA, McNeil BJ. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology 1982;143: 29–36.

[16] Ruf AE, Yantorno SE, Descalzi VI, Andriani OC, Podesta LG, Vilamil FG. Addition of serum sodium into the MELD score predicts waiting list mortality better than MELD alone—a single center experience. Am J Transpl 2004;4:438.

[17] Heuman DM, Abou-assi SG, Williams LM, Stravitz RT, Sanyal AJ, Fisher RA, et al. Persistent ascites and low serum sodium identify cirrhotic with low Model for End Stage Liver Disease (MELD) scores who are at risk for early death. Hepatology 2004; in press.

[18] Mazzaferro V, Regalio E, Doci R, et al. Liver transplantation for the treatment of small hepatocellular carcinomas in patients with cirrhosis. N Engl J Med 1996;334:693–699.

[19] Cheng SJ, Freeman RB, Wong JB. Predicting the probability of progression free survival in patients with small hepatocellular carcinoma. Liver Transpl 2002;8:323–328.

[20] Yao FW, Bass NM, Nikolai B, Davern TJ, Kerlan R, Wu V, et al. Liver transplantation for hepatocellular carcinoma: analysis of survival according to the intention-to-treat principle and dropout from the waiting list. Liver Transpl 2002;8:873–883.

[21] Lee JS, Chu IS, Heo J, Calvisi DF, Sun Z, Roskams T, et al. Classification and prediction of survival in hepatocellular carcinoma by gene expression profiling. Hepatology 2004;40:667–676.

doi:10.1016/j.jhep.2004.11.002

Living donor liver transplantation: is the hype over?

James F. Trotter*

Division of Gastroenterology/Hepatology, University of Colorado Health Sciences Center, 4200 E, 9th Avenue, B-154, Denver, CO 80262, USA

The growth and development of living donor liver transplantation (LDLT) has been rapid over the past 15 years [1]. Following the first successful report in 1989, LDLT became the predominant means of liver transplantation in many parts of Asia where cultural mores largely proscribe procurement of deceased donor (DD) organs. However, the development LDLT in the United States was not fully realized for another 8 years. Until 1997, fewer than 100 LDLT's were performed each year in the United States, largely from adult (parental) donors to pediatric recipients. Subsequently, there was a rapid growth in the procedure, largely in adult-to-adult LDLT. Between 1997

* Tel.: +1 303 372 8866; fax: +1 303 372 8868.

E-mail address: james.trotter@uchsc.edu (J.F. Trotter).

Abbreviations: LDLT, living donor liver transplantation; DD, decreased donor; UNOS, united network for organ sharing; OPO, organ procurement organization; HCC, hepatocellular carcinoma.

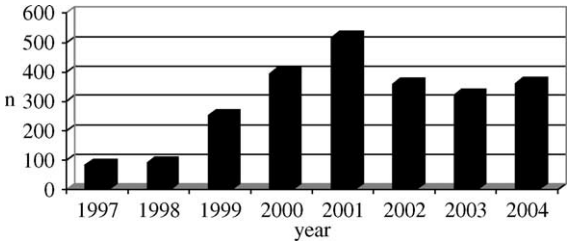

Fig. 1. LDLT in the United States vs. year.

and 2003, the number of cases (% of all liver transplantations) increased nearly four-fold, from 86 (2.1%) to 321 (5.6%) and the projected number of LDLT's for 2004 is slightly higher at 364 or 6% [2] (see Fig. 1).

There were two primary reasons for the proliferation of LDLT's in adult patients during this time. First, the initial right hepatic lobe LDLT was reported in 1994 and thereafter, the technical success of the procedure increased measurably, compared to the smaller left hepatic lobe graft. Second, a critical shortage of DD livers developed during the 1990's when the number of patients listed for transplantation increased nearly ten-fold from 1676 patients in 1991 to 13,999 in 1999, while the number of DD livers available for transplantation increased by only 52% from 2953 to 4478. As a result, the number of patients dying on the transplant list increased more than four-fold from 435 to 1753 over the same period. Therefore, in the 1990's the relative availability of DD livers decreased due to the growing disparity between the number of patients listed for transplantation compared to a relatively stable donor pool. As a result, the waiting time for transplantation increased and the number of patients dying on the list increased. Consequently, selected transplantation centers began to offer LDLT as a means to decrease the time to transplantation in an attempt to reduced waiting list mortality.

During the rapid phase of growth of LDLT after 1997, some surgeons at large LDLT programs projected that up to 50% of all transplants would be performed using live donors and that this procedure could significantly reduce the growing shortage of donor organs in the US [3]. However, the rapid phase of growth of LDLT has not been sustained. Currently, living donors account for closer to 5% of all liver transplants, not 50%. While this procedure remains a viable treatment option for selected patients at many US centers, most physicians have found that some of the initial predictions related to LDLT may not be realized. 'Hype' is a slang term for a deception; that is, 'to promote something as true or valid that is neither'. The three issues, which were perhaps the subject of considerable hype related to LDLT, include the following:

1. LDLT could be offered to the majority of patients listed for transplantation and, therefore, significantly increase the number of transplantations thereby reducing waiting list mortality.
2. Most, if not all, liver transplantation centers would offer the procedure.
3. Outcomes for LDLT recipients would be the same or better compared to DD recipients.

In this review, I plan to address each of these three issues and attempt to frame the role of LDLT in the context of liver transplantation as a whole.

Hype: LDLT could be offered to the majority of patients listed for transplantation and, therefore, significantly increase the number of transplantations thereby reducing waiting list mortality.

Reality: Using current donor and selection criteria, only a fraction of patients listed for transplantation are able to undergo the procedure.

As noted above, the rapid phase of growth in LDLT which occurred between 1997 and 2001 has not been sustained. In fact, the number of LDLT's in the United States decreased from its peak of 518 in 2001, to 361 in 2002 and 321 in 2003. The reasons for the decrease in the number of LDLT's are complex and not entirely clear. One reason is related to concern over donor safety. Following the well-publicized death of a living liver donor in 2001, some surgeons may have simply decided that the risk to the donor outweighed any potential benefit for the recipient and, therefore, decided not to perform the procedure. (See discussion in next section.) Another possible explanation is that the initial rise in LDLT's performed between 1997 and 2001 could reflect a 'backlog effect.' That is, programs with large numbers of patients listed for transplantation offered the procedure to all potential candidates shortly after the procedure was recognized as a treatment option. Thereafter, the number of cases decreased because most patients listed for transplantation are not candidates for LDLT.

Perhaps the most important reason for the reduction in LDLT's is that only a small fraction of patients listed for transplantation are able to undergo the procedure. The greatest advantage of LDLT is perhaps an expeditious transplantation. Once identified as a required treatment, liver transplantation may almost always occur more quickly with a live donor than with a deceased donor. Therefore, the patients who are the most appropriate candidates for LDLT are those who require rapid transplantation due to clinical decompensation. However, most patients listed for liver transplantation in the United States have relatively low Model for Endstage Liver Disease (MELD) scores and exhibit little to no signs of clinical decompensation. Of the 17,849 patients currently listed for liver transplantation in the United States, only 1275 (7%) have a MELD score $>$ 18, as shown in Fig. 2 [2]. Consequently, most patients listed for transplantation do not have an urgent need for surgery and, therefore, would not necessarily benefit from LDLT. In an analysis from our center, we have shown that only 1/3 of patients listed have a sufficient degree of illness to warrant consideration for an expedited liver