Confirmation of the Role of the Mayo Risk Score as a Predictor of Resource Utilization After Orthotopic Liver Transplantation for Primary Biliary Cirrhosis

Richard K. Gilroy, Stephen V. Lynch, Russell W. Strong, Paul Kerlin, Glenda A. Balderson, Katherine A. Stuart, and Darrell H.G. Crawford

Resource utilization is an important consideration when patients are selected for orthotopic liver transplantation (OLT). The Mayo Risk Score has been proposed to help predict optimum time for OLT. We assessed the relation between Mayo risk score, Child-Pugh score, and resource utilization and outcome after OLT for primary biliary cirrhosis. The mean Mayo risk score was greater in patients who died than in the survivors (8.6 ± 1.4 *v* 7.1 ± 1.8; $P < .05$). There was a positive correlation between Mayo risk score and the 4 resource variables studied (intraoperative blood requirements, time ventilated, and duration of intensive care unit and hospital stays). Patients with a Mayo risk score greater than 7.8 used almost twice the resources of patients with a risk score less than 7.8. A positive correlation also existed between Child-Pugh score and duration of hospital stay. The mean Child-Pugh score in patients who died was greater than that in survivors (10.7 ± 2.0 *v* 8.5 ± 2.8, $P = .03$). This study confirms that Mayo Risk score is an important predictor of resource utilization and outcome after OLT. (*Liver Transpl 2000;6:749-752.*)

Primary biliary cirrhosis (PBC), a slowly progressive inflammatory disease of septal and interlobular bile ducts, is a common indication for orthotopic liver transplantation (OLT).[1,2] The shortage of donor organs and the need for judicious decisions in the selection and timing for OLT mandate that OLT be performed at a time that optimizes patient outcome and ensures the appropriate use of limited medical resources.

The Mayo PBC natural history model[3] allows the calculation of a risk score using 5 variables (patient age, total serum bilirubin and albumin concentrations, prothrombin time, and presence of peripheral edema). The Mayo risk score can then be used to estimate patient survival. Recently, Kim et al[4] reported that the Mayo risk score might also have an important role in deciding optimal timing for OLT. Their data showed that the risk for death after OLT acutely increased with a Mayo risk score greater than 7.8. Similarly, resource utilization, measured by days in the intensive care unit and number of intraoperative blood transfusions, was greater in the group of transplant recipients with a Mayo risk score greater than 7.8 at the time of OLT.

Significant diversity often exists among different liver transplant units for factors affecting resource utilization. These factors include patient selection, surgical technique, method of immunosuppression, management of rejection episodes, approach to posttransplantation infectious complications, and clinical experience. Thus, it is important that other liver transplant centers, particularly those outside the United States, also evaluate the predictive value of the Mayo risk score to confirm whether the model has widespread application with respect to outcome and resource utilization after OLT.

Assessment of Mayo risk score is relatively difficult in a clinical setting despite the development of computerized methods of calculation. Child-Pugh score, a commonly used marker of liver disease severity, contains many of the criteria used in the Mayo model.[5] Therefore, the Child-Pugh score, which is easier to calculate than the Mayo risk score, may also be useful in predicting resource utilization after OLT for PBC.

In this study, we evaluated the relation between the Mayo risk score, Child-Pugh score, and resource utilization after OLT in a cohort of patients with PBC from an Australian liver transplant center.

Patients and Methods

The Queensland Liver Transplant Service (Brisbane, Australia) assessed 60 patients with PBC for OLT between July 1986 and December 1998. Of these 60 patients, 48 patients were accepted onto the active waiting list and 5 patients died before OLT. Thus, 43 patients underwent OLT during the study period.

At the time of acceptance onto the transplant program,

From the Queensland Liver Transplant Service, Princess Alexandra Hospital, Brisbane, Australia.

Address reprint requests to Darrell H.G. Crawford, MD, Director, Department of Gastroenterology and Hepatology, Princess Alexandra Hospital, Ipswich Rd, Woolloongabba 4102, Queensland, Australia. Telephone: 61-7-3240-2613; FAX: 61-7-3240-5111; E-mail: crawford@health.qld.gov.au.

1527-6465/00/0606-0101$3.00/0

doi:10.1053/jlts.2000.9746

each patient underwent a complete diagnostic evaluation, and the diagnosis of PBC was established in each patient using a combination of clinical, serological (antimitochondrial antibodies), and histological criteria.[6] The Mayo risk score was calculated immediately before OLT using the following variables: patient age, total serum bilirubin and albumin concentrations, prothrombin time, presence or absence of peripheral edema, and use of diuretics.[3] Standard surgical techniques were used for the transplantation procedure, and immunosuppression consisted of combinations of cyclosporine, tacrolimus, corticosteroids, and azathioprine. Resource utilization was assessed by the following variables: length of stay in the intensive care unit, period of ventilation after the liver transplantation procedure, intraoperative blood product use, surgical time, and duration of hospital stay.

Child-Pugh and Mayo risk scores were calculated for each patient, and a significant correlation ($r = 0.90$) existed between these measures of disease severity. Regression analysis showed that a Mayo risk score of 7.8 approximated a Child-Pugh score of 9. Resource utilization was compared between the group of patients with a Child-Pugh score of 9 or greater and the group with a Child-Pugh score less than 9. These comparisons were also made between the group of patients with a Mayo risk score greater than 7.8 and the group with a Mayo risk score less than 7.8.

Comparisons of resource utilization were made using Wilcoxon's rank-sum test, and the relationships between measures of disease severity and resource utilization were assessed by Pearson's correlation coefficient. Survival time was defined as the time from initial OLT until death. Actual posttransplantation survival was calculated using Kaplan-Meier survival estimates. The curve (Fig. 1) representing expected survival was calculated by averaging the individual survival probabilities according to the Mayo risk score.

Results

Patient Details

Forty of the 43 patients included on this study were women, and the mean age of the study cohort was 47.5 ± 8.5 years. There was a wide range of Mayo risk scores (3.86 to 11.45 points) and Child-Pugh scores (5 to 15). The primary indication for OLT in 5 of the 6 patients with a Mayo risk score less than 6 was pruritus and/or severe fatigue and lethargy.

Patient Outcome

Five patients died while awaiting OLT. The mean Mayo risk score of this group at the time of acceptance onto the active transplant waiting list was 9.6 (range, 8.6 to 10.2). Eleven patients died after OLT, with all but 2 deaths occurring in the early postoperative course (i.e., <3 months). Causes of death were ischemic heart disease and cerebrovascular disease (8 patients), septicemia (2 patients), and primary graft nonfunction (1 patient). One patient underwent retransplantation for primary graft nonfunction but died 4 weeks later. The mean Mayo risk score of patients with PBC who underwent OLT between 1985 and 1990 was 8.25 ± 1.3; between 1990 and 1994, 6.93 ± 1.3; and between 1995 and 1999, 7.28 ± 1.5. The mean Mayo risk score of the patients who died during those periods were 8.86, 7.3, and 8.03, respectively. A comparison between actual and predicted posttransplantation survival according to the Mayo PBC natural history model at yearly intervals is shown in Figure 1. The net survival benefit conferred by OLT was 36% at 2 years and

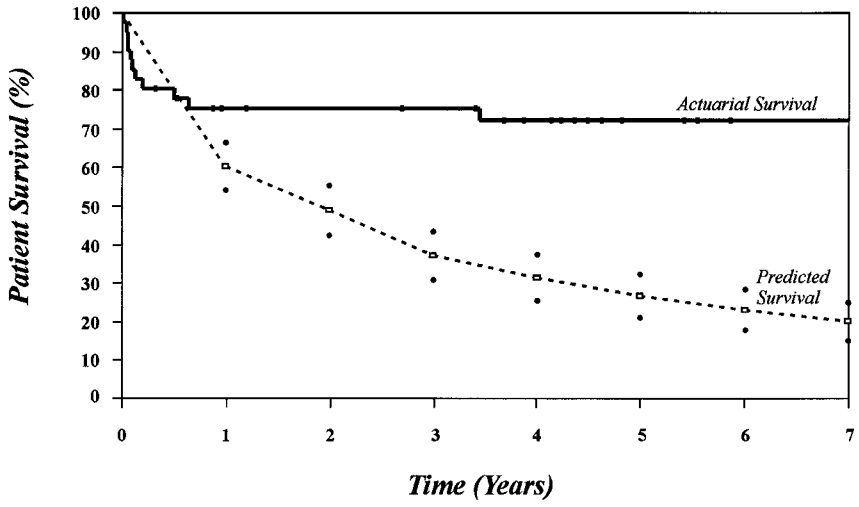

Figure 1. A comparison of actual and predicted posttransplantation survival according to Mayo PBC natural history model.

Table 1. Correlation Between Mayo Risk Score, Child-Pugh Score, and Resource Variables

	Surgical Time	Ventilation Period	Intensive Care Unit Stay	Hospital Stay	Blood Products
Mayo risk score	0.21	0.38	0.32	0.37	0.45
P	NS	.01	.05	.02	.004
Child-Pugh score	0.23	0.18	0.29	0.50	0.50
P	NS	NS	NS	.001	.001

Abbreviation: NS, not significant.

55.6% at 5 years, which is similar to that reported by Kim et al.[4] Six of the 17 patients with a Mayo risk score greater than 7.8 died compared with 5 of the 24 patients with a Mayo risk score less than 7.8 (35.3% *v* 20.8%; *P* = not significant). The mean Mayo risk score was significantly greater in the group of patients who died after OLT compared with the group of survivors (8.6 ± 1.4 *v* 7.1 ± 1.8; $P < .05$).

Resource Utilization

A significant positive correlation existed between the Mayo risk score and 4 of the 5 resource variables (intraoperative blood requirements, time ventilated, and duration of intensive care unit and hospital stays; Table 1). A comparison of resource utilization by patients with PBC with a Mayo risk score greater or less than 7.8 is listed in Table 2. The group of patients with a Mayo risk score greater than 7.8 had significantly longer intensive care unit stays ($P = .001$) and ventilator times ($P = .03$), increased blood transfusion requirements ($P = .001$), and longer hospital stays ($P = .001$) compared with the group of patients with a risk score less than 7.8.

Table 2. Comparison of Resource Utilization According to Mayo Risk Score Greater or Less Than 7.8

	Mayo Risk Score		
Resource Variable*	<7.8	>7.8	*P*
Blood products (L)	1.2	3	.001
Surgical time (h)	7	7.2	NS
Ventilator time (h)	47.5	76	.03
Intensive care unit stay (h)	80	104	.001
Hospital stay (d)	18	31	.001

Abbreviation: NS, not significant.
* Values expressed as median.

Role of Child-Pugh Score

The mean Child-Pugh score of patients who died was significantly greater than that of the survivors (10.7 ± 2.0 *v* 8.5 ± 2.8; $P = .03$), and we found a significant correlation between Child-Pugh score and blood product use and total hospital stay (Table 1). All patients with a Mayo risk score greater than 7.8 had a Child-Pugh score of 9 or greater. Thus, resource utilization was clearly greater in the group of patients with the higher risk score (Table 2).

Discussion

OLT is expensive, and sound economic management is an important responsibility of clinicians in liver transplant centers.[7,8] This study showed that pretransplantation disease severity has an important influence on resource utilization and the outcome of OLT for PBC. We confirmed a previous observation of a direct relationship between pretransplantation Mayo risk score and posttransplantation resource utilization.[4] We have extended these observations and shown that a similar association exists between disease severity assessed by Child-Pugh score and resource utilization. Kim et al[4] also showed that survival after OLT for PBC acutely deteriorated when OLT was performed in patients with a Mayo risk score greater than 7.8. In the current study, we separated patients into 2 groups on the basis of a Mayo risk score greater or less than 7.8. The resources used by the group of patients with the higher Mayo risk score were almost 2-fold those used by the group with the lower score. Collectively, we believe the results of these studies confirm the association between disease severity and resource utilization and suggest that a Mayo risk score of 7.8 is an important cutoff value in determining optimum timing for OLT in patients with PBC.

The Mayo risk score is relatively difficult to calculate despite the development of computerized methods.

Child-Pugh score is commonly used to assess severity of liver disease and can be calculated at the patient's bedside.[5] In this study, we showed that patients with a Child-Pugh score of 9 or greater used almost twice the resources of patients with a score less than 9. Although the Child-Pugh score provides similar information to the Mayo risk score in predicting resource utilization, the Mayo risk score offers accurate prognostic information. The capacity of the Mayo risk score to accurately estimate survival probability in patients with PBC is an important feature that allows improved decision making with respect to timing of OLT in individual patients with PBC and enables calculation of survival benefit in groups of PBC patients who underwent transplantation. In this study, the net survival benefit conferred by transplantation was 36% at 2 years and 55.6% at 5 years. The net survival benefit was possibly less than expected because 13 patients with a Mayo risk score less than 6 underwent OLT. The indications for OLT in these patients were poor quality of life, intractable itch, or severe portal hypertension.

Many factors may influence resource utilization after OLT. For example, a patient with a lower Mayo risk score may be more likely to survive a major complication than a patient with a higher Mayo risk score and ultimately will have a longer hospital stay than a nonsurvivor. Despite the potential for many factors to affect resource utilization variables, we found a correlation between severity of PBC assessed by the Mayo risk score and all but 1 of the resource variables studied. The resource variables used in this study capture 90% of the costs associated with OLT.[9] Thus, the overall cost of OLT for patients with PBC is clearly related to pretransplantation disease severity. The data in this and other studies provide clinicians with an average value of utilization for important resource variables according to category of disease severity. Data of this nature allow clinicians to more accurately predict the cost of OLT in individual patients with PBC and provide a basis for budgeting for transplantation services, taking into account such factors as disease severity.

This analysis does not address the issue of resource utilization in the pretransplantation waiting period. However, it is of interest that the mean Mayo risk score was 9.59 in the 5 patients who died awaiting OLT. It is expected that patients with PBC with more advanced liver disease are more likely to have episodes of gastrointestinal bleeding and hepatic decompensation while awaiting OLT. It is likely that the total costs associated with the care of such patients accepted onto waiting lists would be greater than those for patients with less severe disease. However, this hypothesis remains to be confirmed.

Resource utilization is now an increasingly important consideration in the decision-making process for OLT. Thus, it is important that transplant centers consider variables that are likely to predict resource utilization. This study showed that pretransplantation disease severity influences resource utilization and outcome of OLT for patients with PBC.

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