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Analysis of Donor Criteria for the Prediction of Outcome in Clinical Liver Transplantation

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IN THE PAST few years, liver transplantation has become accepted as a service rather than as an experimental operation and results have continued to improve.[1] This has created a great demand for suitable organs since more transplant centers are offering this procedure to more patients. Optimum utilization of the limited donor pool is therefore important.

Assessment of the quality of potential liver allograft donors is considered important in determining the early outcome of transplantation in the recipient. Criteria for donor selection are not widely agreed upon, however, and, except in extreme circumstances, the limits and reliability of many factors used in assessing donor suitability are unknown. Many liver transplant centers are still in the developmental stages and have conservative donor selection criteria that inhibit optimal exchange of organs and increase organ wastage.

The increasing number of candidates for liver transplantation referred to the University of Pittsburgh, including substantial numbers of very small children and urgently ill patients, has forced us to reassess and liberalize our criteria for donor acceptance continuously. Many of the organs currently acceptable to and successfully transplanted by us have been categorically refused by other transplant centers. Nevertheless, we have been constantly amazed and puzzled at the limits that may be successfully tolerated by donor grafts. Those limits prompted this study, a retrospective statistical analysis of the predictability of early graft outcome based on liver function studies, arterial blood gases, blood pressure, cause of death, and total graft ischemic time for 219 human livers procured and transplanted at the University of Pittsburgh.

MATERIALS AND METHODS

The records for 262 donor hepatectomies performed between January 1, 1985 and December 31, 1985 were reviewed. In an effort to predict the quality of early posttransplant graft function, a group of donor variables that have been widely assumed to be relevant was studied: liver function tests (maximum SGOT, SGPT, bilirubin, prothrombin time, and partial thromboplastin time), arterial blood gases (lowest pO_2, highest pCO_2, worst pH), blood pressure (lowest systolic blood pressure prior to harvest, LOW SBP, and lowest systolic blood pressure during donor hepatectomy, OR SBP), cause of death, and total ischemic time (measured from the time of aortic cross-clamping in the donor to the time of unclamping the vena cava and portal vein in the recipient). The records of the graft recipients were reviewed, and early graft function was classified as good, fair, or poor based on peak SGOT, SGPT, and prothrombin time in the early postoperative period as defined in Table 1. Grafts were classified according to the lowest (poorest) category into which any of the assessed values fell. The donor variables were then analyzed in relationship to this classification of early graft function using the SPSS/PC+ Advanced Statistics discriminant analysis module (SPSS, Chicago) on an IBM/PC-AT microcomputer.[2] Discriminant scores were determined for each case, and scatterplots of predicted v actual results produced.

Because it is still common to use highly conservative criteria for donor selection, we classified donors as good or poor based on SGOT, SGPT, blood pressure, dopamine requirement, and lowest pO_2. Any donor with an SGOT >200 IU, SGPT >100 IU, systolic blood pressure <60 mm Hg, dopamine infusion >15 μg/min, or pO_2 <60 torr

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Table 1. Criteria for the Classification of Early Results After Transplantation

Variable	Good	Fair	Poor
SGPT (IU)	<1,000	≥1,000 and <2,500	≥2,500
SGOT (IU)	<1,500	≥1,500 and <3,500	≥3,500
Prothrombin time (seconds)	≤25	>25	

Grafts were classified according to the poorest category into which any of the assessed parameters fell.

Table 2. Donor Variables for 219 Human Orthotopic Liver Transplantations

Variable	n	Mean ± SD	Maximum	Minimum
SGOT (IU)	209	80.7 ± 80.8	528	4
SGPT (IU)	199	46.2 ± 48.5	366	5
Bilirubin (mg/dL)	210	0.8 ± 0.9	11	0
Prothrombin time	144	13.3 ± 1.9	19.7	9.6
Partial thromboplastin time (seconds)	139	28.6 ± 6.4	55.0	18.8
pO_2 (torr)	112	142.2 ± 101.9	545	18
pCO_2 (torr)	81	31.8 ± 9.6	77	19
pH	84	7.4 ± 0.1	7.7	
Lowest SBP (mm Hg)	128	80.7 ± 21.9	142	20
Lowest OR SBP (mm Hg)	143	89.8 ± 21.7	161	30
Ischemia time (h)	197	5.7 ± 1.4	12.4	1.8

SBP, systolic blood pressure; OR SBP, lowest SBP during donor hepatectomy.

was classified as poor. These donor ratings were cross-tabulated with early graft function and analyzed by the chi-square and proportional reduction in error methods in the SPSS/PC+ Basic Statistics module on the IBM microcomputer.[3]

RESULTS

Adequate data for analysis were available for 219 of the 262 donors reviewed for this study. There were 121 (55.3%) male and 98 (44.7%) female donors ranging from small infants to an adult of 48 years (mean 15.7 ± 11.5 SD years). The causes of death are shown in Fig 1. There were 121 grafts with good early function, 65 grafts with fair function, and 33 grafts with poor early function. There were 15 (6.9%) cases of primary graft non-function either necessitating immediate re-transplantation or resulting in early death of the recipient.

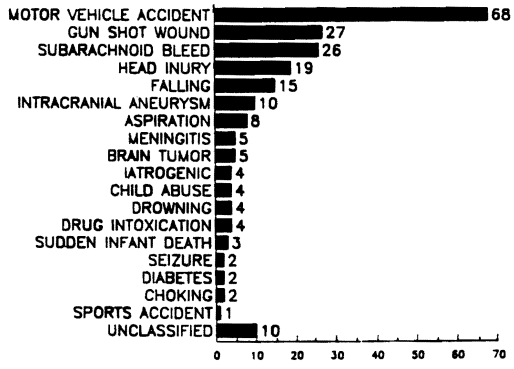

Fig 1. The causes of death for 219 liver allograft donors.

Table 2 summarizes the donor variables used in this study, including the number of cases for which each variable was available. Good and poor donors are cross-tabulated against early graft outcome in Table 3. The donor classification is not predictive of the early graft function (r = .05, P = .75 by chi-square, Goodman and Kruskal's λ = 0.000). Of 168 donors classified as good, 24 (14.3%) produced grafts with poor early post-

Table 3. Donor Assessment and Early Graft Function Are Poorly Correlated

	Donor Rating		
Early Function	Good	Poor	Total
Good	95	26	121
Fair	49	16	65
Poor	24	9	33
Total	168 (10)	51 (5)	219

Parentheses: number of grafts that never functioned.

Table 4. Descriptive Statistics (Mean ± SD) for Donor Variables Grouped According to Early Graft Function

Variable	Good	Fair	Poor
n = 120	67	32	21
SGPT (IU)	44.5 ± 49.4	41.6 ± 30.8	55.6 ± 62.1
SGOT (IU)	77.7 ± 60.4	71.1 ± 70.8	104.4 ± 112.6
Bilirubin (mg/dL)	0.8 ± 0.7	0.9 ± 0.7	0.8 ± 0.4
Prothrombin time (seconds)	13.4 ± 1.7	12.9 ± 1.9	13.5 ± 2.2
Partial thromboplastin time (seconds)	29.4 ± 6.7	29.1 ± 7.5	28.3 ± 5.0
n = 79	49	16	14
pO_2 (torr)	163.8 ± 120.6	117.4 ± 89.4	124.2 ± 39.9
pCO_2 (torr)	30.2 ± 7.2	32.5 ± 11.5	32.0 ± 5.2
pH	7.43 ± 0.09	7.41 ± 0.11	7.43 ± 0.62
n = 89	45	26	18
Lowest SBP (mm Hg)	84.3 ± 21.1	82.3 ± 23.1	82.3 ± 14.6
Lowest OR SBP (mm Hg)	91.3 ± 24.7	89.3 ± 22.6	95.1 ± 19.3
Ischemic time (h)	5.4 ± 1.3	5.6 ± 1.3	5.7 ± 1.2

Abbreviations as in Table 2.

operative function. Conversely, of 51 donors classified as poor, 26 (51.0%) produced grafts with good early function. Ten (6.0%) of the 168 grafts from good donors and 5 (9.8%) of the grafts from poor donors failed to function after transplantation.

Because all donor variables were available for only a few cases, it was necessary to segregate the variables for discriminant analysis. Thus, liver function tests, blood gases, and perfusion—ischemia parameters (blood pressure, cause of death, and total ischemic time) were analyzed independently.

Table 4 shows the mean values and SD for the donor variables grouped according to early graft function. The differences among grafts classified as good, fair, or poor are small; none reach statistical significance.

The results of the discriminant analysis for each group of variables is presented in Table 4 and in the form of scatterplots in Figs 2, 3, and 4.

A three-group discriminant analysis (good, fair, poor) yields two discriminant function scores, D1 and D2, for each case analyzed. In the scatterplots in Figs 2, 3, and 4, the calculated D1 and D2 functions are plotted according to the results predicted by the discriminant analysis model and the actual results

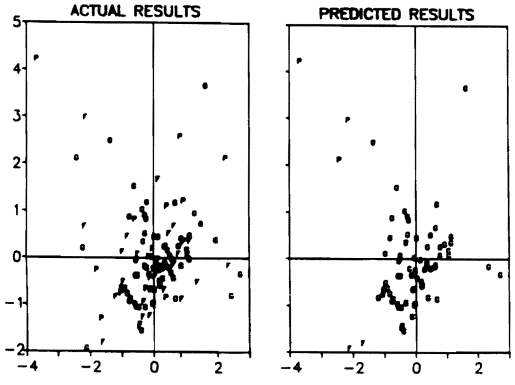

Fig 2. Scatterplots of early graft outcome (G, good; F, fair; P, poor) based on donor liver function tests. Results predicted by discriminant analysis model are compared with actual results.

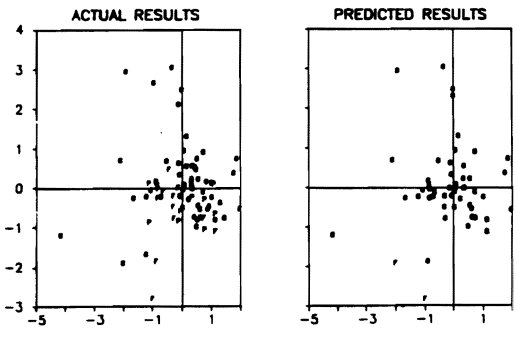

Fig 3. Scatterplots of early graft outcome (G, good; F, fair; P, poor) based on donor arterial blood gases. Results predicted by discriminant analysis model compared with actual results.

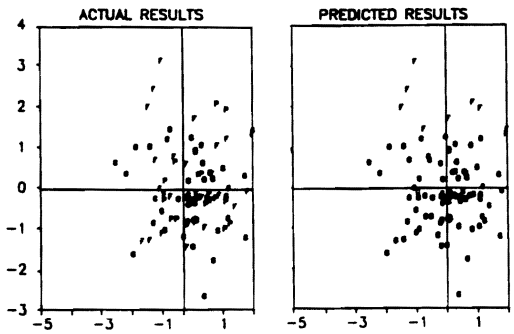

Fig 4. Scatterplots of early graft outcome (G, good; F, fair; P, poor) based on donor blood pressure, cause of death, and total ischemic time. Results predicted by discriminant analysis model are compared with actual results.

Table 5. Efficiency of the Discriminant Analysis Model in Predicting Early Graft Function Based on Three Groups of Donor Parameters: Liver Function Tests, Arterial Blood Gases, and Perfusion–Ischemia (Blood Pressure, Cause of Death, and Total Ischemia Time)

Actual Results		Predicted Results: Good	Fair	Poor
Liver function tests: 55.8% correctly classified				
Good	67	65	1	1
Fair	32	30	1	1
Poor	21	20	0	1
Arterial blood gases: 62.0% correctly classified				
Good	49	48	1	0
Fair	16	15	1	0
Poor	14	14	0	0
Perfusion–ischemia: 53.9% correctly classified				
Good	45	43	2	0
Fair	26	21	5	0
Poor	18	16	2	0

obtained. If the discriminant analysis is an efficient predictor, the scatterplots for predicted and actual results should closely resemble one another. All three analyses, however, showed little concordance between the predicted and the actual results.

The efficiency of the discriminant analysis is also presented in Table 5. For liver function tests, only 55.8% of the cases are properly classified; for arterial blood gases, only 62.0% are so classified; and for the perfusion–ischemia parameters, only 53.9% are so classified. None of the variables proved reliable in predicting poor early graft function.

The actuarial survival rate of recipients of primary liver allografts is classified according to donor quality in Fig 5. There was no significant difference in survival rates up to 2 years after transplantation between recipients of primary transplants from donors rated good and from donors rated poor.

DISCUSSION

This report presents the results of a retrospective statistical analysis of predictors of early graft function for 219 liver allografts harvested in a 12-month period by one highly experienced transplant center. The variables analyzed are frequently used as the basis for

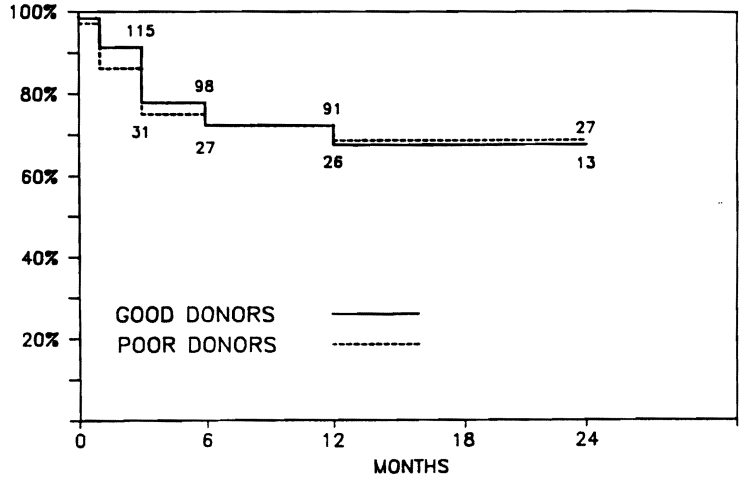

Fig 5. Patient survival for recipients of primary liver transplants classified by donor rating. There was no significant difference in survival between recipients of allografts from donors rated good and those rated poor.

selection of donors for liver transplantation. Such a study has previously not been possible because of the small number of cases available for analysis, the rigid donor selection criteria previously in use, and the influence of other factors that affect outcome, including changing surgical techniques and organ preservation methods.

The principal finding of this study is the unpredictability of early graft function based on widely used parameters of donor assessment. Although a significant percentage of grafts from "good" donors show poor early function, a much larger percentage of grafts from "poor" donors have good early function. Many centers continue to use highly conservative criteria for donor selection based on many of the variables reviewed in this study. The results of the discriminant analysis reveal, however, that these traditional parameters of donor assessment are highly inefficient at predicting poor graft function. Only the donor SGOT and prothrombin time showed suggestive correlations with outcome, but even these parameters did not achieve statistical significance. The low incidence (6.9%) of primary graft nonfunction in this series supports our view that a large number of liver donors are being turned down for inappropriate reasons and that the liver wastage rate is inordinately high.

The ultimate yardstick of success in liver transplantation is patient survival. Long-term survival is influenced by many factors besides the initial quality of the allograft, including technical complications, the incidence and severity of rejection, and infectious complications. Nevertheless, the survival rate of recipients who received allografts from donors rated poor was the same as that for recipients of allografts from donors rated good.

The findings reported here must, however, be considered preliminary. The number of cases available for analysis with all variables is small, and the criteria of classification are, of necessity, arbitrary. To achieve a meaningful number of cases for statistical analysis, it was necessary to segregate groups of variables that may be highly interrelated. Furthermore, the series was not large enough to determine the predictability of primary graft failure. It can be difficult to predict an infrequent event such as primary graft failure even with a highly efficient discriminant analysis model. A model that is 95% efficient at classifying cases may still misclassify most of the minority cases if, as in the case of primary graft failure, the minority event happens only ~5% of the time.

We plan to extend this study soon to include >400 cases. Data for the first half of 1986 will be retrospectively reviewed, and data for the remainder of 1986 are being prospectively studied. The criteria of classification will be reexamined based on this data. Additional parameters not included in this report, such as the consistency of the liver and the impression of the donor surgeon at the time of harvest will also be assessed.

SUMMARY

The results of 219 orthotopic human liver transplants performed during 1985 at the University of Pittsburgh were reviewed to determine whether donor parameters could be used to predict the quality of early graft function. Multivariate discriminant analysis demonstrated that traditional parameters of donor assessment are unreliable predictors of poor graft function. Furthermore, 56% of the donors considered poor by conservative selection criteria produced livers with good early posttransplant function. Survival of recipients of primary allografts from donors rated poor was no different than survival of recipients of allografts from donors rated good.

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