Estimating survival gains in the context of economic evaluation using prognostic modelling techniques: the case of liver transplantation

Tracey Young, Louise Longworth, and Julie Ratcliffe
Health Economics Research Group, Brunel University, Uxbridge

Paper presented to the Health Economists' Study Group Conference,
University of Oxford, January 2001

Introduction

Following the early pioneering efforts of the 1960's, liver transplantation as a procedure developed slowly until the early 1980's when the advent of a new immunosuppression drug, cyclosporin A, combined with improvements in surgical technology led to dramatic improvements in survival rates [Jenkins and Fairchild, 1989]. These advances have furthered the evolution of transplantation as a treatment option for patients with acute or chronic end stage liver disease. In 1980 fewer than 50 liver transplant operations were performed throughout Europe. However, by 1990, over 2000 liver transplant operations were performed by more than 60 separate clinical teams [Buckels, 1995].

In general, patients are considered for liver transplantation once the anticipated survival is less than 12 months or in instances where their quality of life is considered intolerable [Neuberger and Lucey, 1994]. The vast majority of liver transplants are performed using orthotopic transplantation in which the diseased liver is removed and the donor organ (or part of the donor organ) is grafted in that site. Due to the chronic shortage of donor organs, several alternatives to orthotopic transplantation, including hepatocyte transplantation and xenografts are being considered. At present, these remain largely experimental but may be introduced into clinical practice in the future [Michler, 1996]. Current survival rates following liver transplantation are between 80 and 90% at 12 months, falling to between 70 and 76% at five years [Buckels, 1995; UKTSSA, 1998]. Despite the possibility of problems post-transplant including rejection, infection and the side-effects of lifelong immunosuppression, the majority of studies assessing quality of life pre and post transplant report a dramatic improvement in quality of life following liver transplantation [Lowe *et al*, 1990; Bonsel *et al*, 1992; Hicks *et al*, 1992; Bryan *et al*, 1998].

To date, little evaluative research on the costs and benefits of liver transplantation has been undertaken. This is in contrast to other solid organ transplant procedures e.g. heart transplantation, which has been the subject of several major evaluative studies undertaken in the UK, in the US and in the Netherlands [Buxton *et al*, 1985; Evans *et al*, 1986, Van Hout 1993]. The most

comprehensive study of the costs and benefits of liver transplantation thus far undertaken in a European setting concluded that liver transplantation significantly improves the long term survival and quality of life of patients [Bonsel *et al*, 1990]. However, this study was undertaken on a relatively small group of patients (n=76) and included only patients with non-alcoholic cirrhosis. Questions remain regarding the survival and quality of life experiences of patients with alcoholic cirrhosis, who currently make up the largest single group of patients transplanted within the UK [HERG, 1999].

This paper reports upon the survival analysis for patients with alcoholic cirrhosis within the broader context of an economic evaluation of liver transplantation. The objectives of the survival analysis were to compare survival in patients diagnosed with alcoholic cirrhosis who underwent a liver transplant with the survival those patients would have experienced had they not been provided with a liver transplant, such that the net survival gain could be calculated. Given the favourable results achieved in the UK from liver transplantation, a randomised controlled trial research design was rejected as inappropriate by all collaborating centres at the outset of the study. However, the absence of a randomised controlled trial and, therefore, the absence of data from a control, non-transplant group, posed a problem for the survival analysis. It was not possible to generate control survival data in an experimental fashion within the context of the study. Several alternative research methods to estimate survival in the absence of transplantation [Bonsel, 1991] were considered by the research team including:

- formal expert judgement
- historical control group
- quasi-experimental control group;
- intervention delay group;
- prognostic modelling.

Formal expert judgement was initially rejected because of the difficulties of converging upon a group judgement and the potential for bias or error in any estimates produced. The use of an historical control group based upon patients who had received non-transplant care prior to liver transplantation being performed widely in the collaborating centres was also rejected for two

main reasons. Firstly, it became clear that the epidemiology of patients who were selected for transplantation within this study was not the same as the epidemiology of patients presenting historically who had received non-transplant care. Secondly, gradual improvements in non-transplant care over time meant that the effectiveness of non-transplant care would be likely to be underestimated where data from an historical control group were used. A quasi-experimental control group would comprise patients within our study who did not receive liver transplantation due to withdrawal or deselection. However, this group of patients would only form a valid control group if they were rejected or withdrew from liver transplantation for reasons unrelated to survival without transplantation. It became clear at an early stage that the cohort of patients meeting such a definition within our study would form too small a group to enable valid estimates of survival in the absence of transplantation to be obtained. Within the study context, the intervention delay group comprised those patients who waited for a relatively long period of time to receive their liver transplant and those patients who died whilst still on the waiting list. Several technical procedures exist which enable the use of the waiting list experience in estimating survival in the absence of transplantation [Gail, 1982]. However, any estimates obtained using this method are likely to be biased when there is heterogeneity in the prognosis until transplantation of patients when they enter the waiting list or heterogeneity at the time of transplant in the expected prognosis of patients without transplantation. The most powerful non-experimental method to estimate shadow survival is an appropriately applied prognostic model. Such models have been developed by applying Cox's proportional hazards regression procedure [Christensen, 1987] to the survival times of patients receiving non-transplant care in the recent past. Such models can be applied to transplant patients with the same primary diagnosis as those patients used to develop the model. This allows an estimate of shadow survival to be computed whilst controlling for all significant prognostic factors included in the model.

Patients and Methods

A cohort of 778 patients with end stage liver disease assessed for liver transplantation in six Department of Health designated liver transplant centres

between January 1995 and December 1997 formed the basis of an economic evaluation of liver transplant programme in England and Wales. Prospective data on demographic characteristics and resource usage were collected for all patients from the time of assessment for transplantation up to two years post transplant. Within this data set, there existed a cohort of 83 patients with end-stage alcoholic cirrhosis (the diagnosis of which was made on clinical, serological, and histological findings) who underwent liver transplantation. These transplanted patients form the basis of the study reported upon in this paper. At the time of transplant, information on the clinical severity of each patient was collected. This clinical information was applied to two prognostic models for patients with alcoholic cirrhosis in order to estimate survival in the absence of liver transplantation for this group of patients.

Prognostic Models: – The Béclère Model

The Béclère model is a survival model based upon Cox regression analysis, which can be used to predict survival in the absence of transplantation for patients with alcoholic cirrhosis at 1, 3, 6, 9, 12, 18, and 24 months beyond the point where clinical measures of severity, used to estimate survival, were collected [Poynard *et al*, 1994]. The model was derived from a cohort of 797 patients diagnosed with alcoholic cirrhosis at the Antoine Béclère Hospital in France between 1982 and 1992. Clinical, biochemical, and demographic risk factors were considered for inclusion in the Cox regression model. Serum bilirubin, serum albumin, encephalopathy, and age were identified as prognostic markers. Patients were excluded from the cohort if they had hepatitis B or C viral infection, and patients who underwent liver transplantation (n = 3) were included in the cohort up to the time they received a new liver. The model was updated in 1999 to predict survival in the absence of transplantation for a time period of 5 years [Poynard *et al*, 1999].

Individual patient estimates of survival in the absence of transplant may be obtained by using the following equation [1], to estimate an individuals relative risk of survival:

$$RR = 0.451\log_e(\text{Bilirubin in } \mu\text{mol/L}) - 0.036(\text{Albumin in g/dL}^1) + 0.049(\text{Patient age}) + 0.441(\text{Encephalopathy present}) - 3.29 \quad [1]$$

Once individual relative risks have been obtained, the probability of surviving at given time points is estimated using equation [2]:

.

$$\text{The probability of surviving to time t} = S_0(t)^{\exp(RR)} \quad [2]$$

where $S_0(t)$ takes on one of the following values:

t	Month 1	Month 3	Month 6	Month 9	Month 12	Month 18	Month 24
$S_0(t)$	0.903	0.841	0.791	0.767	0.733	0.690	0.643

To illustrate, assume there exists a 50-year-old patient with a bilirubin level of 102 μmol/L, a serum albumin level of 30 g/L (3g/dL) with no encephalopathy present. From equation [1], this patient's relative risk of survival can be calculated as follows:

$$RR = (0.451\log_e(102)) - (0.036*3) + (0.049*50) + (0.441*0) - 3.29 = 1.138$$

Thus, from equation [2], the patient's probability of being alive in the absence of transplantation at 1 month, 12 months, and 24 months later are $0.903^{\exp(1.138)} = 0.727$, $0.733^{\exp(1.138)} = 0.379$, and $0.643^{\exp(1.138)} = 0.252$, respectively.

Prognostic Models: – The Anand Model

The Anand model can also be used to predict survival in the absence of transplantation for patients with alcoholic cirrhosis [Anand *et al* 1997]. This model was based on a cohort of patients referred specifically for liver transplantation at the Queen Elizabeth Hospital, Birmingham, who were not accepted for transplantation for a variety of reasons. A Cox regression model was fitted which showed that serum bilirubin, serum albumin, blood urea, ascites, and spontaneous bacterial peritonitis were suitable predictors of survival within a four year time period. The relative risk of survival in the absence of a liver transplant can be calculated using equation [3] below:

[1] 1g/dL is equivalent to 10g/L

$$RR = 2.07\log_e(\text{Bilirubin in } \mu\text{mol/L}) + 2.33\log_e(\text{Urea in mmol/L}) - 0.07(\text{Albumin in g/L}) - 2.49(\text{Ascities present}) + 4.31(\text{Spontaneous bacterial peritonitis present}) - 9.61 \quad [3]$$

As with the Béclère model, non-transplant survival can be estimated at 1, 3, 6, 9, 12, 18, and 24 months using equation [2] and the estimates for $S_0(t)$ given below.

t	Month 1	Month 3	Month 6	Month 9	Month 12	Month 18	Month 24
$S_0(t)$	0.935	0.885	0.784	0.681	0.650	0.589	0.455

Statistical methods

Actual, 2-year post transplant survival was calculated using Kaplan-Meier survival estimates, and the mean short-term survival was obtained by calculating the area under the Kaplan-Meier survival curve [Kaplan and Meier, 1980]. Estimates of survival in the absence of transplantation were calculated using the two prognostic models described above. After calculating each individuals probability of surviving to time point t, the average probability for the whole cohort of surviving at this time point was calculated. These probabilities were then plotted over time in order to depict non-transplant survival.

For the non-transplant survival group, there exist individual estimates of non-transplant survival over time for each patient. Therefore, individual short-term survival estimates were converted to years (or months) expected to survive, by calculating the area under each individual's survival curve. The average, short-term, non-transplant survival for the whole cohort was then derived by taking the average estimate for all patients. Non-parametric statistical tests were then used to compare differences in survival between transplant and non-transplant survival estimates.

Missing data

In 34% of cases, some of the clinical data needed to predict survival in the absence of transplantation was missing. In the majority of cases only one or two variables were unknown. Rather than ignoring these cases and reducing the sample size of the non-transplant group to 55 patients, the technique of

multiple imputation was used to estimate values for this missing data [Schafer, 1997]. Multiple imputation uses Monte Carlo simulation techniques to replace the missing values with a set of m 'plausible values drawn from their predictive distribution' that at the same time reflect the uncertainty of the data due to the missing variables. After the missing values have been replaced, it was then possible to calculate survival in the absence of transplantation using the published prognostic models for all 83 patients in the cohort. NORM was used to estimate the values for the missing data and the SPlus statistical computer package was used for all other analysis [Schafer, 1999; S-Plus 2000]. A p-value of 5% or less was considered to be significant in all statistical tests.

Results

Patient characteristics

A total of 83 patients with alcoholic liver disease were transplanted within the study period, of whom 67 (80.7%) were alive up to 2-years after their transplant operation. Table 1 shows the distribution of gender, age, and number of elective transplants, overall and by centre. No statistically significant differences were found across the six centres, although the proportion of male patients at centre 5 was much lower than that for the other five centres.

The number of post-transplant deaths is also presented in Table 1. The Wilcoxon test for equality of survival showed that there was no significant difference in the proportion of patients surviving a liver transplant operation across centres

($c_5^2 = 5.22$, p = 0.390).

Clinical characteristics

In addition to patient characteristics, details of the clinical variables used to predict survival in the absence of transplantation using published prognostic models for patients with alcoholic cirrhosis are presented in Table 1. No significant difference in serum bilirubin, blood urea, or INR were found across the six centres participating in the study (p = 0.878, p = 0.163, and p = 0.347 respectively). There were differences in the number of patients with

encephalopathy (0% at centre 4 and 90% at centre 3 (c_5^2 = 24.90, p < 0.001)) and in levels of serum albumin (Kruskal Wallis $c_5^2 = 14.47$, p = 0.013). However, this difference is due to a low serum albumin in patients in centre 3 and does not differ across the other centres (Kruskal Wallis $c_4^2 = 4.28$, p = 0.370). Despite consultations with clinical colleagues, no plausible explanation can be offered for this discrepancy.

Comparison of survival after transplantation with anticipated survival without transplantation

1. The Béclère model

The authors of the Béclère model "validated" their model using a cohort of patients who underwent liver transplantation. The cohort of patients used to validate the model tended to be slightly younger (mean age 46.5 years), were less likely to have encephalopathy (18% present) and higher serum albumin levels (mean 32.0 g/l) than those for our current cohort. However, the bilirubin levels did not differ significantly (mean l78.0 mmol/l).

Actual post-transplant survival and estimated survival in the absence of transplantation is shown in Figure 1. Estimates for survival in the absence of transplantation are much lower than for the actual survival of patients receiving a liver transplant, the 95% confidence limits between the two curves never overlap. The average short-term survival of transplanted patients is 20.95 months (CI: 19.29 to 22.61 months). If patients were not transplanted the average short term survival would be 10.78 months (CI: 9.80 to 11.76 months) using Béclère predictions. Thus, the number of life years gained by transplantation, over two years, is 0.85 years (10.17 months (CI: 9.96 to 10.38 months)) which shows a statistically significant benefit of liver transplantation (Wilcoxon sign rank test: z = -7.91, p < 0.001).

2. The Anand model

The Anand model was also fitted to the present data and the results were compared with those from the Béclère model. From Figure 1, it can be seen that the Anand model predicted higher survival rates in the absence of transplantation than the Béclère model. As with the Béclère cohort, patients in

the Anand cohort tended to be slightly younger, were less likely to have encephalopathy and had higher serum albumin levels than those for the liver transplantation cohort.

The average predicted survival, over two years, using the Anand model was 18.41 months (CI: 16.73 to 20.10 months) and the average life years gained using the Anand predictions was 0.27 years (3.2 months (CI: 2.92 to 3.49 months). Statistical tests showed that there was no significant benefit of liver transplantation using this model (Wilcoxon sign rank test: $z = -0.48$, $p = 0.634$).

Discussion

The marked difference between the estimated non-transplant survival from the Béclère model and the Anand model is concerning. However, it is difficult to form any strong conclusions as to which model would be superior in predicting survival in the absence of transplantation.

The time periods in which the data for the studies were collected are similar, Anand 1987 to 1994, and Béclère 1982 to 1996. This effectively eliminates the time frame as a possible reason for differences in results between the two models (improvements in non-transplant care over time could result in changes to survival predictors). However, the sample sizes of the two cohorts do differ notably (Béclère: N = 778, Anand: N = 76). It is possible, therefore, that the smaller number of patients in the Anand model has resulted in a wider variation in estimated survival predictions for this model. Support for this hypothesis is shown by the wide confidence intervals in Figure 1.

Differences in estimated non-transplant survival could simply be due to the different types of cohort used to derive the predictive models (rather than their absolute numbers *per se*). The Béclère cohort consisted of all patients with ALD presented to the Béclère hospital within the study period, regardless of whether they were assessed for liver transplantation or not [Poynard *et al* 1994, 1999]. In contrast, the Anand cohort consisted only of patients who were

assessed for liver transplantation, though not thought to be suitable candidates, for various reasons [Anand *et al* 1997].

In a recent article concerning the validity of prognostic models, Altman and Royston stated that the number of events, in this case deaths, per variable (EPV) should be at least ten times the number of potential prognostic variables to be included in the models [Altman and Royston, 2000]. With the Anand model, five variables were included in the model, indicating that there should be at least fifty deaths for the parameter estimates to be reliable. The number of deaths for the model cohort is not stated in the paper, though, from published information on survival which incorporates other patients, we estimate the proportion to be approximately 49% (38 deaths), which is lower than the 50 required for a five variable model [Anand *et al*, 1997]. A total of 375 patients had died after 5-years in the Béclère cohort, which is well over the forty deaths required when fitting a four variable model.

It is also recommended that prognostic models are validated internally in terms of data splitting or cross validation, temporally on subsequent patients at the same centre, and externally using another retrospective data set [Altman and Royston, 2000]. To our knowledge, the Anand model does not appear to have been validated internally or externally so it is difficult to draw any conclusions about this. Poynard *et al* validated their model internally by splitting the cohort into three groups, according to survival risk (high/medium/low) and externally on patients undergoing liver transplantation at 12 French centres and 192 patients in the placebo arm of a clinical trial at four centres [Poynard *et al,* 1994]. It was concluded that the model predicted survival accurately. However, when the Béclère model was fitted to the Anand cohort, survival differed by as much as 34% between actual and Béclère predicted survival at 2-years [Anand *et al*, 1997]. This implies that the Béclère model may not be so accurate at predicting survival in a different cohort of patients than the one from which it was developed.

Although the apparent internal validity of the Béclère model would suggest that it is preferable to the Anand model for estimating non-transplant survival in patients exhibiting alcoholic cirrhosis, in practice the Anand model does have

some advantages as it was based on a cohort of UK patients at one of the collaborating centres participating in the economic evaluation study from which this data originates. Thus, the Anand cohort is more likely to be similar in terms of patient characteristics and patient selection to the UK patient population within the economic evaluation than the Béclère cohort of French patients.

In the absence of data from a randomised controlled trial it is difficult to establish the short-term clinical benefit from transplantation in patients with a primary liver disease diagnosis of alcoholic cirrhosis. Depending upon which prognostic model is used, the short-term gain of liver transplantation over not transplanting patients with end stage ALD differs substantially. Ultimately this discrepancy could affect policy decisions as to whether liver transplantation is considered an appropriate treatment for these patients. If prognostic models are to become more widely used as a measurement for predicting short-term survival in the absence of a randomised controlled trial for liver disease and other clinical areas, the results of our study suggest that further research is required in order to establish the theoretical and practical validity of such models in this context.

References

Altman D.G. Royston P. [2000] What do we mean by validating a prognostic model? *Statistics in Medicine*, **vol 19**, pp453-473.

Anand A.C. Ferraz-Neto B.H. Nightingale P *et al* [1997] Liver transplantation for alcoholic liver disease: evaluation of a selection protocol. *Hepatology*, **vol 25**, pp 1478-1484.

Bonsel G.J. [1990]. Methods of medical technology assessment, PhD Thesis, Erasmus University, Rotterdam.

Bonsel G.J. Klompmaker I.J. van 'T Veer F. *et al* [1990] Use of prognostic models for assessment of value of liver transplantation in primary biliary cirrhosis. *The Lancet*, **vol 335**, pp493-97.

Bryan S. Ratcliffe J. Neuberger J. *et al*. [1998]. An assessment of patient's quality of life following liver transplantation. *Quality of Life Research*, **vol 7**, pp115-120.

Buckels J.A.C. [1995]. Liver transplantation: current status, complications and prevention. *Journal of Antimicrobial Chemotherapy*, **vol 36**, ppS39-S49.

Buxton M. Acheson R. Caine N. *et al* [1984] *Costs and benefits of the heart transplant programmes at Harefield and Papworth hospitals.* Department of Health and Social Security Research Report No. 12.

Christensen C. [1987] Multivariate analysis using Cox's regression model, *Hepatology*, **vol 7**, pp1346-1358.

Evans R.W. Manninen B.J. Gersch L.G. *et al*. [1986]. Donor availability as the primary determinant of the future of heart transplantation. *Journal of the American Medical Association*, **vol 255**, pp1892-1898.

Gail M.H. [1982]. Does cardiac transplantation prolong life? *Annals of Internal Medicine*, **vol 76**, pp815-817.

HERG [1999]. Interim data 'Economic evaluation of the liver transplantation programme in England and Wales', Brunel University, Uxbridge.

Hicks F.D. Larson J.L. Ferrans C.E. [1992]. Quality of life after liver transplant. *Research in Nursing and Health*, **vol 15**, pp115-119.

Jenkins R.L. Fairchild R.B. [1989]. The role of transplantation in liver disease. *Liver Surgery*, **vol 69**, pp371-382.

Kaplan E.L. Meier P. [1980]. Nonparametric estimation from incomplete observations. *Journal of the American Statistical Association*, **vol 53**, pp475-481.

Lowe D. O'Grady J.G. McEwen J. Williams R. [1990]. Quality of life following liver transplantation:a preliminary report. *Journal of the Royal College of Physicians of London*, **vol 24**, pp43-46.

Michler R.E. [1996]. Xenotransplantation: risks, clinical potential and future prospects. *Journal of Emerging Infectious Diseases*, **vol 2**, pp64-70.

Neuberger J. Lucey M.R. [1994] *Liver Transplantation: Practice and Management.* BMJ Publishing Group.

Poynard T. Barthelemy P. Fratte S. e*t al* [1994] Evaluation of efficacy of liver transplantation in alcoholic cirrhosis by a case-control study and simulated controls. *The Lancet*, **vol 344**, pp502-507.

Poynard T. Naveau S. Doffoel M. [1999] Evaluation of efficacy of liver transplantation in alcoholic cirrhosis using matched and simulated controls. *Journal of Hepatology*, **vol 30**, pp1130-1137.

Schafer J.L. [1997]. *Analysis of incomplete multivariate data.* Chapman & Hall, London.

Schafer J.L. [1999]. *NORM: Multiple imputation of incomplete multivariate data under a normal model, version 2.* Software for Windows 95/98/NT, available from http://www.stat.psu.edu/~jls/misoftwa.html.

S-PLUS 2000 Guide to Statistics, Volume 1 & 2, Data analysis products division, MathSoft, Seattle, WA.

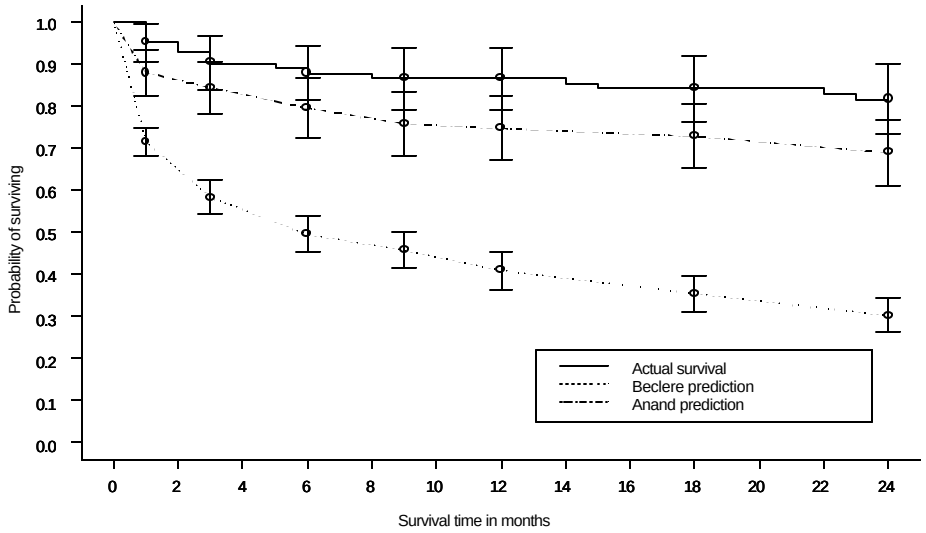
UKTSSA [1998]. Audit of liver transplantation in the UK, UKTSSA, Bristol.

Van Hout B. [1993]. Heart transplantation, costs effect and prognosis. PhD thesis, Erasmus University, Rotterdam.

Table 1: Descriptive and clinical characteristics for 83 patients with alcoholic liver disease who received a liver transplant by centre and overall.

	Centre 1 (N = 21)	Centre 2 (N = 8)	Centre 3 (N = 10)	Centre 4 (N = 13)	Centre 5 (N = 16)	Centre 6 (N = 15)	Overall (N = 83)	P-value
Mean age (SD)	50.2 (8.06)	49.9 (6.79)	50.9 (7.50)	48.4 (9.69)	54.13 (8.58%)	49.1 (6.76)	**50.53 (8.04)**	**0.460**
Median bilirubin in mol/l (IQR)	59 (28 to 94)	62 (21 to 125)	77 (44 to 104)	50 (22 to 99)	42 (18 to 64)	37 (23 to 71)	**50 (25 to 104)**	**0.747**
Medium serum albumin in g/l (IQR)	29 (25 to 32)	27.5 (25 to 30)	24.5 (23 to 27)	31 (29 to 33)	31 (28 to 35)	31 (27 to 34)	**29 (27 to 33)**	**0.013**
Medium blood urea in mmol/l (IQR)	4.9 (4.3 to 8.0)	3.0 (2.4 to 5.2)	4.5 (2.4 to 5.4)	10.8 (5.8 to 10.8)	5.9 (3.2 to 8.1)	5.7 (3.6 to 7.0)	**5.1 (3.2 to 8.0)**	**0.194**
Median INR (IQR)	1.8 (1.3 to 2.0)	1.6 (1.4 to 1.8)	1.8 (1.5 to 2.1)	1.7 (1.5 to 2.0)	1.5 (1.4 to 1.6)	1.6 (1.3 to 1.9)	**1.7 (1.4 to 2.0)**	**0.374**
Males (%)	19 (90.5%)	6 (75.0%)	9 (90.0%)	13 (100.0%)	9 (56.3%)	11 (73.3%)	**67 (80.7%)**	**0.062**
Routine Tx. (%)	21 (100.0%)	8 (100.0%)	10 (100.0%)	13 (100.0%)	16 (100.0%)	15 (100.0%)	**81 (97.6%)**	**N/A**
Died post-Tx. (%)	3 (14.3%)	2 (25.0%)	4 (40.0%)	2 (15.4%)	2 (12.5%)	3 (20.0%)	**16 (19.3%)**	**0.569**
Ascities present (%)	17 (81.0%)	8 (100.0%)	9 (90.0%)	10 (76.9%)	9 (56.3%)	15 (100.0%)	**68 (81.9%)**	**0.025**
Encephlopathy present (%)	10 (47.6%)	1 (12.5%)	9 (90.0%)	0 (0.0%)	5 (31.3%)	9 (60%)	**34 (41.0%)**	**< 0.001**
SBP present (%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	**0 (0.0%)**	**N/A**

N/A - statistical test not appropriate



	1 month	3 months	6 months	9 months	12 months	18 months	24 months
Actual survival	0.952	0.904	0.880	0.867	0.867	0.843	0.818
(95% CI)	(0.906 to 0.998)	(0.841 to 0.967)	(0.817 to 0.943)	(0.794 to 0.940)	(0.794 to 0.940)	(0.765 to 0.921)	(0.734 to 0.902)
Anand prediction	0.880	0.845	0.796	0.759	0.748	0.729	0.690
(95% CI)	(0.825 to 0.935)	(0.782 to 0.907)	(0.726 to 0.866)	(0.684 to 0.833)	(0.673 to 0.824)	(0.652 to 0.806)	(0.610 to 0.771)
Beclere prediction	0.716	0.584	0.496	0.458	0.410	0.355	0.303
(95% CI)	(0.683 to 0.750)	(0.543 to 0.625)	(0.453 to 0.539)	(0.415 to 0.502)	(0.366 to 0.453)	(0.313 to 0.398)	(0.262 to 0.344)

Figure 1: Two-year survival in the absence of transplant and post transplant survival for 83 patients transplanted for alcoholic cirrhosis at 6 Department of Health liver transplant centres in England and Wales.