NHS BLOOD AND TRANSPLANT

LIVER ADVISORY GROUP

RISK MODEL FOR POST-TRANSPLANT SURVIVAL

The post-transplant survival model that was developed as part of the National Adult Liver Offering Scheme (LAG(14)31c) identified a list of risk factors that are statistically significant or clinically relevant at explaining survival of patients to five years post liver transplantation, as follows:

Recipient factors[1]
Disease group based on the Roberts' hierarchy that considers up to three reported indications for transplantation (Roberts *et al.,* 2004. *Liver Transplantation,* 10(7), pp. 886-897)
Age at transplant
Sex
HCV indicator
Creatinine
Bilirubin
INR
Sodium
Potassium
Albumin
Renal replacement therapy
Patient location
Previous abdominal surgery
Encephalopathy
Ascites
Waiting time to transplant
Diabetes

Donor factors[1]
Age
Cause of death
BMI
History of diabetes
Donor type

Transplant factors
Donor-recipient blood group compatibility
Liver split indicator

For patients registered with cancer as an indication to transplantation maximum AFP level, maximum tumour size and number of tumours were also included in the model, with number of tumours treated as a three level categorical factor (one, two and three or more tumours).

The model results are shown in the **Appendix** for both the non-cancer and cancer cohorts. Full details on how the model was developed were presented in LAG(14)31c.

It is proposed that this risk-adjusted model for 5-year survival post liver transplantation is incorporated in future analyses and reporting of NHSBT where long term survival is relevant.

ACTION

LAG members are asked to consider the model and agree with this proposal.

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[1] Interaction factors: HCV and donor diabetes, HCV and donor age, recipient age and disease group, recipient age and recipient creatinine, donor type and disease group, donor type and recipient age, donor type and recipient creatinine.

Appendix

Table A1	Model results for non-cancer cohort						
Term	Level	N	Hazard Ratio	95% Hazard Ratio Confidence Limits		Wald test p-values	Type III p-values
Recipient							
Age at transplant		2495	0.91	0.83	0.99	0.03	
Sex	Male	1505	1	-	-	-	0.96
	Female	990	1.00	0.81	1.23	0.96	
Disease group	HCV	349	0.79	0.07	9.37	0.8	
	ALD	692	1	-	-	-	
	HBV	39	13.18	0.48	361.68	0.13	
	PSC	309	0.90	0.18	4.52	0.9	
	PBC	310	0.23	0.03	2.14	0.2	
	AID	221	0.92	0.15	5.52	0.93	
	Metabolic liver disease	166	2.27	0.30	16.85	0.4	
	Other liver disease	199	1.15	0.23	5.89	0.9	
	One or more previous transplant	210	1.79	0.36	8.89	0.5	
HCV indicator	No	2142	1	-	-	-	
	Yes	353	0.74	0.14	4.09	0.7	
Ln(creatinine)		2495	0.38	0.14	1.01	0.05	
Ln(bilirubin)		2495	1.04	0.93	1.15	0.5	0.5
Ln(INR)		2495	0.64	0.44	0.95	0.03	0.03
Sodium		2495	0.99	0.97	1.01	0.4	0.4
Potassium		2495	1.01	0.86	1.20	0.9	0.88
Albumin		2495	0.99	0.97	1.00	0.05	0.05
Renal replacement therapy	No	2360	1	-	-	-	0.0003
	Yes	135	1.82	1.31	2.51	0.0003	
Patient location	Outpatient	1958	1	-	-	-	0.02
	Inpatient	537	1.32	1.04	1.67	0.02	
Previous abdominal surgery	No	2002	1	-	-	-	0.3
	Yes	493	1.16	0.87	1.53	0.3	
Encephalopathy	No	1684	1	-	-	-	0.93
	Yes	811	1.01	0.82	1.24	0.93	
Ascites	No	1036	1	-	-	-	0.8
	Yes	1459	1.03	0.84	1.26	0.8	

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		N	Est	Lower	Upper	p	p(overall)
Ln(waiting time)		2495	1.00	0.93	1.07	0.93	0.93
Diabetes	No	2098	1	-	-	-	0.3
	Yes	397	1.15	0.90	1.48	0.3	
Donor							
Donor age		2495	1.01	1.00	1.01	0.09	
Donor cause of death	CVA	1675	1	-	-	-	0.2
	RTA	177	1.27	0.90	1.80	0.2	
	Other trauma	111	0.71	0.43	1.18	0.2	
	Other	532	0.93	0.73	1.18	0.6	
History of diabetes	No	2286	1	-	-	-	
	Yes	124	0.79	0.48	1.32	0.4	
	Unknown	85	1.11	0.66	1.86	0.7	
Donor BMI		2495	1.01	0.99	1.03	0.3	0.3
Donor type	Donors after brain death (DBD)	2138	1	-	-	-	
	Donors after circulatory death (DCD)	357	39.88	1.21	1309.22	0.04	
Transplant							
Blood group compatibility	Identical	2463	1	-	-	-	0.7
	Compatible	32	1.18	0.56	2.48	0.7	
Liver split	Whole	2250	1	-	-	-	0.03
	Split	245	1.43	1.03	2.00	0.03	
Interactions							
HCV*donor diabetes	HCV=No or donor diabetes=No	2467	1	-	-	-	0.07
	HCV and donor diabetes=Yes	17	2.32	0.86	6.25	0.1	
	HCV and donor diabetes=Unknown	11	2.47	0.86	7.14	0.09	
HCV*donor age	No	2142	1	-	-	-	0.10
	Yes	353	1.02	1.00	1.03	0.1	
Recipient age*disease group	HCV	349	1.00	0.96	1.04	0.96	0.6
	ALD	692	1	-	-	-	
	HBV	39	0.94	0.87	1.02	0.14	
	PSC	309	1.01	0.98	1.04	0.6	
	PBC	310	1.03	0.99	1.07	0.2	
	AID	221	1.00	0.97	1.04	0.94	
	Metabolic liver disease	166	0.99	0.95	1.03	0.5	
	Other liver disease	199	1.00	0.97	1.03	0.94	
	One or more previous transplant	210	1.00	0.97	1.03	0.98	
Recipient age*ln(creatinine)		2495	1.02	1.00	1.04	0.03	0.03

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		N	HR	Lower CI	Upper CI	p-value	Overall p
Donor type *disease group	DBD or ALD	2259	1.00	-	-	-	0.8
	DCD and HCV	66	0.77	0.36	1.63	0.5	
	DCD and HBV	7	0.68	0.07	6.59	0.7	
	DCD and PSC	31	1.09	0.49	2.42	0.84	
	DCD and PBC	56	0.78	0.34	1.79	0.6	
	DCD and AID	26	0.48	0.13	1.74	0.3	
	DCD and Metabolic liver disease	25	1.52	0.60	3.81	0.4	
	DCD and Other liver disease	22	0.50	0.14	1.85	0.3	
	DCD and One or more previous transplant	3	0.66	0.07	5.86	0.7	
Donor type*recipient age	DBD	2138	1.00	-	-	-	0.6
	DCD	357	1.01	0.98	1.03	0.6	
Donor type*ln(creatinine)	DBD	2138	1.00	-	-	-	0.04
	DCD	357	0.45	0.21	0.97	0.04	

C statistic[2] (full model) = 0.62 (0.59, 0.64) (SE=0.011192)

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[2] Gönen and Heller (Gönen and Heller, 2005. *Biometrika,* 92(4), pp.965-970) concordance probability, which is a measure of a model's predictive ability. It can vary from 0.5 (no predictive ability) to 1.0 (perfect predictive ability). The associated standard error (SE) was used to calculate a 95% confidence interval for this probability.

Table A2	Model results for cancer cohort						
Term	Level	N	Hazard Ratio	95% Hazard Ratio Confidence Limits		Wald test p-values	Type III p-values
Recipient							
Age at transplant		430	1.43	0.91	2.25	0.12	
Sex	Male	345	1	-	-	-	0.3
	Female	85	0.71	0.37	1.36	0.3	
HCV indicator	No	240	1	-	-	-	
	Yes	190	0.34	0.06	2.14	0.3	
Ln(creatinine)		430	127.10	0.36	45065.72	0.11	
Ln(bilirubin)		430	1.03	0.70	1.51	0.9	0.9
Ln(INR)		430	0.92	0.25	3.36	0.9	0.9
Sodium		430	1.05	0.99	1.11	0.09	0.09
Potassium		430	1.35	0.82	2.25	0.2	0.2
Albumin		430	1.02	0.98	1.06	0.3	0.3
Renal replacement therapy	No	413	1	-	-	-	0.2
	Yes	17	0.30	0.04	2.24	0.2	
Patient location	Outpatient	413	1	-	-	-	0.7
	Inpatient	17	0.80	0.22	2.89	0.7	
Previous abdominal surgery	No	383	1	-	-	-	0.9
	Yes	47	1.06	0.50	2.23	0.9	
Encephalopathy	No	389	1	-	-	-	0.2
	Yes	41	1.58	0.77	3.26	0.2	
Ascites	No	328	1	-	-	-	0.07
	Yes	102	1.69	0.97	2.94	0.07	
Ln(waiting time)		430	1.05	0.85	1.29	0.7	0.7
Diabetes	No	312	1	-	-	-	0.4
	Yes	118	1.27	0.74	2.20	0.4	
Ln(maximum AFP level)		430	1.05	0.93	1.20	0.4	0.4
Maximum tumour size		430	1.28	1.03	1.60	0.03	0.03
Number of tumours	1	283	1.00	-	-	-	0.7
	2	100	1.02	0.58	1.79	0.95	
	3 or more	47	0.70	0.30	1.65	0.4	
Donor							
Donor age		430	1.02	1.00	1.04	0.09	

Donor cause of death	CVA	285	1	-	-	-	0.3
	RTA	14	2.31	0.73	7.25	0.15	
	Other trauma	17	0.42	0.10	1.85	0.3	
	Other	114	1.00	0.59	1.69	0.99	
Donor BMI		430	0.98	0.94	1.04	0.5	0.5
History of diabetes	No	392	1	-	-	-	
	Yes	23	1.18	0.27	5.15	0.8	
	Unknown	15	0.94	0.12	7.29	0.95	
Donor type	DBD	311	1	-	-	-	
	DCD	119	5.74	0.001	29899.16	0.7	
Transplant							
Blood group compatibility	Identical	422	1	-	-	-	0.03
	Compatible	8	3.54	1.13	11.11	0.03	
Liver split	Whole	396	1	-	-	-	0.4
	Reduced	34	1.53	0.54	4.35	0.4	
Interactions HCV*donor diabetes	HCV=No or donor diabetes=No	416	1	-	-	-	0.2
	HCV and donor diabetes=Yes	9	4.50	0.78	25.96	0.09	
	HCV and donor diabetes=Unknown	5	2.58	0.14	47.27	0.5	
HCV*donor age	No	240	1	-	-	-	0.10
	Yes	190	1.03	0.99	1.06	0.10	
Recipient age*ln(creatinine)		430	0.92	0.83	1.02	0.11	0.11
Donor type*recipient age	DBD	311	1.00	-	-	-	0.3
	DCD	119	1.04	0.97	1.11	0.3	
Donor type*ln(creatinine)	DBD	311	1.00	-	-	-	0.4
	DCD	119	0.48	0.08	2.77	0.4	

C statistic^2 (full model) = 0.70 (0.64, 0.75) (SE=0.026251)