NHS BLOOD AND TRANSPLANT

LIVER ADVISORY GROUP

LIVER SPLITTING ACTIVITY REPORT

SUMMARY

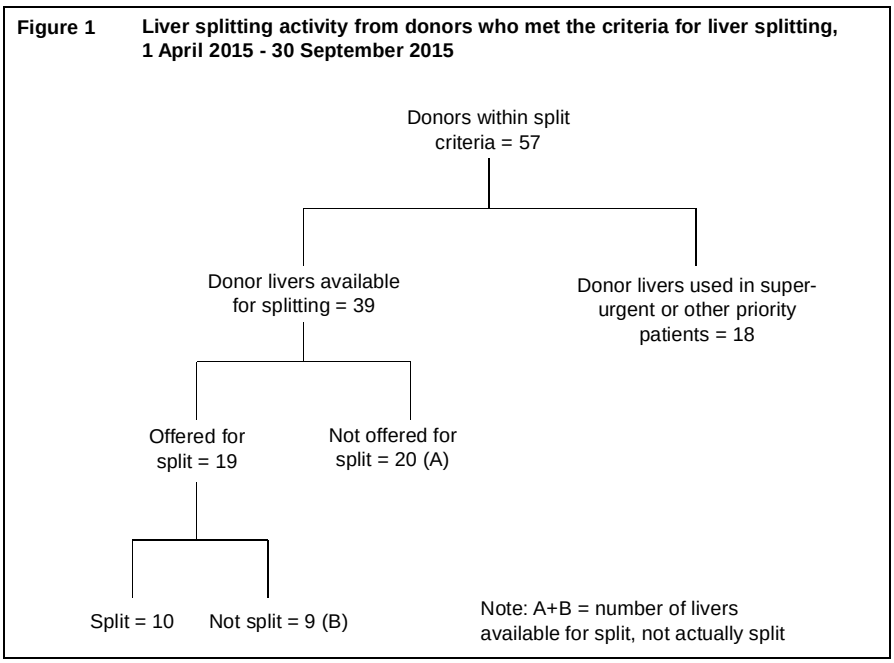
BACKGROUND

1 Donors after brain death (DBD) aged < 40 years, weighing > 50kg and known to have spent < five days in an intensive care unit meet the criteria for liver splitting. If a donated liver is split it can be used to transplant two patients; typically one adult and one paediatric patient. This paper reports on the outcome of livers from DBD donors who donated their liver in a recent time period and who met the criteria for liver splitting. It also reports on survival outcomes of patients who received split liver transplants.

ACTIVITY

2 **Figure 1** shows a summary of the liver splitting activity in the 6-month period 1 April 2015 to 30 September 2015. In over a quarter of the 20 cases where the liver was available for splitting but was not offered for splitting, abnormal or raised liver function tests were cited as the reason. Nine livers were offered for splitting but instead used whole or reduced; common reasons were the fattiness of the organ or a lack of suitable patients for the left lateral segment. There were 10 donors whose livers were split, which led to 20 transplants.

Figure 1 **Liver splitting activity from donors who met the criteria for liver splitting, 1 April 2015 - 30 September 2015**



3 The percentage of livers split of those available for splitting increased by about 10% from 22-23% in 2006/2007 to 32-33% in 2012/13. In 2012/13, 27 livers were split. Since then there has been a fall to only 16 livers split in 2014/15 - approx 15% of those available for splitting.

TRANSPLANT OUTCOMES

4 Unadjusted analysis of transplant outcomes, April 2006 – March 2015, showed:

- No significant difference in 5 year transplant survival when comparing:
  - retained and imported split livers in paediatric recipients (p=0.7)
  - retained and imported split livers in adult recipients (p=0.08).
  - livers split by an adult or paediatric unit surgeon (p>0.8)

- Some evidence that whole liver transplant outcomes were better than split liver transplant outcomes for April 2006-March 2010 (p=0.09)

- No significant difference between whole and split liver transplant survival at 3 years for recent transplants (April 2010-March 2015), p=0.9.

- Three year split liver transplant survival has significantly improved over the two time periods (p=0.04).

5 Risk adjusted analysis of transplant outcomes, April 2010-March 2015, showed:

- Comparable outcomes for whole and split liver recipients, p=0.4 (HR for split=1.2, 95% CI 0.8-1.9)

- Comparable outcomes for livers split by adult (N=22) and paediatric (N=205) unit surgeons, p=0.9 (HR for adult unit=0.9, 95%CI 0.2-4.3)

- No significant difference in outcome between retained (N=155) and imported (N=72) split livers, p=0.3 (HR for imported=1.6, 95% CI 0.7-3.6).

ACTION

6 Risk adjusted analysis of three year transplant survival shows no difference in outcome of split and whole liver transplants. Despite this, in 2014/15 only 15% of available livers were split, representing the lowest rate and number over the last 9 years. Members are asked to consider what action should be taken to optimise use of split liver transplantation.

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Statistics and Clinical Studies **October 2015**

NHS BLOOD AND TRANSPLANT

LIVER ADVISORY GROUP

LIVER SPLITTING ACTIVITY REPORT

INTRODUCTION

1 If a liver from a deceased donor is split it can be used to transplant two patients; typically an adult patient receives the right liver lobe and a paediatric patient receives the left lobe or the left lateral segment. This paper reports on the outcome of livers from donors after brain death (DBD) who donated their liver between 1 April 2015 and 30 September 2015 and who met the criteria for liver splitting. The paper also reports briefly on activity over the last 9 years.

2 Analysis of liver transplant survival outcomes for patients who received a DBD donor split liver transplant between 1 April 2006 and 31 March 2015. Comparisons are made between livers retained by the splitting centre and those imported as a split from another centre. A comparative analysis was also performed between split livers that were split by adult vs paediatric unit surgeons. A comparison of the survival of whole versus split livers transplanted into adult patients is also shown. Both univariate and multivariate analyses are reported.

LIVER SPLITTING ACTIVITY

Data and methods

3 Donors meeting the criteria for liver splitting are under 40 years of age, weighing more than 50kg and known to have spent less than five days in an intensive care unit (ICU). Time in ICU is calculated as the time between start of ventilation and time of second test for brainstem death.

4 Data were obtained from the UK Transplant Registry (UKTR) on the 57 UK DBD donors whose liver was donated between 1 April 2015 and 30 September 2015 and who met the criteria for liver splitting. These livers were transplanted in the UK or the Republic of Ireland. Comparable data were also obtained on the 72 UK DBD liver donors 1 October 2014 - 31 March 2015 who met the criteria for liver splitting.

5 Donated livers were classed as split livers when they were used to transplant two patients and as reduced livers when cut down and used for one patient. Consequently reduced livers were not classed as split livers.

6 Livers were classed as offered for splitting if there was a record in the UKTR stating that part of the liver had been offered to a centre (offers that were withdrawn were discounted), as recorded by the ODT Duty Office.

7 Account is taken of the requirement in place from 6 October 2014 stating that all within-criteria livers offered to Hepatoblastoma patients must be considered for splitting.

Results

8 The status of each liver that was transplanted is shown in **Table 1** for April 2015 to September 2015, with October 2014 to March 2015 figures for comparison. For the latest 6

months, 39 (68%) of the 57 DBD donors meeting the splitting criteria were available for splitting. Of these 39 livers, 19 (48%) were offered for splitting. Of the 19 livers offered for splitting, 10 (53%) were actually split. This activity is summarised in **Figure 1**.

9 These 57 livers resulted in 75 transplants, of which 21 (28%) were performed in paediatric patients.

10 The percentage of livers split out of those available for splitting (N_S / N_A) are plotted in **Figure 2** over the last 9 financial years. This shows a slight rise in the percentage split, followed by a fall in the most recent financial year.

Figure 2 Percentage of livers split out of those available for splitting, 1 April 2006 - 31 March 2015

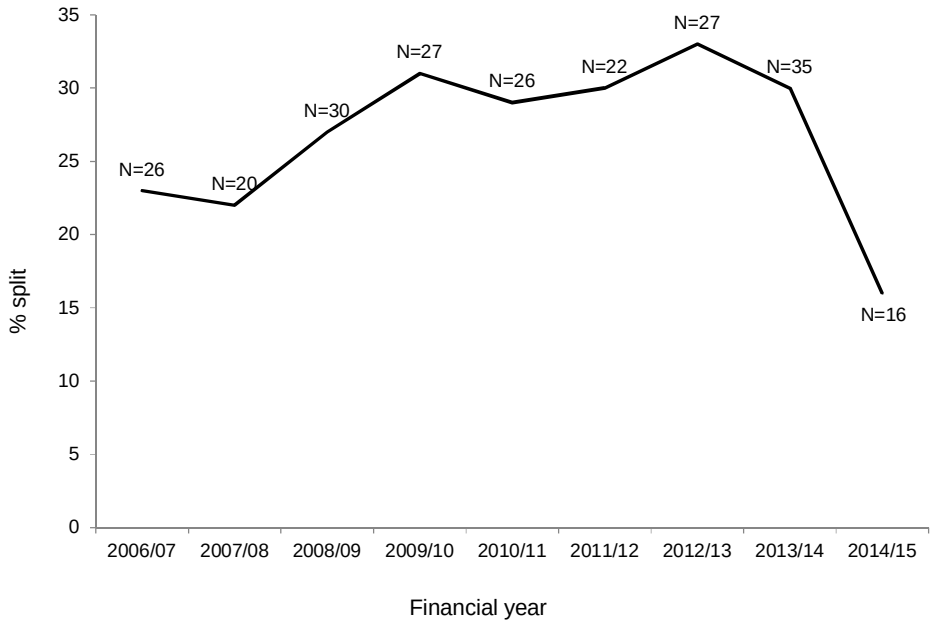


Table 1 Donors meeting criteria for liver splitting, by donor allocation zone, 1 April 2015 to 30 September 2015 (1 October 2014 to 31 March 2015)

Donor allocation zone	Total meeting liver splitting criteria and transplanted N		Super-urgent liver or intestinal/ hepatoblastoma recipients N_{P1}		Elective intestinal/ multi-organ recipients N_{P2}		Available for splitting N_A		Offered for splitting N_o		% of available		Split N_s		% of offered		Whole N_w		Reduced N_r	
Birmingham	15	(15)	3	(5)	1	(1)	11	(9)	5	(3)	45	(33)	4	(0)	80	(0)	1	(3)	0	(0)
Cambridge	4	(11)	3	(4)	0	(0)	1	(7)	1	(2)	100	(29)	0	(2)	0	(100)	0	(0)	1	(0)
Edinburgh	5	(7)	2	(2)	0	(0)	3	(5)	1	(2)	33	(40)	0	(1)	0	(50)	1	(1)	0	(0)
King's College	18	(14)	4	(4)	1	(1)	13	(9)	8	(2)	62	(22)	4	(1)	50	(50)	4	(1)	0	(0)
Leeds	8	(12)	3	(2)	0	(1)	5	(9)	1	(1)	20	(11)	1	(0)	100	(0)	0	(1)	0	(0)
Newcastle	3	(4)	1	(0)	0	(0)	2	(4)	1	(3)	50	(75)	1	(1)	100	(33)	0	(2)	0	(0)
Royal Free	4	(9)	0	(2)	0	(2)	4	(5)	2	(3)	50	(60)	0	(2)	0	(67)	2	(1)	0	(0)
TOTAL	**57**	**(72)**	**16[1]**	**(19[2])**	**2[3]**	**(5[4])**	**39**	**(48)**	**19**	**(16)**	**49**	**(33)**	**10**	**(7)**	**53**	**(44)**	**8**	**(9)**	**1**	**(0)**

[1] Seven of these livers were split and six were used to transplant one super-urgent/ hepatoblastoma recipient and one elective liver only recipient and one was used to transplant one super-urgent recipient and one hepatoblastoma recipient
[2] Three of these livers were split and used to transplant one super-urgent/ hepatoblastoma recipient and one elective liver only recipient
[3] One of these livers were split and used to transplant one multi-organ recipient and one elective liver only recipient
[4] One of these livers were split and used to transplant one multi-organ recipient and one elective liver only recipient

Note: Due to small numbers the percentages presented must be viewed with caution
Livers were not necessarily transplanted by the centre that resides in the donor allocation zone
$N = N_{P1} + N_{P2} + N_A$; $N_o = N_s + N_w + N_r$

Reasons for not offering for split transplantation

11 **Table 2** details the reasons given by the transplanting centre or noted by the ODT Duty Office for 20 livers not being offered for splitting (69% of the 29 livers available for splitting that were not split). In 8 cases there were concerns over liver function tests. The donor AST level, reported on the Core Donor Data Form, is presented in the table but it was only reported for 3 of the donors.

Table 2 Reasons given for why 20 livers from donors meeting the liver splitting criteria, between 1 April 2015 and 30 September 2015, were not offered for splitting

Donor	Donor allocation zone	Transplanting centre	Reason for liver not being offered for splitting	AST (iu/l)
Donor reasons				
1	Birmingham	Birmingham	Donor history & abnormal liver functions tests.	
2	Edinburgh	Edinburgh	Deranged liver functions tests.	265
3	Edinburgh	Leeds	Deranged liver functions tests.	93
4	Leeds	Leeds	High risk cause of death - IV drug overdose. Size and anatomy of organ.	
5	King's College	Birmingham	Medical history of donor.	
6	Leeds	Leeds	Deranged liver functions tests.	
7	Leeds	Newcastle	Function.	
8	Newcastle	Leeds	Function.	
9	Royal Free	Royal Free	Length of ITU stay (4.6 days) and bilirubin levels (23 µmol/L).	
10	Birmingham	Birmingham	Birmingham accepted whole liver and intended to split but was not possible for anatomical reasons.	
11	King's College	King's College	Significant liver laceration.	
12	King's College	Edinburgh	Trauma - Subcapsular Haematoma.	137
13	King's College	King's College	Due to left lateral draining into middle hepatic vein.	
14	Birmingham	Birmingham	Raised liver functions tests.	
15	Birmingham	Birmingham	Not split due to patient past medical history of IV drug use.	
16	Birmingham	Birmingham	Not splittable due to anatomy.	
Recipient reasons				
17	Birmingham	Birmingham	Recipient expected to bleed heavily so whole liver needed.	
18	Leeds	Leeds	Left lobe offered to Birmingham and King's who both declined as no suitable recipients for AB donor.	
Other reasons				
19	King's College	Newcastle	Not considered for splitting because coordinator not prompted that donor met criteria when offer made.	
20	Royal Free	Royal Free	Liver functions tests were slightly raised and trending upwards. Also centre had to change recipient at a point at which CIT precluded splitting.	

Reasons why livers offered for split transplant were not split

12 Nine livers were offered for splitting but were not split. The reasons given for not splitting are detailed in **Table 3**.

Table 3 Reasons given for why 9 livers from donors meeting the split liver criteria, between 1 April 2015 and 30 September 2015, that were offered for splitting were not split

Donor	Donor allocation zone	Transplanting centre	Details of why liver was not split	AST (iu/l)
Donor reasons				
1	Royal Free	Royal Free	Liver not splittable due to anatomy. Whole liver transplanted in Royal Free.	
2	King's College	King's College	Left lateral was accepted in Leeds then later declined as liver was mild/moderately fatty. Whole liver transplanted in King's.	69
3	King's College	King's College	Left lateral was accepted in Leeds but later declined due to function, size and fatty. Whole liver transplanted in King's.	
4	Cambridge	Cambridge	Liver was split but left lateral unusable so only right lobe transplanted.	
Recipient reasons				
5	Birmingham	King's College	Left lateral was accepted but later declined as intended recipient was unfit.	29
6	King's College	King's College	Left lateral declined by Birmingham and Leeds as no suitable recipients.	
Other reasons				
7	King's College	King's College	Left lobe offered and declined by Birmingham (no capacity) and Leeds (function). Whole liver transplanted in King's as they didn't feel splittable due to deranged liver functions tests (ALT: 566, ALK PHOS: 137).	
8	Royal Free	Royal Free	Paediatric centres declined (downtime, no suitable recipients). Whole liver transplanted in Royal Free.	69
9	Edinburgh	Edinburgh	Left lateral was accepted in Leeds but later declined due to CIT. Whole liver transplanted in Edinburgh.	24

13 There were 8 liver transplant recipients with Hepatoblastoma who were transplanted from a DBD donor between 1 April 2015 and 30 September 2015. Of these 6 were split liver transplants, and 2 were reduced liver transplants. Details of these transplants are in **Table 4**.

Table 4 Details of Hepatoblastoma patients transplanted between 1 April 2015 and 30 September 2015

Donor	Transplanting centre	Transplant type	Donor age (years)	Recipient age (years)	Reason for not splitting
1	Birmingham	Reduced	43	0	Donor outside splitting criteria
2	Birmingham	Split	18	5	
3	Birmingham	Split	43	4	
4	King's College	Split	20	1	
5	King's College	Split	34	1	
6	King's College	Split	24	6	
7	Leeds	Reduced	44	12	Donor outside splitting criteria
8	Leeds	Split	23	1	

Note: On 6 October 2014 it became a requirement to split livers, within criteria for splitting, offered to Hepatoblastoma patients

TRANSPLANT SURVIVAL

Data and methods

14 Data on 745 NHS group 1 first elective split liver only transplants in the UK using livers from DBD donors between 1 April 2006 and 31 March 2015 were analysed. Auxiliary and intestinal transplants were excluded from this cohort as were regrafts. Follow-up data were as recorded on the UKTR on 9 October 2015.

15 Each split liver was categorised into "retained"/ "imported" and "split by adult unit surgeon"/ "split by paediatric unit surgeon" (where surgeons from Birmingham, King's College and Leeds are classed as paediatric unit surgeons). Data returned via the Split Liver Information form was the primary source for categorising split livers into these groups. "Retained"/ "imported" was determined using the centre where the splitting was performed, which was reported in 42% of cases, and "split by adult unit surgeon"/ "split by paediatric unit surgeon" was determined by the centre where the splitting surgeon was appointed, which was reported in 40% of cases. The secondary source for finding out this information was the ODT Duty Office notes. If it was not clear from these notes where the liver was split and who performed the split, a judgement call was made (for instance, if the zonal centre was a paediatric centre who retained the left lobe and exported the right lobe, then we assumed that the paediatric centre performed the split in-house if the primary and secondary sources were insufficient, <0.01% of cases).

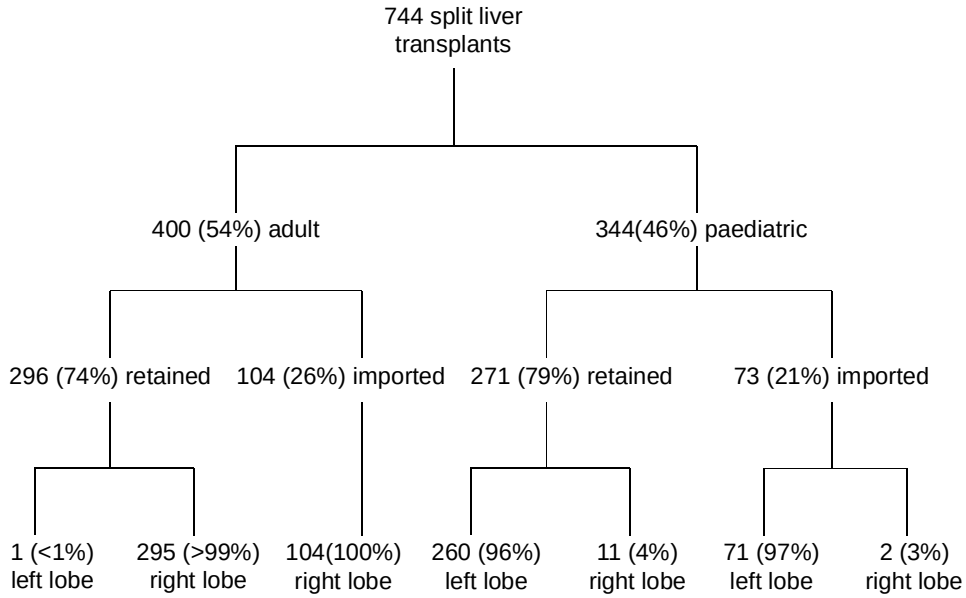
16 Survival up to five years post-split liver transplant (where the outcome event is graft failure or patient death) was compared for "retained" and "imported" split livers and for "adult unit surgeon" and "paed unit surgeon" split livers, separately for adult and paediatric patients. These analyses were performed using the Kaplan-Meier estimation method and the log-rank test. Risk-adjusted Cox regression models were also fitted to control for confounding factors. Risk factors included were those factors found to be significant in the post transplant outcome modelling in the development of the liver transplant benefit allocation scheme. Factors adjusted for were: recipient - age, HCV status, ln(creatinine), ln(INR), albumin, location, whether they were on renal replacement therapy; donor – age, diabetes; transplant – split or whole, imported/retained, adult/paediatric unit surgeon. Median cold ischaemia time (CIT) was also compared, for retained and imported split livers, using the Mann-Whitney U test.

17 A comparison of the survival of whole and split liver transplants up to five years was also made, for adult recipients only. This analysis included 3,630 NHS group 1 first adult elective patients transplanted in the UK between 1 April 2006 and 31 March 2015. A sub-group analysis was performed on just those transplants performed between 1 April 2010 and 31 March 2015 (N=2,151). Again, auxiliary and multi-organ transplants and regrafts were excluded and follow-up data were as recorded on the UKTR on 9 October 2015.

Results

18 **Figure 3** shows a breakdown of the 744 split liver transplants by recipient age group (adult (>=17 years), paediatric (<17 years)) and whether the liver was retained or imported.

Figure 3 Breakdown of NHS group 1 elective split liver only transplants in the UK using livers from donors after brain death, 1 April 2006 and 31 March 2015



19 **Table 5** shows a breakdown of the 744 split liver transplants by recipient age group, transplant centres and whether the liver was retained or imported.

Table 5 NHS group 1 first elective split liver only transplants in the UK using livers from donors after brain death, 1 April 2006 – 31 March 2015

Transplant centre	Retained N (%)	Imported N (%)	Total
Paediatric recipients			
Birmingham	104 (85)	19 (15)	123
King's College	123 (75)	41 (25)	164
Leeds	44 (77)	13 (23)	57
Total	**271 (79)**	**73 (21)**	**344**
Adult recipients			
Birmingham	119 (96)	5 (4)	124
Cambridge	13 (43)	17 (57)	30
Edinburgh	22 (35)	41 (65)	63
King's College	92 (96)	4 (4)	96
Leeds	36 (82)	8 (18)	44
Newcastle	4 (29)	10 (71)	14
Royal Free	10 (34)	19 (66)	29
Total	**296 (74)**	**104 (26)**	**400**
TOTAL	**567 (76)**	**177 (24)**	**744**

20 **Table 6** shows the median and range of CIT, in hours, of retained and imported split livers transplanted in adult and paediatric patients (left lobes transplanted in adult patients and right lobes transplanted in paediatric patients were excluded (N=14)). On average, CIT was 2.7 hours longer for imported liver lobes compared with retained liver lobes for both adult and paediatric recipients (Mann-Whitney U test: p<0.0001 for both). Data are shown separately for 2006-2010 and 2010-2015 and the more recent cohort shows a CIT that is 1.6 hours longer for imported rather than retained left lobes for paediatric patients, and 2.7 hours longer for imported right lobes for adult patients. In all groups, CIT are shorter in the most recent time period.

Table 6 Cold ischaemic times (CIT) of retained and imported split livers, transplanted in NHS group 1 elective liver only patients in the UK between 1 April 2006 and 31 March 2015

		N[1]	CIT (hours) Median	CIT (hours) Range
Left lobes transplanted in paediatric patients				
1 April 2006 – 31 March 2010	Retained	101	9.0	3.6 – 13.1
	Imported	32	11.8	6.0 – 16.5
1 April 2010 – 31 March 2015	Retained	102	8.9	3.8 – 16.2
	Imported	25	10.5	2.9 – 16.3
Overall	**Retained**	**203**	**9.0**	**3.6 – 16.2**
	Imported	**57**	**11.7**	**2.9 – 16.5**
Right lobes transplanted in adult patients				
1 April 2006 – 31 March 2010	Retained	131	10.0	4.8 – 17.6
	Imported	31	12.9	9.7 – 16.3
1 April 2010 – 31 March 2015	Retained	146	9.5	3.9 – 18.1
	Imported	68	12.2	6.6 – 15.6
Overall	**Retained**	**277**	**9.7**	**3.9 – 18.1**
	Imported	**99**	**12.4**	**6.6 – 16.3**

[1] CIT was not reported for a total of 94 split livers

Unadjusted survival analysis

21 **Figure 4** shows the Kaplan-Meier estimated survival curves up to five years post-transplant for paediatric and adult patients, by whether the split liver was retained or imported. The log-rank test showed no statistical difference in the overall survival curves in the paediatric analysis (p=0.7). Similarly, there was no significant difference between the survival curves in the adult analysis (p=0.08), although retained livers appear to do better.

22 **Figure 5** shows the Kaplan-Meier estimated survival curves up to five years post-transplant for paediatric and adult patients, by whether the liver was split by an adult unit surgeon or a paediatric unit surgeon. Note that there were only six events in the “split by adult unit surgeon” group in the paediatric analysis and only eight in the adult analysis, so

the results should be viewed with caution. There was no statistically significant difference found between these groups in the paediatric or adult analyses.

Figure 4 **Five year transplant survival of split livers transplanted in NHS group 1 elective patients in the UK, April 2006 - March 2015 – RETAINED vs IMPORTED**

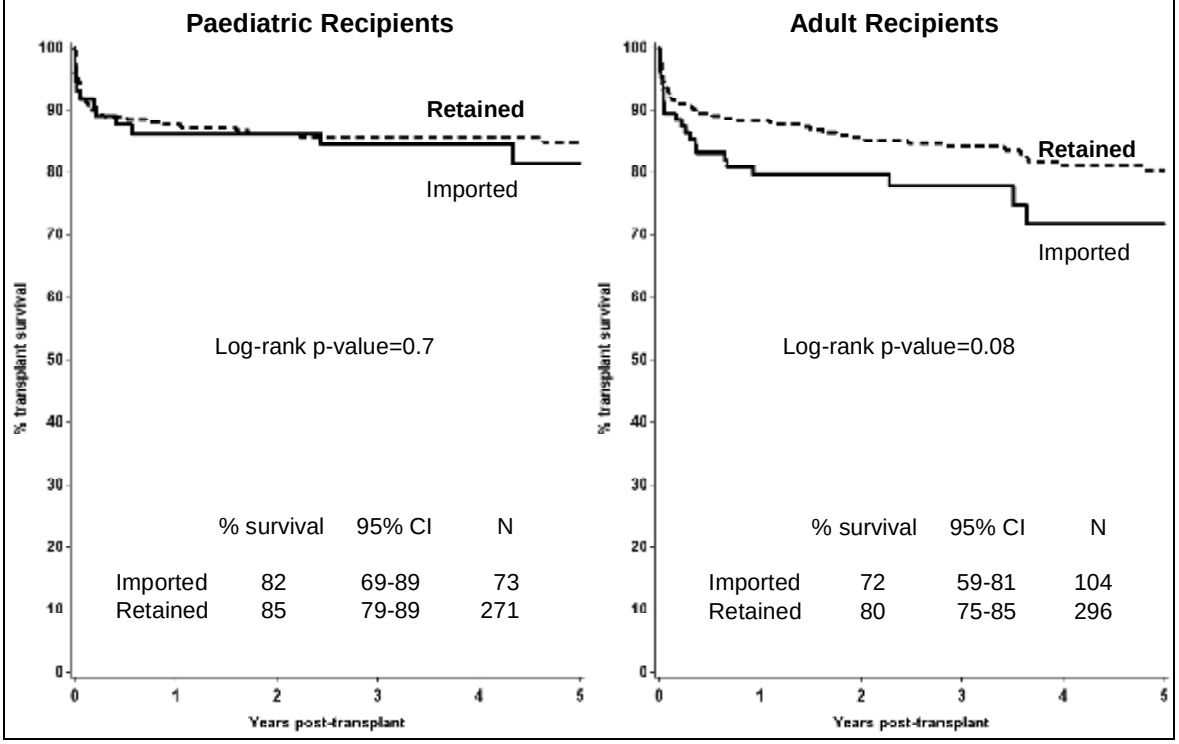
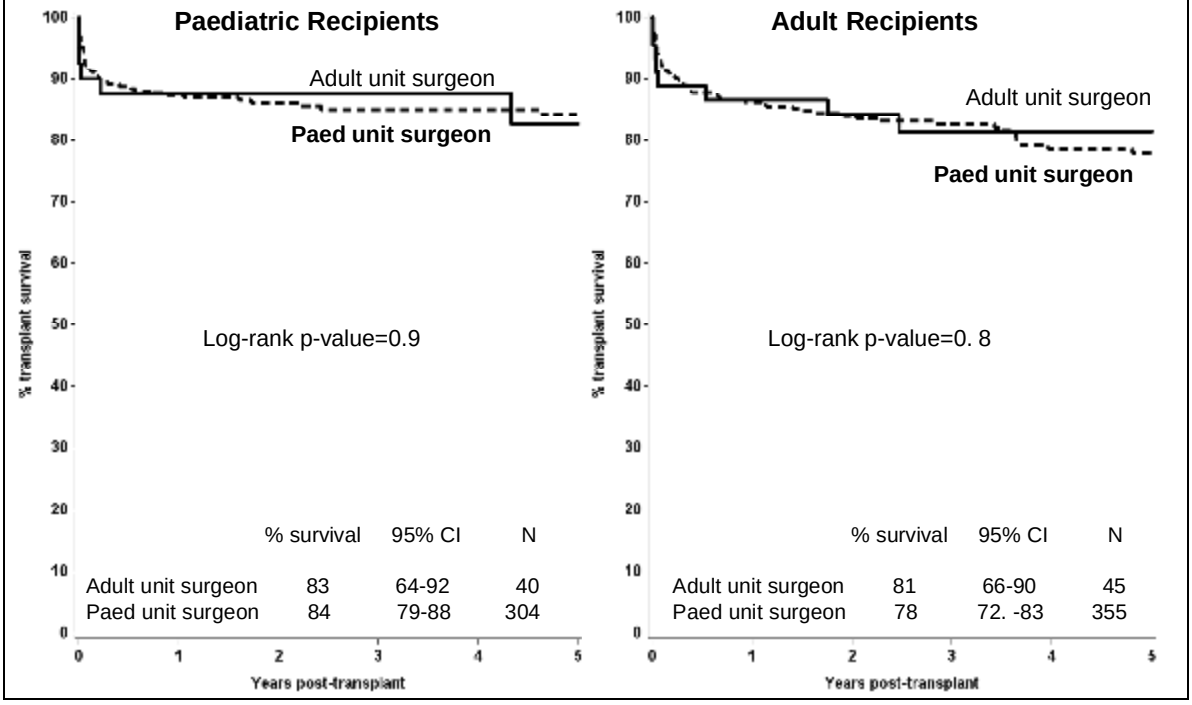


Figure 5 **Five year transplant survival of split livers split transplanted in NHS group 1 elective patients in the UK, April 2006 - March 2015 – ADULT vs PAEDIATRIC UNIT SURGEONS**

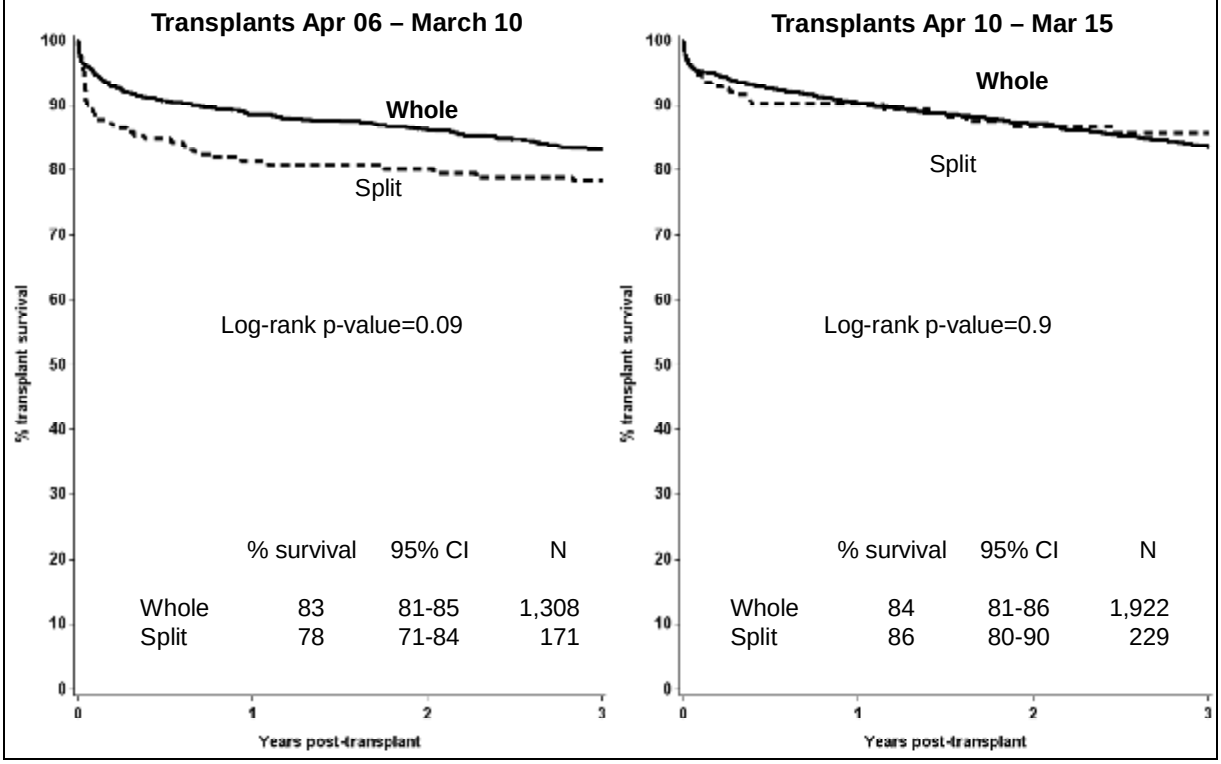


23 Causes of graft failure or patient death that were reported to the UKTR for the 123 out of 744 split liver transplant recipients who died or whose graft failed within five years following transplant are presented for reference in **Appendix I** by age group, by whether the split liver was retained/ imported and by whether the liver was split by an adult/ paediatric unit surgeon.

24 Unadjusted survival analysis at three years post-transplant for more recent transplants (1 April 2010 - 31 March 2015) can be seen in **Appendix II**. Results support the lack of a significant difference in all comparisons.

25 **Figure 6** shows the Kaplan-Meier estimated survival curves comparing transplant survival up to three years for whole and split liver transplants between 1 April 2006 and 31 March 2010 and between 1 April 2010 and 31 March 2015. For transplants between April 2006 and March 2010, the unadjusted analysis suggests some evidence of superior survival for whole liver transplants (p=0.09). However, for just those transplants carried out more recently there is no difference in the unadjusted survival curves at three years post-transplantation (p=0.9). The improvement in split liver outcomes over this period is statistically significant (p=0.04) while there is no change for whole liver transplants (p=0.5).

Figure 6 Three year transplant survival of whole and split livers transplanted in NHS group 1 elective adult patients in the UK, April 2006 - March 2010 and April 2010 - March 2015



26 Risk-adjusted analyses were carried out using Cox Proportional Hazards regression modelling for three year transplant survival. The results are shown in **Table 7** for transplants April 2006 – March 2010 and in **Table 8** for April 2010 – March 2015. After risk adjustment split liver transplants have a significantly higher hazard of patient death or graft failure for the earlier time period (p=0.03) but not for the most recent time period (p=0.4), reflecting the improvement in split liver transplant outcomes seen in the

univariate analysis. Further, the results showed no difference between retained and imported livers or between paediatric and adult unit surgeons in either time period.

Table 7 **Cox regression model for risk of graft failure or patient death within 3 years, 1 April 2006 – 31 March 2010**

		Whole and split liver transplants			Split liver transplants		
Factor	**Level**	N	Hazard ratio (95% CI)	p-value	N	Hazard ratio (95% CI)	p-value
Transplant							
Liver split	Whole	1237	1.00	-	-	-	-
	Split	166	1.58 (1.05 - 2.38)	0.03	-	-	-
Unit surgeon	Paediatric	-	-	-	145	1.00	-
	Adult	-	-	-	21	1.12 (0.37 - 3.36)	0.8
Location	Retained	-	-	-	135	1.00	-
	Imported	-	-	-	31	1.52 (0.62 - 3.73)	0.4
Recipient							
Age at transplant		1403	0.99 (0.98-1.01)	0.3	166	0.99 (0.96 - 1.02)	0.5
HCV indicator	No	1107	1.00	-	137	1.00	-
	Yes	296	1.24 (0.92-1.67)	0.2	29	0.88 (0.33 - 2.32)	0.8
Ln(creatinine)		1403	1.58 (1.08 - 2.32)	0.02	166	1.26 (0.44 - 3.64)	0.7
Ln(INR)		1403	0.55 (0.32 - 0.95)	0.03	166	0.7 (0.15 - 3.26)	0.7
Albumin		1403	0.98 (0.96 - 1)	0.04	166	0.98 (0.93 - 1.04)	0.5
Renal replacement therapy	No	1347	1.00	-	158	1.00	-
	Yes	56	1.42 (0.82 - 2.44)	0.2	8	1.55 (0.39 - 6.17)	0.5
Patient location	Outpatient	1189	1.00	-	146	1.00	-
	Inpatient	214	1.28 (0.9 - 1.82)	0.2	20	1.04 (0.36 - 2.99)	0.9
Donor							
Donor age		1403	1.01 (1 - 1.02)	0.04	166	0.98 (0.95 - 1.01)	0.2
History of diabetes	No	1323	1.00	-	165	1.00	-
	Yes	80	1.43 (0.89 - 2.3)	0.14	1	0 (0 - 0)	0.99

Table 8 **Cox regression model for risk of graft failure or death within 3 years, 1 April 2010 – 31 March 2015**

		Whole and split liver transplants			Split liver transplants		
Factor	**Level**	N	Hazard ratio (95% CI)	p-value	N	Hazard ratio (95% CI)	p-value
Transplant							
Liver split	Whole	1845	1.00	-	-	-	-
	Split	227	1.22 (0.79 - 1.91)	0.37	-		
Unit surgeon	Paediatric	-	-	-	205	1.00	-
	Adult	-	-	-	22	0.93 (0.2 - 4.32)	0.93
Location	Retained	-	-	-	155	1.00	-
	Imported	-	-	-	72	1.57 (0.69 - 3.56)	0.28
Recipient							
Age at transplant		2072	1.01 (0.99 - 1.02)	0.4	227	1.01 (0.98 - 1.04)	0.47
HCV indicator	No	1633	1.00	-	181	1.00	-
	Yes	439	1.26 (0.94 - 1.68)	0.12	46	2.04 (0.86 - 4.86)	0.11
Ln(creatinine)		2072	1.32 (0.93 - 1.88)	0.12	227	0.4 (0.13 - 1.22)	0.11
Ln(INR)		2072	0.82 (0.5 - 1.33)	0.42	227	1.7 (0.49 - 5.85)	0.4
Albumin		2072	0.99 (0.98 - 1.01)	0.49	227	1.01 (0.96 - 1.06)	0.86
Renal replacement therapy	No	1957	1.00	-	217	1.00	-
	Yes	115	1.06 (0.62 - 1.8)	0.84	10	1.07 (0.23 - 4.91)	0.93
Patient location	Outpatient	1742	1.00	-	198	1.00	-
	Inpatient	330	1.39 (1 - 1.94)	0.05	29	2.87 (1.1 - 7.49)	0.03
Donor							
Donor age		2072	1.01 (1 - 1.02)	0.24	227	1 (0.97 - 1.04)	0.83
History of diabetes	No	1924	1.00	-	221	1.00	-
	Yes	148	1.51 (1 - 2.28)	0.05	6	1.67 (0.22 - 12.62)	0.62

27 Data on 41 NHS group 1 first super urgent split liver only transplants in the UK using livers from DBD donors between 1 April 2006 and 31 March 2015 were also analysed. Auxiliary and intestinal transplants were excluded from this cohort as were regrafts. Follow-up data were as recorded on the UKTR on 9 October 2015. Of these there were 9 (27%) deaths or failed grafts in the 33 paediatric recipients, and 2 (25%) deaths or failed grafts in the 8 adult recipients. Due to these small numbers no survival analysis could be performed.

SUMMARY

ACTIVITY

28 There were 57 livers donated between 1 April 2015 and 30 September 2015 from donors who met the criteria for liver splitting (21% fewer than previous six months). Of these, 39 (68%) were available for splitting for elective recipients, having not been used in super-urgent, hepatoblastoma, intestinal or multi-organ recipients. Of these, 19 (49%) were offered for splitting and 10 (53% of the 19) were actually split (43% more than previous six months). In over a quarter of the 20 cases where the liver was available for splitting but was not offered for splitting, abnormal or raised liver function tests were cited as the reason for not considering splitting. Nine livers were offered for splitting but instead used whole or reduced. Common reasons for not splitting these livers were the fattiness of the organ or a lack of suitable paediatric patients for the left lateral segment.

29 The percentage of livers split of those available for splitting increased by about 10% from 22-23% in 2006/2007 to 32-33% in 2012/13. In 2012/13, 27 livers were split. Since then there has been a fall to only 16 livers split in 2014/15 - approx 15% of those available for splitting.

TRANSPLANT OUTCOMES

30 Unadjusted analysis of transplant outcomes, April 2006 – March 2015, showed:

- No significant difference in 5 year transplant survival when comparing:
  - retained and imported split livers in paediatric recipients (p=0.7)
  - retained and imported split livers in adult recipients (p=0.08).
  - livers split by an adult or paediatric unit surgeon (p>0.8)

- Some evidence that whole liver transplant outcomes were better than split liver transplant outcomes for April 2006-March 2010 (p=0.09)

- No significant difference between whole and split liver transplant survival at 3 years for recent transplants (April 2010-March 2015), p=0.9.

- Three year split liver transplant survival has significantly improved over the two time periods (p=0.04).

31 Risk adjusted analysis of transplant outcomes, April 2010-March 2015, showed:

- Comparable outcomes for whole and split liver recipients, p=0.4 (HR for split=1.2, 95% CI 0.8-1.9)

- Comparable outcomes for livers split by adult (N=22) and paediatric (N=205) unit surgeons, p=0.9 (HR for adult unit=0.9, 95%CI 0.2-4.3)

- No significant difference in outcome between retained (N=155) and imported (N=72) split livers, p=0.3 (HR for imported=1.6, 95% CI 0.7-3.6).

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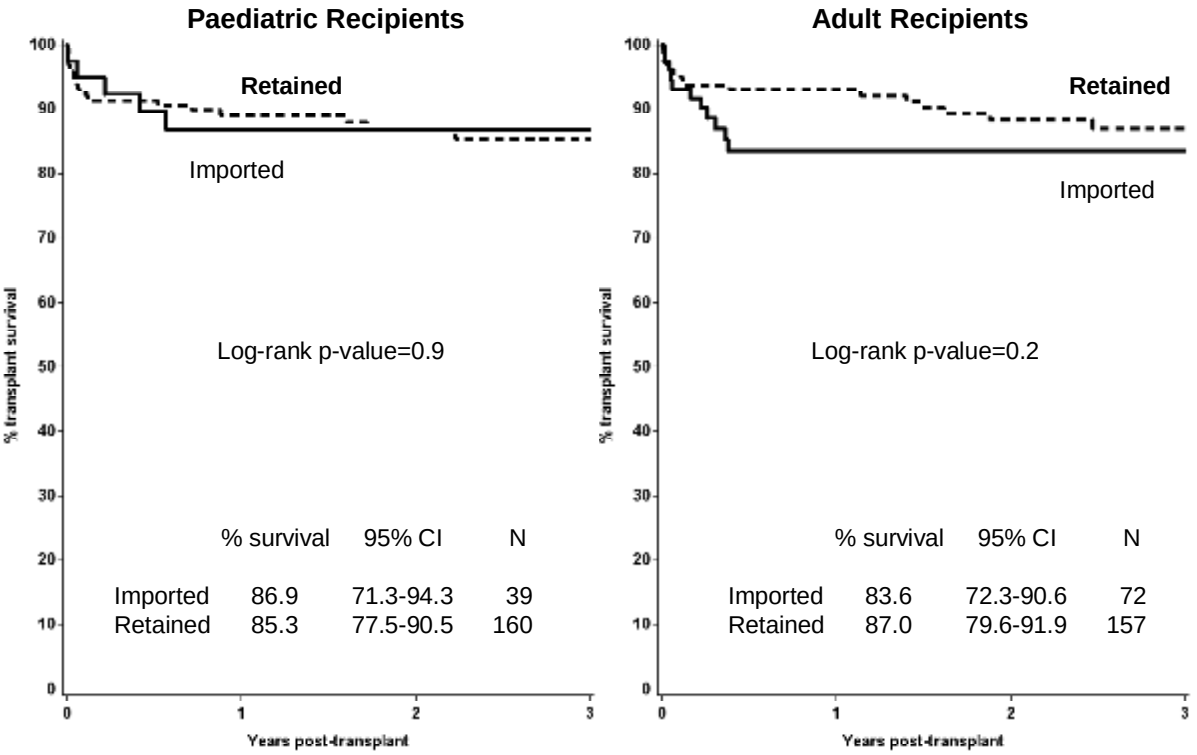
Statistics and Clinical Studies **October 2015**

Appendix I Causes of graft failure or patient death for NHS group 1 elective split liver only transplant recipients in the UK between 1 April 2006 and 31 March 2015 who died or whose graft failed within five years following transplant, by age group, whether the split liver was retained/ imported and whether the liver was split by an adult/ paediatric unit surgeon

Causes of graft failure or patient death	Retained split liver	Imported split liver	Liver split by paediatric unit surgeon	Liver split by adult unit surgeon	Total
	N	N	N	N	N
PAEDIATRIC PATIENTS					
Cause of graft failure - patient did not die					
Hepatic artery thrombosis	12	3	13	2	15
Primary non-function	3	2	3	2	5
Chronic rejection	1	1	2	0	2
Other	4	0	4	0	4
Not reported	1	0	1	0	1
Total	**21**	**6**	**23**	**4**	**27**
Cause of death					
Multi-system failure	5	2	7	0	7
Haemorrhage	1	2	2	1	3
Primary non-function -> multi-system failure	3	0	3	0	3
Septicaemia	1	0	1	0	1
Recurrent disease	1	0	1	0	1
Other	6	0	6	0	6
Not reported	0	1	0	1	1
Total	**17**	**5**	**20**	**2**	**22**
TOTAL	**38**	**11**	**43**	**6**	**49**
ADULT PATIENTS					
Cause of graft failure - patient did not die					
Hepatic artery thrombosis	12	5	14	3	17
Other	5	3	7	1	8
Total	**17**	**8**	**21**	**4**	**25**
Cause of death					
Multi-organ failure	5	5	9	1	10
Hepatic artery thrombosis -> multi-system failure/myocardial infarction/pulmonary infection	4	4	7	1	8
Non-lymphoid malignant disease	5	1	6	0	6
Non-thrombotic infarction -> multi-system failure/septicaemia	4	0	4	0	4
Recurrent disease	2	0	2	0	2
Cerebro-vascular accident	2	0	2	0	2
Renal failure	2	0	2	0	2
Vascular occlusion -> multi-system failure	2	0	2	0	2
Rejection/primary non-function	1	1	1	1	2
Other	5	3	7	1	8
Not reported	2	1	3	0	3
Total	**34**	**15**	**45**	**4**	**49**
TOTAL	**51**	**23**	**66**	**8**	**74**

Appendix II

Comparison of three year transplant survival of split livers transplanted in NHS group 1 elective patients in the UK between 1 April 2010 and 31 March 2015 – Retained vs Imported



Comparison of three year transplant survival of split livers split transplanted in NHS group 1 elective patients in the UK between 1 April 2010 and 31 March 2015 – Adult vs Paediatric unit surgeons