

NHS BLOOD AND TRANSPLANT
LIVER ADVISORY GROUP
LIVER SPLITTING ACTIVITY REPORT

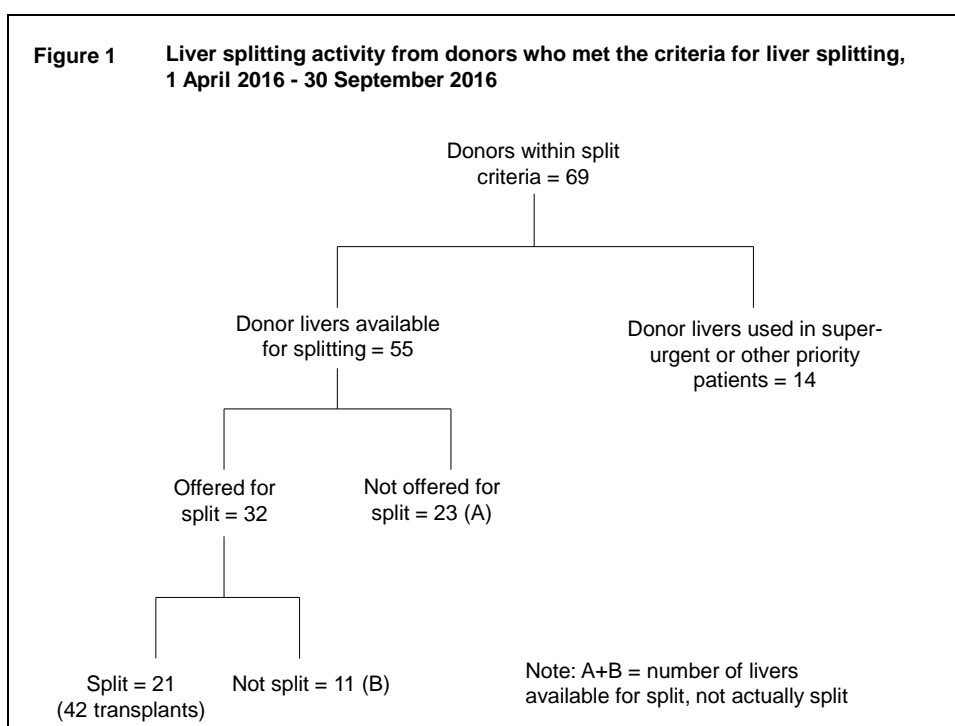
SUMMARY

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 over the last ten years.

ACTIVITY

- 2 **Figure 1** shows a summary of the liver splitting activity in the 6-month period 1 April 2016 to 30 September 2016.



- 3 The percentage of livers split of those available for splitting increased by about 10% from 23% in 2006/07 to 33% in 2012/13. In 2012/13, 27 livers were split. Since then there has been a fall to only 16 (16%) livers split in 2014/15, and only 18 (20%) in 2015/16. There were 21 (38%) livers split in the first half of 2016/17.
- 4 There was one additional donor outside of the donor splitting criteria that led to 2 split liver transplants between 1 April 2016 and 30 September 2016.

- 5 In the last ten years CIT was on average 2.7 hours longer for imported liver lobes compared with retained liver lobes for both adult and paediatric recipients.

TRANSPLANT OUTCOMES

- 6 Risk adjusted analysis of transplant outcomes, 1 April 2011- 31 March 2016, showed:
- No significant difference in outcomes for split liver recipients compared to whole, $p=0.07$ (HR for split=1.5, 95% CI 1.0-2.2)
 - No significant difference in outcomes for livers split by adult (N=28) and paediatric (N=356) unit surgeons, $p=0.9$ (HR for adult unit=0.9, 95%CI 0.3-3.1)
 - No significant difference in outcomes of retained (N=280) and imported (N=104) split livers, $p=0.1$ (HR for imported=1.6, 95% CI 0.9-3.0).

ACTION

- 7 In 2014/15 and 2015/16, only 16% and 20% of available livers were split, respectively, representing the lowest rates over the last 10 years. In the first half of 2016/17, this rate increased to 38%.
- 8 Members are asked to consider the information presented in this report and consider what action should be taken to continue optimising the use of split liver transplantation.

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October 2016

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 2016 and 30 September 2016 and who met the criteria for liver splitting. The paper also reports briefly on activity over the last 10 years.
- 2 Liver transplant survival outcomes are analysed for patients who received a DBD donor split liver transplant between 1 April 2006 and 31 March 2016. 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 versus 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 the start of ventilation and the time of the second test for brainstem death.
- 4 Data were obtained from the UK Transplant Registry (UKTR) on the 69 UK DBD donors whose liver was donated in the 6 months between 1 April 2016 and 30 September 2016 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 77 UK DBD liver donors in the previous 6 months (1 October 2015 - 31 March 2016), 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 3** for 1 April 2016 to 30 September 2016, with 1 October 2015 to 31 March 2016 figures for comparison. For the latest 6 months, 55 (80%) of the 69 DBD donors meeting the splitting criteria were available for splitting. Of these 55 livers, 32 (58%) were offered for splitting. Of the 32 livers offered for splitting, 21 (66%) were actually split. This activity is summarised in **Figure 1**.
- 9 These 69 livers resulted in 96 transplants, of which 32 (33%) 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 10 financial years. This shows a slight rise in the percentage split, followed by a fall in 2014/15. The percentage split is slightly higher in the most recent full financial year, but this is based on small numbers. The percentage of livers split of those available for splitting is given in **Table 1**, by donor allocation zone. The number of livers split that were outside splitting criteria is also provided.

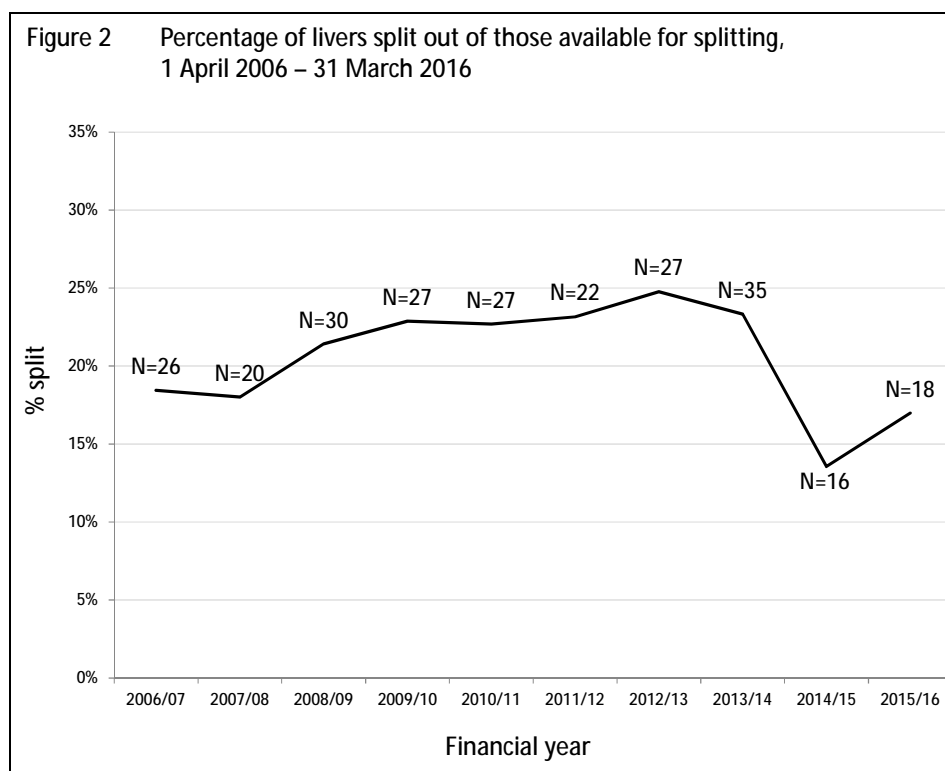


Table 1 Percentage of livers split within criteria and number outside criteria, 1 April 2012 to 30 September 2016

Allocation zone	Available for split within criteria	Split within criteria		Split outside criteria
	N	N	%	N
Birmingham	91	23	25	17
Cambridge	42	8	19	3
Edinburgh	68	16	24	4
King's College	95	35	37	18
Leeds	73	19	26	10
Newcastle	31	8	26	3
Royal Free	46	9	20	3
TOTAL	446	118	26	58

- 11 A comparison of the number of split liver and living donor liver transplants over the last decade is shown in **Figure 3**. This shows fewer split liver transplants in the last two full financial years and an increase in living donor transplants in the last decade. The number of split liver transplants includes those from donors in **Table 3** and also those where the donor did not meet splitting criteria whose livers were split for transplant. So far in 2016/17 (1 April 2016 - 30 September 2016) there was only one donor outside of the donor splitting criteria. This donor is only included in **Figure 3** in the report, and summarised in **Table 2**.

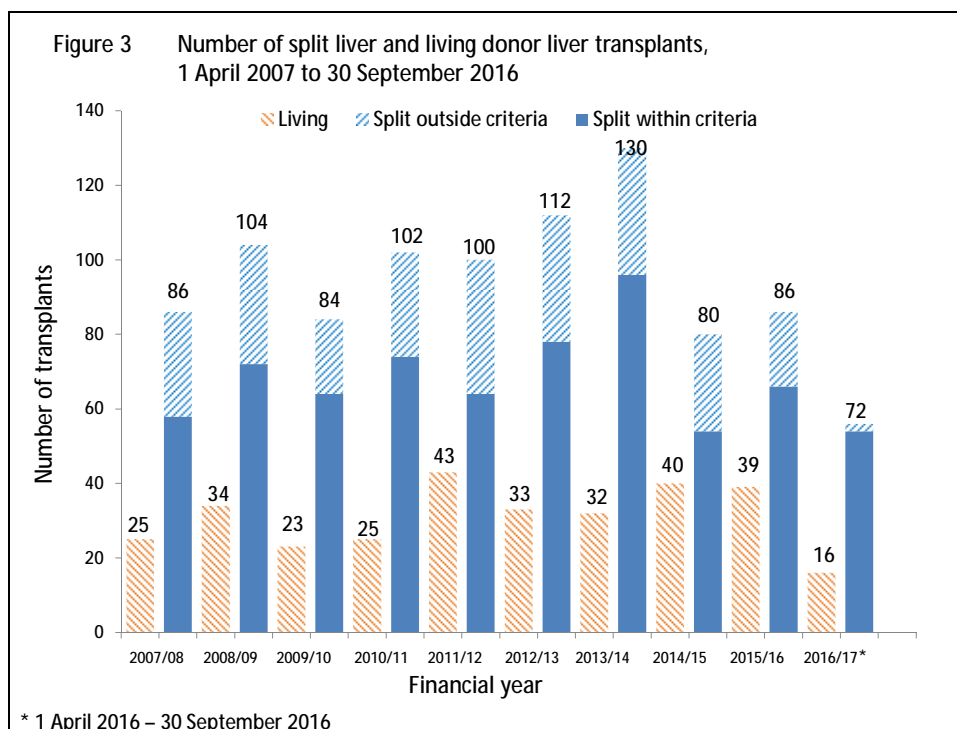


Table 2 Characteristics of liver donors who were outside of splitting criteria but whose livers went on to be split, 1 April 2007 to 30 September 2016

Year	Aged 40 or more		Weighing 50kg or less		Spent 5 days or more in ICU		Total
	N	%	N	%	N	%	
2007/08	11	79	1	7	2	14	14
2008/09	7	44	7	44	3 ²	19	16
2009/10	7	70	0	0	3 ¹	30	10
2010/11	9	64	2	14	4 ¹	29	14
2011/12	10	56	5	28	5	28	18
2012/13	12	71	4	24	2	12	17
2013/14	11	65	5	29	3	18	17
2014/15	6	46	4	31	3	23	13
2015/16	8	80	2	20	1	10	10
2016/17 ³	0	0	1	100	0	0	1

Note: Numbers and % may not add up to total in each row as some donors are outside of more than one criteria

¹ includes one donor with unknown ICU length of stay

² includes two donors with unknown ICU length of stay

³ 1 April 2016 – 30 September 2016

Table 3 Donors meeting criteria for liver splitting, by donor allocation zone, 1 April 2016 to 30 September 2016 (1 October 2015 to 31 March 2016)

Donor allocation zone	Total meeting liver splitting criteria and transplanted		Super-urgent liver or intestinal/hepatoblastoma recipients		Elective intestinal/multi-organ recipients		Available for splitting		Offered for splitting				Split		Whole		Reduced			
	N		N _{P1}		N _{P2}		N _A		N _O		% of available		N _S		% of offered		N _W		N _R	
Birmingham	18	(15)	5	(6)	1	(3)	12	(6)	7	(2)	58	(33)	3	(2)	43	(100)	2	(0)	2	(0)
Cambridge	4	(9)	1	(2)	0	(2)	3	(5)	2	(3)	67	(60)	2	(2)	100	(67)	0	(1)	0	(0)
Edinburgh	12	(9)	0	(3)	1	(0)	11	(6)	6	(3)	55	(50)	3	(1)	50	(33)	3	(2)	0	(0)
King's College	16	(17)	4	(3)	0	(1)	12	(13)	7	(3)	58	(23)	7	(2)	100	(67)	0	(1)	0	(0)
Leeds	8	(14)	0	(6)	0	(1)	8	(7)	5	(2)	63	(29)	3	(0)	60	(0)	2	(2)	0	(0)
Newcastle	3	(5)	0	(1)	0	(0)	3	(4)	2	(0)	67	(0)	1	(0)	50	-	1	(0)	0	(0)
Royal Free	8	(8)	2	(0)	0	(0)	6	(8)	3	(4)	50	(50)	2	(1)	67	(25)	1	(3)	0	(0)
TOTAL	69	(77)	12¹	(21²)	2	(7³)	55	(49)	32	(17)	58	(35)	21	(8)	66	(47)	9	(9)	2	(0)

¹ Six of these livers were split and used to transplant one super-urgent/ hepatoblastoma recipient and one elective liver only recipient

² Four of these livers were split and used to transplant one super-urgent/ hepatoblastoma recipient and one elective liver only recipient

³ Three 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

12 **Table 4** details the reasons given by the transplanting centre or noted by the ODT Duty Office for 23 livers not being offered for splitting (68% of the 34 livers available for splitting that were not split). In seven 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 is not well reported.

Table 4 Reasons given for why 23 livers from donors meeting the liver splitting criteria, between 1 April 2016 and 30 September 2016, 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 medical history and abnormal liver function tests	63
2	Birmingham	Birmingham	Long downtime and abnormal liver function tests	618
3	Birmingham	Birmingham	Large and moderately fatty liver	
4	Birmingham	Birmingham	Donor medical history	
5	Cambridge	Cambridge	Very unstable donor. All organs were offered to a local centre, and not via normal offering sequences	
6	Edinburgh	Birmingham	Function (Liver function tests)	
7	King's College	Cambridge	Donor medical history and logistics	47
8	King's College	King's College	Donor medical history and underlying hematology problems	1004
9	King's College	King's College	Donor BMI	
10	Leeds	Leeds	Abnormal liver function tests (ALT 300)	
11	Leeds	Leeds	Abnormal liver function tests	172
12	Royal Free	Royal Free	Abnormal liver function tests	
13	Royal Free	Royal Free	Donor cardiac arrest	113
14	Edinburgh	Royal Free	Downtime and abnormal liver function tests	75
Recipient reasons				
15	Edinburgh	Edinburgh	Top band recipient who had a previous transplant so whole liver was required	30
16	Edinburgh	Edinburgh	Recipient had two previous transplants so whole liver was required	206
17	Edinburgh	Edinburgh	Top band recipient who had two previous transplants so whole liver was required	206
18	King's College	King's College	Recipient had a previous transplant so whole liver was required	
19	Newcastle	Royal Free	Recipient required whole liver due to size	
20	Royal Free	Royal Free	Recipient had a previous transplant so whole liver was required	24
Other reasons				
21	Birmingham	Cambridge	The ODT Duty Office has discussed this case with liver team in Cambridge, who was unable to give a reason why liver was not split. Birmingham declined liver on logistics and Newcastle declined liver due to no suitable recipients.	
22	King's College	Leeds	Declined by all other centres due to no suitable recipients	50
23	Leeds	Birmingham	Declined by all other centres due to no suitable recipients	

Reasons why livers offered for split transplant were not split

13 Eleven livers were offered for splitting but were not split. The reasons given for not splitting are detailed in **Table 5**.

Table 5 Reasons given for why 11 livers from donors meeting the split liver criteria, between 1 April 2016 and 30 September 2016, 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	Birmingham	Royal Free	Left lateral segment declined by all paediatric centres due to virology	
2	Edinburgh	Edinburgh	Left lateral segment declined by all paediatric centres due to donor medical history	71
3	Edinburgh	Edinburgh	Left lateral segment declined by all paediatric centres due to function and donor medical history	192
4	Newcastle	Royal Free	Left lateral segment declined by all paediatric centres due to virology	
5	Royal Free	Royal Free	Left lateral segment declined by all paediatric centres due to donor medical history	
6	Birmingham	Birmingham	Left lobe was too big for paediatric recipients	74
7	Leeds	Leeds	Liver was sent to Birmingham for splitting. However, the surgeon deemed it was unsuitable to split due to anatomy	
8	Leeds	Leeds	Liver was not split due to anatomy	100
Other reasons				
9	Birmingham	Birmingham	Liver was reduced and not split. Liver was not split due to organ damage	394
10	Birmingham	King's College	All other centres had declined liver due to no suitable recipients	56
11	Edinburgh	Edinburgh	Left lobe declined by other centres due to size, no suitable recipients and donor medical history	102

- 14 There were three liver transplant recipients with Hepatoblastoma transplanted from a DBD donor between 1 April 2016 and 30 September 2016. Details of these transplants are in **Table 6**.

Donor	Transplanting centre	Transplant type	Donor age (years)	Recipient age (years)	Reason for not splitting
1	King's College	Split	27	3	
2	Birmingham	Split	28	3	
3	Leeds	Split	17	1	

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

TRANSPLANT SURVIVAL

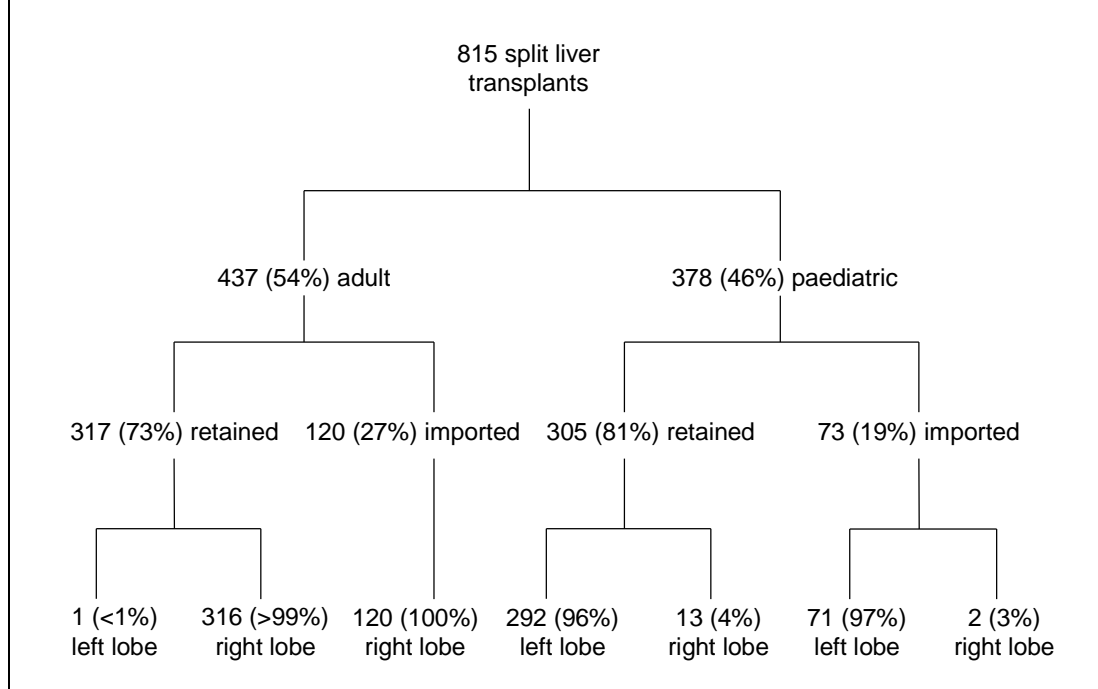
Data and methods

- 15 Data on 815 NHS group 1 first elective split liver only transplants in the UK using livers from DBD donors between 1 April 2006 and 31 March 2016 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 2016.
- 16 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 61% 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 62% 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, <1% of cases).
- 17 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 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 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.
- 18 A comparison of the survival of whole and split liver transplants up to three years was also made, for adult recipients only. This analysis included 4,071 NHS group 1 first adult elective patients transplanted in the UK between 1 April 2006 and 31 March 2016. A sub-group analysis was performed on just those transplants performed between 1 April 2011 and 31 March 2016 (N=2,212). Again, auxiliary and multi-organ transplants and regrafts were excluded and follow-up data were as recorded on the UKTR on 9 October 2016.

Results

- 19 **Figure 4** shows a breakdown of the 815 split liver transplants by recipient age group (adult (≥ 17 years), paediatric (< 17 years)) and whether the liver was retained or imported.

Figure 4 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 2016



20 **Table 7** shows a breakdown of the 815 split liver transplants by recipient age group, transplant centres and whether the liver was retained or imported.

Table 7 NHS group 1 first elective split liver only transplants in the UK using livers from donors after brain death, 1 April 2006 – 31 March 2016

Transplant centre	Retained N (%)	Imported N (%)	Total
Paediatric recipients			
Birmingham	122 (87)	19 (13)	141
King's College	133 (76)	41 (24)	174
Leeds	50 (79)	13 (21)	63
Total	305 (81)	73 (19)	378
Adult recipients			
Birmingham	130 (95)	7 (5)	137
Cambridge	13 (39)	20 (61)	33
Edinburgh	22 (34)	43 (66)	65
King's College	98 (92)	9 (8)	107
Leeds	39 (80)	10 (20)	49
Newcastle	4 (27)	11 (73)	15
Royal Free	11 (35)	20 (65)	31
Total	317 (73)	120 (27)	437
TOTAL	622 (76)	193 (24)	815

- 21 **Table 8** shows the median and range of CIT (min - max), 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=16)). 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 2006-2011 and 2011-2016 and the more recent cohort shows a CIT that is 1.7 hours longer for imported rather than retained left lobes for paediatric patients, and 3.0 hours longer for imported right lobes for adult patients. In adult recipient transplants CIT are longer in the most recent time period.

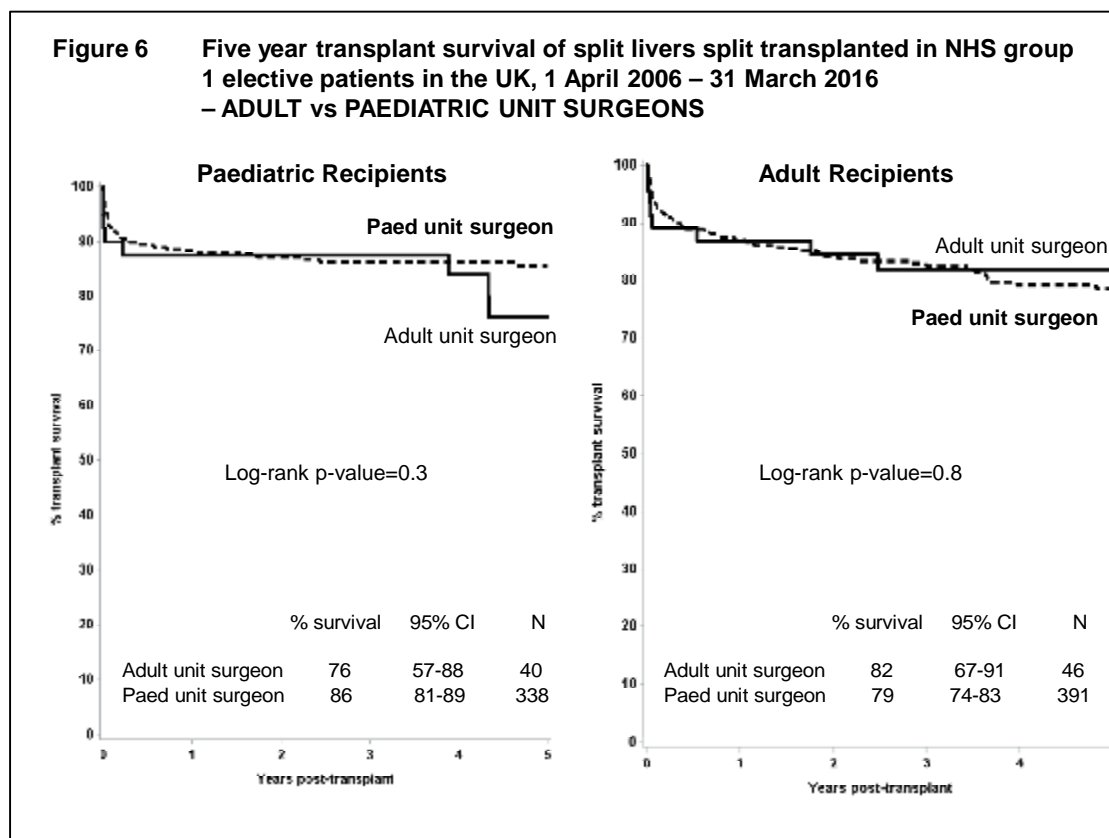
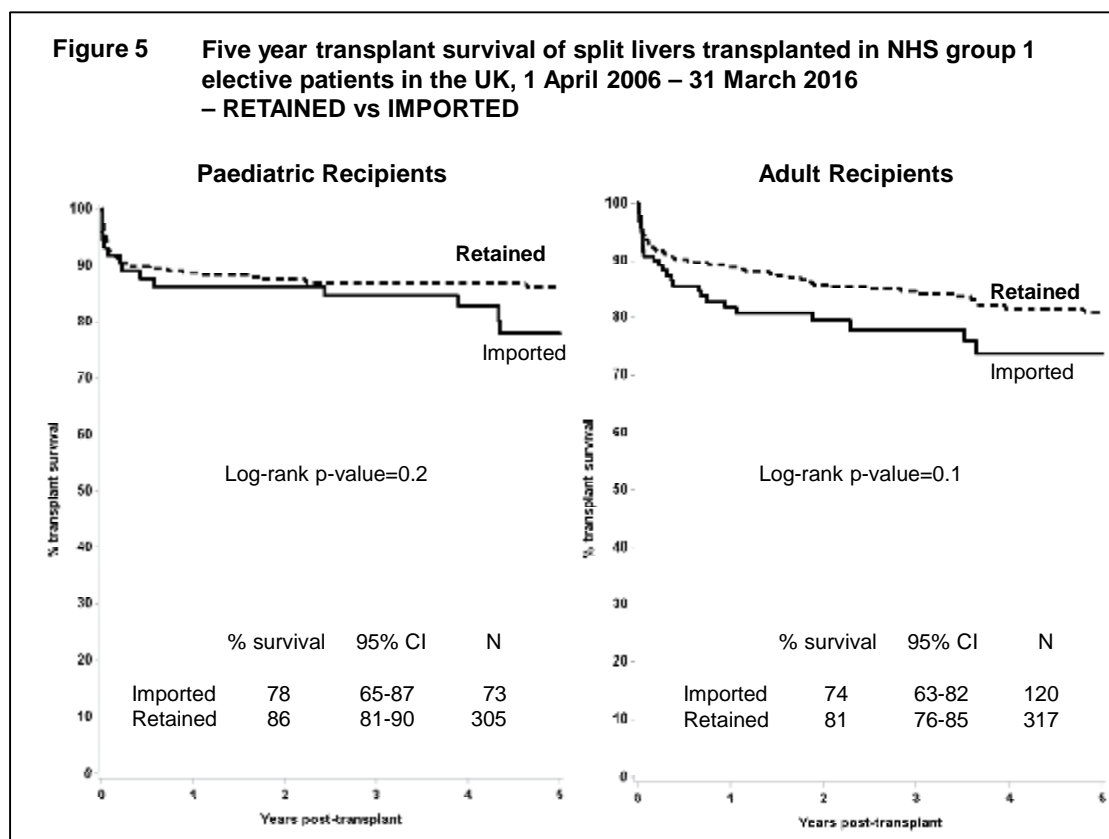
		N ¹	CIT (hours)	
			Median	Range
Left lobes transplanted in paediatric patients				
1 April 2006 – 31 March 2011	Retained	130	9.0	3.6 – 13.9
	Imported	39	11.7	2.9 – 16.5
1 April 2011 – 31 March 2016	Retained	95	9.0	3.8– 16.2
	Imported	18	10.7	7.0 – 16.0
Overall	Retained	225	9.0	3.6 – 16.2
	Imported	57	11.7	2.9 – 16.5
Right lobes transplanted in adult patients				
1 April 2006 – 31 March 2011	Retained	164	9.8	4.8 – 17.6
	Imported	42	12.5	6.6 – 16.3
1 April 2011 – 31 March 2016	Retained	129	9.4	2.6 – 18.1
	Imported	70	12.4	6.6 – 15.6
Overall	Retained	293	9.7	2.6 – 18.1
	Imported	112	12.4	6.6 – 16.3

¹ CIT was not reported for a total of 112 split livers

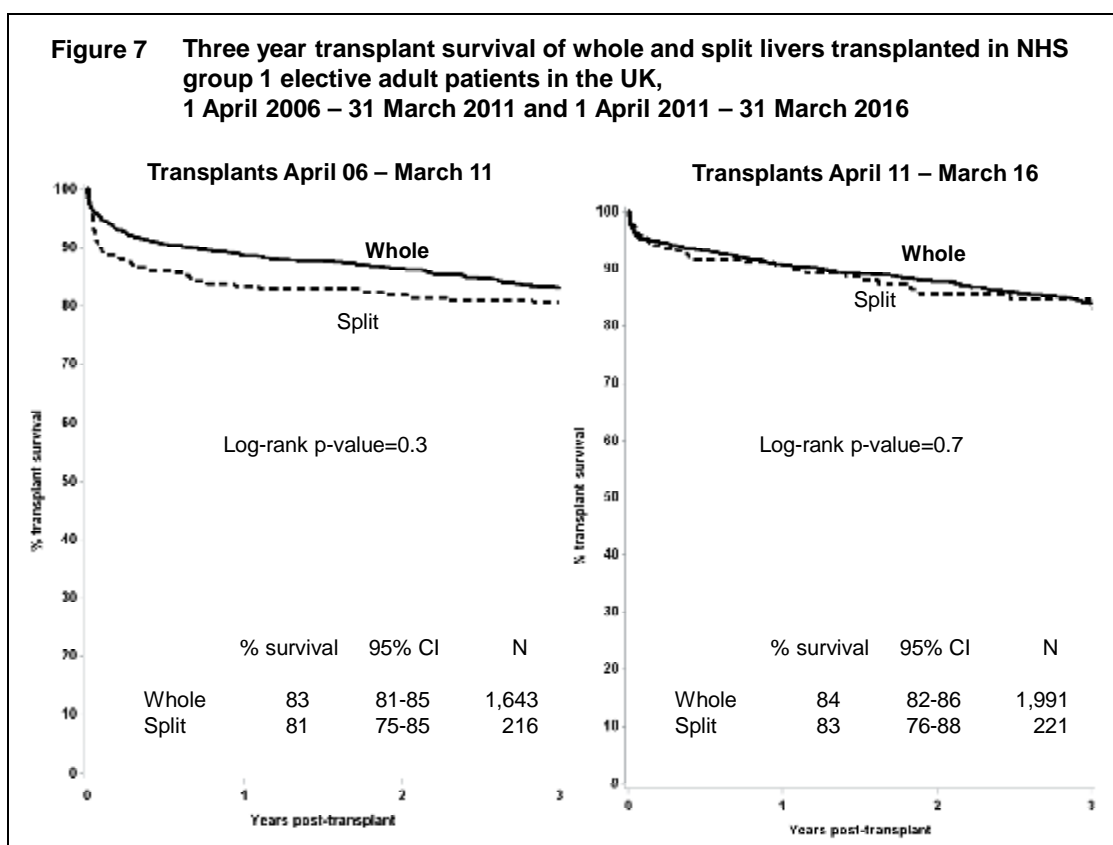
Unadjusted survival analysis

- 22 **Figure 5** 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 ($p=0.2$) or the adult analysis ($p=0.1$), although retained livers appear to do better in the adult patients with a 7% survival benefit at 5 years.
- 23 **Figure 6** 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 eight events in the “split by adult unit surgeon” group in the paediatric analysis and also 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.



- 24 Causes of graft failure or patient death that were reported to the UKTR for the 132 out of 815 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.
- 25 Unadjusted survival analysis at three years post-transplant for more recent transplants (1 April 2011 - 31 March 2016) can be seen in **Appendix II**. Results support the lack of a significant difference in all comparisons.
- 26 **Figure 7** 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 2011 and between 1 April 2011 and 31 March 2016. There is no significant difference between whole and split liver transplants although there is a suggestion that split liver outcomes are improved in the short-term in the later period. There is no significant change in split liver outcomes ($p=0.2$) or whole liver outcomes ($p=0.2$) over this time period.



Risk-adjusted survival analysis

27 Risk-adjusted analyses were carried out using Cox Proportional Hazards regression modelling for three year transplant survival. The results are shown in **Table 9** for transplants 1 April 2006 – 31 March 2011 and in **Table 10** for 1 April 2011 – 31 March 2016. After risk adjustment there is some indication, albeit not statistically significant, that split liver transplants have a higher hazard of patient death or graft failure for the most recent time period ($p=0.07$), not seen in the unadjusted results. Note that the median (IQR) donor age for split liver transplants was 29 (21-37), compared to whole liver transplants 54 (43-64) in the recent period. The results showed no difference between retained and imported livers or between paediatric and adult unit surgeons in either time period.

Table 9		Cox regression model for risk of graft failure or patient death within 3 years, 1 April 2006 – 31 March 2011						
Factor	Level	Whole and split liver transplants			Split liver transplants			
		N	Hazard ratio (95% CI)	p-value	N	Hazard ratio (95% CI)	p-value	
Transplant								
Liver split	Whole	1581	1.00	-	-	-	-	
	Split	382	1.35 (0.94 - 1.92)	0.1	-	-	-	
Unit surgeon	Paediatric	-	-	-	331	1.00	-	
	Adult	-	-	-	51	0.77 (0.34 - 1.72)	0.5	
Location	Retained	-	-	-	301	1.00	-	
	Imported	-	-	-	81	1.13 (0.62 - 2.05)	0.7	
Recipient								
Age at transplant	Adult	1769	1.00	-	211	1.00	-	
	Paediatric	194	1.32 (0.8 - 2.17)	0.3	171	1.10 (0.57 - 2.11)	0.8	
HCV indicator	No	1575	1.00	-	341	1.00	-	
	Yes	388	1.21 (0.93 - 1.57)	0.1	41	0.95 (0.41 - 2.18)	0.9	
Ln(creatinine)		1963	1.58 (1.18 - 2.13)	0.002	382	1.40 (0.82 - 2.40)	0.2	
Ln(INR)		1963	0.53 (0.34 - 0.82)	0.005	382	0.56 (0.22 - 1.41)	0.2	
Albumin		1963	0.99 (0.97 - 1.00)	0.1	382	1.01 (0.97 - 1.05)	0.6	
Renal replacement therapy	No	1881	1.00	-	367	1.00	-	
	Yes	82	1.53 (0.98 - 2.37)	0.06	15	2.16 (0.85 - 5.45)	0.1	
Patient location	Outpatient	1645	1.00	-	324	1.00	-	
	Inpatient	318	1.34 (1.00 - 1.80)	0.05	58	1.18 (0.59 - 2.37)	0.6	
Donor								
Donor age		1963	1.01 (1.00 - 1.02)	0.03	382	1.01 (0.98 - 1.03)	0.7	
History of diabetes	No	1860	1.00	-	378	1.00	-	
	Yes	103	1.36 (0.89 - 2.07)	0.2	4	0 (0 - 0)	>0.9	

Table 10		Cox regression model for risk of graft failure or death within 3 years, 1 April 2011 – 31 March 2016					
Factor	Level	Whole and split liver transplants			Split liver transplants		
		N	Hazard ratio (95% CI)	p-value	N	Hazard ratio (95% CI)	p-value
Transplant							
Liver split	Whole	1939	1.00	-	-	-	-
	Split	384	1.47 (0.97 - 2.22)	0.07	-	-	-
Unit surgeon	Paediatric	-	-	-	356	1.00	
	Adult	-	-	-	28	0.93 (0.28 - 3.09)	0.9
Location	Retained	-	-	-	280	1.00	
	Imported	-	-	-	104	1.63 (0.88 - 3.04)	0.1
Recipient							
Age at transplant	Adult	2127	1.00	-	218	1.00	
	Paediatric	196	0.91 (0.48 - 1.76)	0.8	166	0.64 (0.24 - 1.76)	0.4
HCV indicator	No	1915	1.00	-	348	1.00	
	Yes	408	1.21 (0.89 - 1.64)	0.2	36	2.28 (1.01 - 5.16)	0.05
Ln(creatinine)		2323	1.25 (0.92 - 1.70)	0.1	384	0.70 (0.39 - 1.25)	0.2
Ln(INR)		2323	0.90 (0.57 - 1.43)	0.7	384	1.76 (0.69 - 4.45)	0.2
Albumin		2323	1.00 (0.98 - 1.02)	0.9	384	1.02 (0.98 - 1.06)	0.5
Renal replacement therapy	No	2186	1.00	-	363	1.00	
	Yes	137	0.93 (0.54 - 1.58)	0.8	21	0.83 (0.20 - 3.53)	0.8
Patient location	Outpatient	1960	1.00	-	319	1.00	
	Inpatient	363	1.21 (0.86 - 1.69)	0.3	65	1.40 (0.65 - 3.04)	0.4
Donor							
Donor age		2323	1.01 (1.00 - 1.02)	0.09	384	1.00 (0.97 - 1.04)	0.8
History of diabetes	No	2155	1.00	-	375	1.00	
	Yes	168	1.31 (0.87 - 2.00)	0.2	9	1.68 (0.40 - 7.09)	0.5

28 Data on 47 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 2016 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 2016. Of these there were 10 (26%) deaths or failed grafts in the 38 paediatric recipients, and 3 (33%) deaths or failed grafts in the 9 adult recipients. Due to these small numbers no survival analysis could be performed.

SUMMARY**ACTIVITY**

- 29 There were 69 livers donated between 1 April 2016 and 30 September 2016 from donors who met the criteria for liver splitting (10% less than previous six months). Of these, 55 (80%) were available for splitting for elective recipients, having not been used in super-urgent, hepatoblastoma, intestinal or multi-organ recipients. Of these, 32 (58%) were offered for splitting and 21 (66% of the 32) were actually split (63% more than previous six months). In almost a third of the 23 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. Eleven livers were offered for splitting but instead used whole or reduced. Common reasons for not splitting these livers were donor medical history or a lack of suitable paediatric patients for the left lateral segment.
- 20 The percentage of livers split of those available for splitting increased by about 10% from 23% in 2006/2007 to 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, and only 18 in 2015/16. So far in 2016/17 (1 April 2016 - 30 September 2016) 21 livers were split.

TRANSPLANT OUTCOMES

- 31 Unadjusted analysis of transplant outcomes, 1 April 2006 – 31 March 2016, showed:
- No significant difference in 5 year transplant survival when comparing:
 - retained and imported split livers in paediatric recipients ($p=0.2$)
 - retained and imported split livers in adult recipients ($p=0.1$).
 - livers split by an adult or paediatric unit surgeon ($p>0.3$)
 - No significant difference between whole and split liver transplant survival at 3 years for earlier transplants (1 April 2006 - 31 March 2011), $p=0.3$, or more recent transplants (1 April 2011- 31 March 2016), $p=0.7$.
- 32 Risk adjusted analysis of transplant outcomes, 1 April 2011- 31 March 2016, showed:
- No significant difference in outcomes for split liver recipients compared to whole, $p=0.07$ (HR for split=1.5, 95% CI 1.0-2.2)
 - No significant difference in outcomes for livers split by adult (N=28) and paediatric (N=356) unit surgeons, $p=0.9$ (HR for adult unit=0.9, 95%CI 0.3-3.1)
 - No significant difference in outcomes of retained (N=280) and imported (N=104) split livers, $p=0.1$ (HR for imported=1.6, 95% CI 0.9-3.0).

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 2016 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					
<i>Cause of graft failure - patient did not die</i>					
Hepatic artery thrombosis	13	3	14	2	16
Primary non-function	3	2	3	2	5
Chronic rejection	1	1	2	0	2
Other	4	1	4	1	5
Not reported	1	0	1	0	1
Total	22	7	24	5	29
<i>Cause of death</i>					
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	3	1	2	3
Total	17	7	21	3	24
TOTAL	39	14	45	8	53
ADULT PATIENTS					
<i>Cause of graft failure - patient did not die</i>					
Hepatic artery thrombosis	12	5	14	3	17
Other	5	4	8	1	9
Total	17	9	22	4	26
<i>Cause of death</i>					
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	6	1	7	0	7
Non-thrombotic infarction -> multi-system failure/septicaemia	4	0	4	0	4
Recurrent disease	2	1	3	0	3
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	4	8	1	9
Not reported	3	1	4	0	4
Total	36	17	49	4	53
TOTAL	53	26	71	8	79

Appendix II

