

# Split Versus Whole Liver Transplantation

OPTN/UNOS Ethics Committee

*Prepared by: Lee Bolton  
UNOS Policy Department*

## Contents

Executive Summary	1
What problem will this resource solve?	1
Why should you support this resource?	1
How was this resource developed?	1
How well does this resource address the problem statement?	2
Was this resource changed in response to public comment?	2
Which populations are impacted by this resource?	3
How does this resource impact the OPTN Strategic Plan?	3
How will the OPTN implement this resource?	3
How will members implement this resource?	3
Will this resource require members to submit additional data?	3
How will members be evaluated for compliance with this resource?	4
White Paper	5

# Split Versus Whole Liver Transplantation

*Affected Policies:* N/A  
*Sponsoring Committee:* Ethics  
*Public Comment Period:* August 15, 2016 – October 15, 2016

## Executive Summary

Beginning in 1993, the Ethics Committee (the Committee) developed a series of white papers that are available through the OPTN website. In 2014, the Committee began a systematic review of these white papers to evaluate if each of the white papers were accurate and relevant, and therefore valuable resources for the transplant community. The Committee determined that the white paper addressing split versus whole liver transplantation, originally approved in 2004, required revision.

Over the past year, the Committee completed a substantive revision of the white paper addressing split liver allocation, which includes recommendations for changes to liver allocation policies, an extensive set of citations, new appendices, and new illustrations.

## What problem will this resource solve?

The resource could provide an ethical and logistical framework for future policy development

## Why should you support this resource?

The resource provides an ethical analysis and recommendations regarding split liver transplantation that should be beneficial to transplant hospitals or OPOs considering split liver transplantation. The resource could be helpful to transplant candidates who may be evaluating split liver transplantation versus whole liver transplantation.

The proposed revisions to this white paper demonstrate that the Committee continues to consider and provide guidance on important issues faced by the transplant community. This white paper will be a resource that members could consult if considering split liver allocation especially in light of the new strategic focus to increase the number of transplants. Additionally, the white paper could help guide the Liver & Intestinal Organ Transplantation Committee's decision-making if it ever pursues changes to split liver allocation policy.

## How was this resource developed?

Beginning in 1993, the Committee developed a series of white papers that are available through the OPTN website. In spring 2014, the Policy Oversight Committee and the Executive Committee approved a proposed project to review all existing white papers to determine the accuracy and relevancy of each resource. The Committee began a systematic review of all of the white papers to determine if the papers remained accurate and relevant. Some of the more recently developed white papers were accurate and relevant while the Committee determined that other papers needed minor revision or substantive revision. The Committee determined that the white paper addressing split versus whole liver transplantation required substantive revision.

Over the past year, Committee members performed a line by line review of the split liver white paper and determined that some of the language was outdated, did not reflect current practice, and none of the recommendations were supported by current literature.

Several drafts of this revised white paper were developed and provided to Committee members for review and feedback. Some members of the Liver and Pediatric Committees were asked to review this resource and to provide feedback prior to the start of the public comment period. The Committee considered all feedback before finalizing the white paper.

The original plan for this project was for the resource to be considered by the Board in June 2016. The Committee was aware that the Board would consider if all guidance documents should require public comment at this same meeting. The Committee elected to delay sending the white paper for Board consideration in June and to send the white paper for public comment.

This white paper was on the consent agenda for regional meetings and was approved in all regions. This white paper was presented during two national webinars during the public comment period. No comments were submitted regarding the white paper following either of the national webinars.

During the public comment period, the American Society of Transplantation (AST), the American Society of Transplant Surgeons, the North American Transplant Coordinators Organization (NATCO) and the Organization of Organ Procurement Organizations (AOPO) responded in support of the white paper. The OPTN/UNOS Pediatric Committee also responded in support of the proposal.

The Committee met on September 12 and October 20, 2016 to review the public comment responses (Exhibit A). Committee members considered and responded to questions or concerns, raised during public comment, and discussed whether to revise the white paper based on public comment. The white paper was not changed in response to public comment.

The Committee met on November 17, 2016 and voted in support of sending this white paper for Board consideration.

## **How well does this resource address the problem statement?**

This revised white paper addresses: Committee considered the following questions while revising the white paper:

- Most split liver transplants involving an adult and pediatric recipients have good outcomes.
- What is the increased risk in a split liver transplant involving two adult recipients?
- Are organs allocated to transplant candidates or to transplant hospitals?
- What precipitates a plan or decision for a split liver transplant?
- Who decides which livers are split?
- Who decides which segment of the liver goes to each candidate?
- What are the incentives and disincentives for splitting a liver? What are the financial implications?
- If a segment (of adult) liver is used for a child, what happens with the remaining organ segment?
- Do pediatric candidates get priority for liver transplants?
- Could an adult liver candidate need to decide between taking a segment of liver versus continuing to wait for a potential whole liver transplant?

## **Was this resource changed in response to public comment?**

No, the resource was not changed in response to public comment

## Which populations are impacted by this resource?

1. Of 113,394 deceased donor livers recovered and ultimately transplanted from 1/1/1995 - 12/31/2015, 1546 (1.36%) were recovered with the intention of being used in split liver transplants.
2. Of 1546 donor livers split from 1/1/1995 - 12/31/2015, 1439 (93%) provided a liver allograft to a pediatric recipient. 6.8% of whole liver transplants were done in pediatric recipients.
3. From 6/1/2001 - 12/31/2015, there were 151,250 adult registrations for liver transplantation; at listing, 129,276 (85%) noted a willingness to accept a split liver. In 2015, 10,100 (90%) of 11,256 registrants noted a willingness to accept a split liver.

The resource could be helpful to transplant candidates who may be evaluating split liver transplantation versus whole liver transplantation, and transplant physicians that may be evaluating whether to perform split liver transplants for their candidates.

## How does this resource impact the OPTN Strategic Plan?

1. Increase the number of transplants: The resource provides an ethical analysis and recommendations regarding split liver transplantation that should be beneficial to transplant hospitals or OPOs considering split liver transplantation.
2. Improve equity in access to transplants: Increased utilization of split liver transplantation would increase the number of organs available for transplant and improve access to transplants.
3. Improve waitlisted patient, living donor, and transplant recipient outcomes: There is no impact to this goal.
4. Promote living donor and transplant recipient safety: There is no impact to this goal.
5. Promote the efficient management of the OPTN: There is no impact to this goal.

## How will the OPTN implement this resource?

If this resource is approved by the OPTN/UNOS Board of Directors, it will be available through the OPTN website.

The resource will not require programming in UNet<sup>SM</sup>.

## How will members implement this resource?

Members are not required to take any action regarding this resource. This is a resource that members may consider on a voluntary basis. Members may access this resource through the OPTN website.

## Will this resource require members to submit additional data?

No, this resource does not require additional data collection.

## **How will members be evaluated for compliance with this resource?**

This resource does not affect member compliance. Members could consult this resource on a voluntary basis.

# White Paper

RESOLVED, that the white paper entitled *Split Versus Whole Liver Transplantation*, as set forth below, is hereby approved, effective December 6, 2016

FURTHER RESOLVED, that the previous version of this white paper also entitled *Split Versus Whole Liver Transplantation*, as shown in Exhibit B of this briefing paper, is hereby rescinded, effective December 6, 2016

## 1 SPLIT VERSUS WHOLE LIVER TRANSPLANTATION

2 *CAVEAT: The purpose of this White Paper is to outline potential ethical issues and other considerations*  
3 *relevant to split liver transplantation. The document should not be construed as a recommendation to*  
4 *require that all centers adopt split liver transplantation. Throughout this document, surrogate decision-*  
5 *makers can speak on behalf of patients when those patients lack decision-making capacity.*

6

7 A disparity exists between the number of donor livers available for transplant and the number of persons  
8 on the waiting list for a liver transplant. The practice of splitting deceased donor liver allografts to provide  
9 liver transplants for two recipients from one deceased donor could ease this disparity by increasing the  
10 number of organs available for transplant.

11 Since November 2007, an OPTN match run has identified a donor liver as one with the potential to be  
12 split if all these criteria are met:

- 13 1. Donor is less than 40 years old;
- 14 2. Donor is on a single vasopressor or less;
- 15 3. Donor transaminases are no greater than three times the normal level;
- 16 4. Donor body mass index (BMI) is 28 or less.

17 More than 10% of all deceased donors, and more than 20% of donors less than 35 years old, meet these  
18 criteria, yet only <1.5% of all donor livers have been split since criteria adoption (Appendix-1). The Ethics  
19 Committee (the Committee) supports efforts to increase liver allograft splitting when these (and other)  
20 criteria are met, including development of an allocation scheme to optimize use of these donor livers. As  
21 described below, the Committee acknowledges that substantial barriers must be overcome before the  
22 practice could become more common.

### 23 **The ethics of optimal allocation**

24 The Committee affirms that optimal allocation policies involving whole liver or split liver allografts should  
25 reflect a balance between the principles of equity and utility. Additionally, the Committee notes that the  
26 moral principle of respect for autonomy is generally important in organ allocation to the extent that a  
27 competent transplant candidate or surrogate retains the right to refuse an organ offer including a split liver  
28 organ. The autonomy of transplant candidates (or their surrogates) should not be compromised by  
29 situations in which they may feel coerced to make a decision about accepting a particular organ or  
30 allowing splitting of a liver to take place. The Committee also recognizes the value of transparency during  
31 the process of revising allocation policies so that stakeholders and the public may have adequate  
32 opportunity to respond to proposals.

### 33 **Current liver allocation of deceased donor liver allografts**

34 In current practice, liver allografts are allocated such that priority is generally given to candidates with the  
35 highest risk of death on the waiting list. This priority is predicted by the Model for End-stage Liver Disease  
36 (MELD), or Pediatric End-stage Liver Disease (PELD) score, and most patients are critically ill before  
37 receiving priority for a liver transplant. In addition, liver allocation often prioritizes patients with  
38 standardized "exception points" due to hepatocellular carcinoma, hepatopulmonary syndrome, and  
39 portopulmonary hypertension, and there is published evidence that non-standardized exception points are

40 not awarded consistently region to region or by race<sup>1,2</sup>.

41 The Committee does not believe that current liver allocation is optimal, because it neither takes into  
42 account post-transplant outcomes (an important metric of efficiency), nor does it maximize equitable  
43 distribution. Proposals to revise the current liver allocation system are under consideration by the OPTN.  
44 In the text below, we consider split liver transplantation in the context of the current allocation system, but  
45 also consider how the practice might be implemented under different allocation systems.

46 **Clinical background: The practice of splitting a deceased donor liver allograft**

47 Historically, split liver transplantation has primarily benefited pediatric recipients who are too small to be  
48 transplanted with a full-sized liver (Appendix-2). This scenario usually arises when a child is offered a liver  
49 that is too large, but the ability to split that liver and transplant the child with the left lateral section  
50 (segments II and III; see Figure 1) results in transplantation sooner than if the child had to wait for an age-  
51 or size-matched deceased donor liver. Since pediatric donors are less common than adult donors, split  
52 liver transplantation has significantly reduced time and mortality for patients on the pediatric waitlist<sup>3,4</sup>.  
53 The “extended right lobe” remnant graft (segments IV, V, VI, VII and VIII; see Figure 1) can then be  
54 transplanted into an adult, thus transplanting two candidates from one deceased donor. For pediatric and  
55 adult recipients, graft and patient survival after this type of split liver transplantation are similar to those for  
56 recipients of whole organs, though complications are more frequent<sup>5,6,7,8,9,10,11,12</sup>.

57 Splitting a single liver allograft for two large (e.g., adult sized) recipients is also possible. The two grafts  
58 resulting from this type of liver splitting are: “right lobe” (segments V through VIII; see Figure 2), and “left  
59 lobe” (segments II, III and IV; see Figure 2). Both recipients in this scenario are usually adults. There is  
60 less experience with this type of split transplant and the recipient outcomes are not as consistently

---

<sup>1</sup> Goldberg DS, Makar G, Bittermann T, French B. Center variation in the use of nonstandardized model for end-stage liver disease exception points. *Liver transplantation : official publication of the American Association for the Study of Liver Diseases and the International Liver Transplantation Society*. 2013;19(12):1330-1342

<sup>2</sup> Hsu EK, Shaffer M, Bradford M, Mayer-Hamblett N, Horslen S. Heterogeneity and disparities in the use of exception scores in pediatric liver allocation. *Am J Transplant*. 2015;15(2):436-444.

<sup>3</sup> Gridelli B, Spada M, Petz W, et al. Split-liver transplantation eliminates the need for living-donor liver transplantation in children with end-stage cholestatic liver disease. *Transplantation*. 2003;75(8):1197-1203.

<sup>4</sup> Cintorino D, Spada M, Gruttadauria S, et al. In situ split liver transplantation for adult and pediatric recipients: an answer to organ shortage. *Transplant Proc*. 2006;38(4):1096-1098.

<sup>5</sup> Hong JC, Yersiz H, Farmer DG, et al. Longterm outcomes for whole and segmental liver grafts in adult and pediatric liver transplant recipients: a 10-year comparative analysis of 2,988 cases. *J Am Coll Surg*. 2009;208(5):682-689; discussion 689-691.

<sup>6</sup> Spada M, Cescon M, Aluffi A, et al. Use of extended right grafts from in situ split livers in adult liver transplantation: a comparison with whole-liver transplants. *Transplantation proceedings*. 2005;37(2):1164-1166.

<sup>7</sup> Broering DC, Topp S, Schaefer U, et al. Split liver transplantation and risk to the adult recipient: analysis using matched pairs. *Journal of the American College of Surgeons*. 2002;195(5):648-657.

<sup>8</sup> Renz JF, Yersiz H, Reichert PR, et al. Split-liver transplantation: a review. *Am J Transplant*. 2003;3(11):1323-1335.

<sup>9</sup> Takebe A, Schrem H, Ringe B, et al. Extended right liver grafts obtained by an ex situ split can be used safely for primary and secondary transplantation with acceptable biliary morbidity. *Liver Transplantation*. 2009;15(7):730-737.

<sup>10</sup> Mabrouk Mourad M, Liossis C, Kumar S, et al. Vasculobiliary complications following adult right lobe split liver transplantation from the perspective of reconstruction techniques. *Liver Transplantation*. 2015;21(1):63-71.

<sup>11</sup> Cauley RP, Vakili K, Fullington N, et al. Deceased-donor split-liver transplantation in adult recipients: is the learning curve over? *J Am Coll Surg*. 2013;217(4):672-684 e671.

<sup>12</sup> Cauley RP, Vakili K, Potanos K, et al. Deceased donor liver transplantation in infants and small children: are partial grafts riskier than whole organs? *Liver Transpl*. 2013;19(7):721-729.

61 favorable<sup>13,14,15</sup>, though at least one recent report indicates good results may be achieved in low-MELD  
62 recipients<sup>16</sup>.

63 However, there are a number of clinical limitations to the practice of splitting liver allografts. First, some  
64 adult recipients are not well suited to receive a partial liver. Critically ill patients are not optimal candidates  
65 for a partial liver because they are less able to tolerate the more-frequent complication(s). A second  
66 limitation (noted earlier, Appendix-1) is the limited number of donated livers (more than 10% of all  
67 donated livers) that meet OPTN-specified criteria for splitting. A third limitation is center expertise,  
68 because split liver transplantation requires substantial clinical experience on the part of both the procuring  
69 surgeons and the recipients' clinical teams. This lack of experience may be one reason why only about  
70 1% of livers are split. In practice, very few centers have consistently performed split liver transplantation  
71 over the past decade.

72 To ground these limitations in concrete examples, we suggest that split liver transplantation may be  
73 considered in the following clinical scenarios. These scenarios all assume appropriate center expertise  
74 and candidate readiness. Donor "suitability" refers to clinical criteria listed above:

75 *Scenario 1*

76 A suitable donor is identified, a suitable pediatric candidate in whom the left-lateral section is size-  
77 appropriate has allocation priority, and a suitable larger (adult or pediatric) candidate is identified to  
78 receive the extended right lobe graft remnant (Figure 1).

79 *Scenario 2*

80 A suitable donor is identified, a suitable large pediatric or adult candidate has allocation priority, and a  
81 suitable pediatric candidate in whom the left-lateral section is size-appropriate is identified (Figure 1).

82 *Scenario 3*

83 A suitable donor is identified, a suitable candidate (adult or pediatric) too small for the whole liver or  
84 extended right lobe graft (but requiring more than the left-lateral section) has allocation priority, and a  
85 second suitable adult or pediatric candidate is also identified. In this scenario, the liver is split more evenly  
86 (Figure 2).

87 **The ethics of modifying allocation and practice to promote split liver transplantation**

88 The main ethical justification for split liver transplantation is that the practice may increase efficiency when  
89 two liver segments can provide greater net survival to two appropriately selected recipients instead of a  
90 single recipient. Split liver transplantation could also increase transplant access for pediatric candidates.  
91 As discussed in another white paper from the Committee<sup>17</sup>, children may be considered among the 'worst  
92 off' transplant candidates, and affording this group some allocation preference is reasonable.

93 When the index candidate (the candidate at the top of the allocation match run) is a child who requires  
94 only the left-lateral section of a suitable donor, we feel it is fair and efficient for this candidate's center to  
95 split the liver for the child and a larger (adult or pediatric) candidate in whom the extended right lobe graft  
96 is size-appropriate (Scenario 1; see also Figure 1). Necessary elements of splitting the liver include, but

---

<sup>13</sup> Aseni P, De Feo TM, De Carlis L, et al. A prospective policy development to increase split-liver transplantation for 2 adult recipients: results of a 12-year multicenter collaborative study. *Annals of surgery*. 2014;259(1):157-165.

<sup>14</sup> Giacomoni A, Lauterio A, Donadon M, et al. Should we still offer split-liver transplantation for two adult recipients? A retrospective study of our experience. *Liver transplantation : official publication of the American Association for the Study of Liver Diseases and the International Liver Transplantation Society*. 2008;14(7):999-1006.

<sup>15</sup> Wan P, Li Q, Zhang J, Xia Q. Right lobe split liver transplantation versus whole liver transplantation in adult recipients: A systematic review and meta-analysis. *Liver transplantation : official publication of the American Association for the Study of Liver Diseases and the International Liver Transplantation Society*. 2015;21(7):928-943.

<sup>16</sup> Hashimoto K, Quintini C, Aucejo FN, et al. Split liver transplantation using Hemiliver graft in the MELD era: a single center experience in the United States. *Am J Transplant*. 2014;14(9):2072-2080.

<sup>17</sup> OPTN/UNOS. Pediatric Transplantation and Ethics Committees. Ethical principles of pediatric organ allocation; [Ethical Principles of Pediatric Organ Allocation](#)



97 are not limited to, medical suitability of the candidates and donor, as well as current center-specific  
98 experience with split liver transplantation. The ethical rationales for this practice are that survival gains  
99 from transplantation are provided to two individuals and that the index pediatric candidate is not  
100 disadvantaged.

101 If splitting the donor liver is planned, the transplant center should notify the organ procurement  
102 organization (OPO) managing the donor as early as possible, to allow the OPO to offer the remnant graft  
103 to other candidates on the match run. According to OPTN policy, if the remnant graft has not been  
104 allocated by the start of organ retrieval, the index candidate's transplant center should offer it to medically  
105 appropriate candidates on its list according to their waitlist priority. The goal of these efforts is to ensure  
106 fair and efficient remnant graft allocation and minimize remnant graft discard. Ideally, the initial match run  
107 for a suitable donor would identify two recipients for consideration before offering the liver as a whole  
108 graft: the index pediatric recipient to receive the left-lateral section and a larger (adult or pediatric)  
109 recipient for the extended right lobe graft. Notably, since 2001 approximately 85% of candidates have  
110 been listed as agreeing to receive a partial liver (Appendix-3). The Committee supports consideration of a  
111 change in allocation policy to facilitate this scenario.

112 Scenario 2 differs only in that the index candidate is not the proposed recipient of the left-lateral section.  
113 This results when a larger (pediatric or adult) recipient is the index candidate for a liver from which the  
114 extended right lobe graft would suffice, leaving the left-lateral section for a medically suitable smaller  
115 pediatric candidate (Figure 1). Again, when a suitable donor is identified, it would be appropriate for the  
116 match run to identify two potential recipients: the index adult or large pediatric candidate for the extended  
117 right lobe graft and a smaller pediatric candidate for the left-lateral section. This would encourage centers  
118 with an opportunity to split a liver to allow an additional child to receive a transplant to do so – again,  
119 transplanting two recipients from a single donor. Among other considerations, the index candidate's  
120 individual situation and current center-specific experience, practice, and outcomes are all important in the  
121 decision to perform split liver transplantation in this scenario. It is again recognized that critically ill  
122 patients may not be optimal candidates for a partial liver allograft and could, therefore, be disadvantaged  
123 if all donor livers meeting split criteria were primarily offered only as a split. This disadvantage could be  
124 mitigated by allowing candidates with a certain MELD threshold (e.g., >35) to receive priority for the whole  
125 liver over candidates who appear on the split liver match run.

126 Alternatively, and less commonly, the index candidate is an adult or pediatric recipient in whom a right  
127 lobe graft (segments V, VI, VII, VIII) or left lobe graft (segments II, III, and IV) would be size-appropriate.  
128 As previously mentioned, reported results<sup>13-15</sup> from this type of split (Scenario 3) are less consistently  
129 favorable than Scenario 1 or 2. Thus, in this case, providing a partial liver to the index candidate and  
130 offering the other liver segment to another suitable candidate on the waiting list may not promote  
131 efficiency versus whole liver allocation. Given this problem and graft weight/body weight ratio  
132 requirements, particularly for high-MELD patients, we do not currently advocate a change in policy to  
133 facilitate this scenario.

#### 134 **Informed consent**

135 The principle of autonomy requires that transplant candidates (or their surrogates) have transparent  
136 discussion and disclosure of information about allograft quality, expected outcomes with the transplant  
137 versus remaining wait-listed, and center experience. These requirements of informed consent should  
138 encompass discussion about split liver transplantation where clinically appropriate. These processes of  
139 informed consent should first be addressed while the patient is on the waiting list (ideally at the time of  
140 listing) and when organs are offered. Patients (or surrogates) may change their decisions about  
141 willingness to accept certain types of organs because of changes in clinical status or other reasons. If a  
142 center and/or patient decline a split liver offer, they should retain their position on the list; in this scenario,  
143 the split liver can be offered to the next candidate on the match run willing to receive a partial liver graft.

144 The specific clinical circumstances of liver transplantation include challenges to informed consent that the  
145 Committee acknowledges. First, liver transplant candidates often become critically ill on the waiting list,  
146 impairing their capacity and requiring consent from surrogates. Ideally, informed consent would involve  
147 discussions when candidates are capable of understanding the risks and benefits, although candidates  
148 are sometimes added to the waiting list when hepatic encephalopathy precludes such discussions.  
149 Second, because a patient's or their center's circumstances might change while the patient is on the

150 waiting list, recurring informed consent discussions regarding this issue, along with potential updating of  
151 their willingness with the OPTN, are appropriate. Third, transplant candidates or their surrogates should  
152 not be put in a position of undue pressure, in which the transplant staff may be perceived as coercing  
153 them to accept a split liver transplant at the time of organ offer. Instead, allocation procedures should be  
154 developed such that when two patients are identified on the match run that are likely to have favorable  
155 outcomes with a split liver, then split liver transplantation should be offered to the candidates as the only  
156 transplantation option with that organ, rather than asking the candidates whether they want the entire liver  
157 or a split liver. This approach avoids candidate (or surrogate) coercion and recognizes that deceased  
158 donor livers – whether transplanted as whole or split organs – are a community resource that should be  
159 allocated according to the principles articulated earlier in this document.

#### 160 **Center expertise**

161 With the preceding discussion, the Committee acknowledges that the risk-benefit ratio of split liver  
162 transplantation will vary between transplant programs and the acuity of illness of their listed candidates.  
163 Our intent is not to require a change in practice if liver splitting is not appropriate for a center; rather,  
164 centers with appropriate experience and/or expertise are encouraged to consider split liver transplantation  
165 in order to safely increase the number of liver transplants performed. Because of similar outcomes with  
166 Scenarios 1 and 2 when compared with whole liver transplantation, changes in allocation and practice  
167 (e.g., offering the liver to two recipients as a split) may be appropriate at this time to encourage this type  
168 of split liver transplantation, as net survival would be expected to increase. If good outcomes become  
169 consistently documented with Scenario 3, changes to encourage this practice should also be considered.

170 In addition to the individual medical suitability of donors and recipients, the Committee recognizes other  
171 stakeholders and/or factors, some with competing interests. If *in situ* splitting is planned, for example, the  
172 donor hospital's capabilities and resources (personnel, operating room time, equipment) need to be  
173 considered. Increased intraoperative time would impact the extrahepatic organ retrieval team(s); the  
174 donor may become hemodynamically compromised, impacting *all* organs and those targeted candidates;  
175 if split liver candidates are at different centers, both centers might want their surgeon(s) involved in the  
176 splitting, further complicating case coordination. If *ex vivo* splitting is planned and the candidates are at  
177 different centers, additional challenges may emerge. Lastly, intraoperative findings (e.g., anomalous  
178 vascular anatomy) may preclude safe splitting. For logistical reasons, therefore, it is likely unfeasible to  
179 split every donor liver that meets split liver transplantation criteria. It is worth noting again, however, that  
180 split liver transplantation is probably underutilized in contemporary practice.

181 Each liver transplant program should develop a written protocol that addresses their policies related to  
182 split liver transplantation, including information about processes of informed consent. This informed  
183 consent should incorporate information about the national and the center's experience and outcomes with  
184 liver splitting.

#### 185 **Additional Challenges**

186 Expansion of the practice of liver splitting poses other challenges. One challenge in the context of current  
187 allocation is that MELD-driven allocation usually directs liver allografts toward individuals with the highest  
188 level of illness and probability of death on the waiting list, yet split liver allografts may not be well suited to  
189 those individuals. Potential solutions might address this challenge. First, under current allocation, many  
190 transplant candidates receive exception points due to hepatocellular carcinoma and have MELD-  
191 exception points despite not being critically ill. Split liver grafts could be directed to these individuals,  
192 and/or, as previously mentioned, a minimum MELD/PELD score could be set (e.g., 35) beyond which a  
193 liver meeting split criteria is offered to those candidates as a whole graft before allowing consideration of  
194 splitting. Second, future revisions to liver allocation processes that take into account post-transplant  
195 survival (in addition to waiting list survival) might result in highest priority for individuals who are not  
196 necessarily critically ill and might also benefit from split liver transplantation.

197 A change in allocation policy to identify two individuals on a match run would also have to indicate which  
198 candidate's center would have priority in deciding splitting technique and how the blood supply and bile  
199 duct would be shared. It would also need to address whole graft allocation when plans for split liver  
200 transplantation are aborted late in the process.

201 We also acknowledge the possibility that gains in efficiency from liver splitting might come at the cost of a  
202 small reduction in access to liver transplantation for persons who are not well suited for receiving a split  
203 liver allograft. For instance, individuals with a very large body mass index might not have good outcomes  
204 with a split allograft because of organ/recipient size mismatch and might decline these splits. However,  
205 the reduction in access to transplantation for obese individuals should be modest. First, the percentage of  
206 livers eligible for splitting is low. Second, most obese candidates could accept split livers procured as part  
207 of Scenario 1 or Scenario 2 because these split livers are relatively substantial in size. Third, these split  
208 allografts are high quality because of the donor characteristics, which counterbalance or may outweigh  
209 perceived size disadvantages of the split allograft. As noted earlier, split liver transplantation might also  
210 disadvantage high MELD individuals, a problem that could be mitigated if allocation policy discouraged  
211 splitting when a high MELD candidate (e.g., MELD >35) had allocation priority.

212 We also acknowledge that the transplant field has only general information about appropriate recipient  
213 candidacy for split liver transplantation. The field would benefit from greater research in this area.

## 214 **Summary**

215 There are many ethical and logistical issues to be considered in splitting a donor liver. The following  
216 points deserve emphasis:

- 217 1. The transplant community has an ethical obligation to maximize the outcomes from donated organs,  
218 while also promoting equity. Split liver transplantation might improve net survival of liver transplant  
219 candidates, while also increasing the number of individuals who benefit from transplantation,  
220 especially children. Splitting suitable livers for suitable patients is appropriate in centers with  
221 adequate experience and outcomes.
- 222 2. An overriding responsibility of transplant professionals is to properly inform candidates of national and  
223 center-specific practices and outcomes of split versus whole liver transplantation. Patients have the  
224 right to decide which risks to accept and the right to refuse an organ, including a split liver.
- 225 3. Informed consent discussions regarding split liver transplantation should take place early: when  
226 candidates are initially listed, or, for those patients already listed, when a split liver program is  
227 initiated. Recurring discussions will often be necessary, as candidates' and programs' circumstances  
228 may change.
- 229 4. The decision to split a donor liver must be made and communicated as early as possible to allow  
230 efficient and fair allocation of the remnant graft. Allocation of both resulting grafts on the initial match  
231 run for a suitable donor would be optimal. Contingency whole graft allocation is also important, if  
232 plans to split a liver are aborted.
- 233 5. Split liver transplantation involves many stakeholders and complicated logistics. Each stakeholder  
234 bears an inherent responsibility to promote appropriate stewardship of donor livers to optimize  
235 transplant outcomes and should collaboratively work through logistical issues on behalf of all  
236 transplant candidates.

237

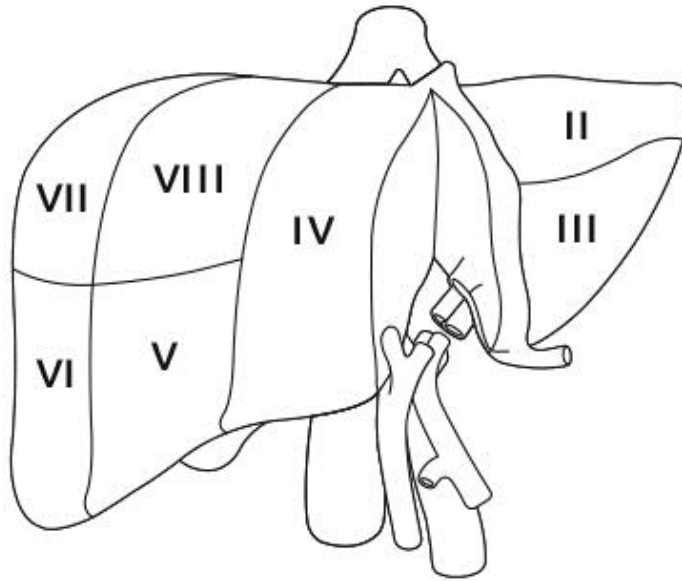
238 The Committee supports all reasonable efforts to increase the number of transplants safely performed.  
239 Changes in allocation and practice to encourage split liver transplantation are a potential means to that  
240 end.

241

242 **Figure 1.** Segmental anatomy of the liver; the liver is being divided along the plane to be split and  
243 transplanted into small pediatric recipient and a larger (pediatric or adult) recipient (Scenarios 1 and 2 in  
244 the text).

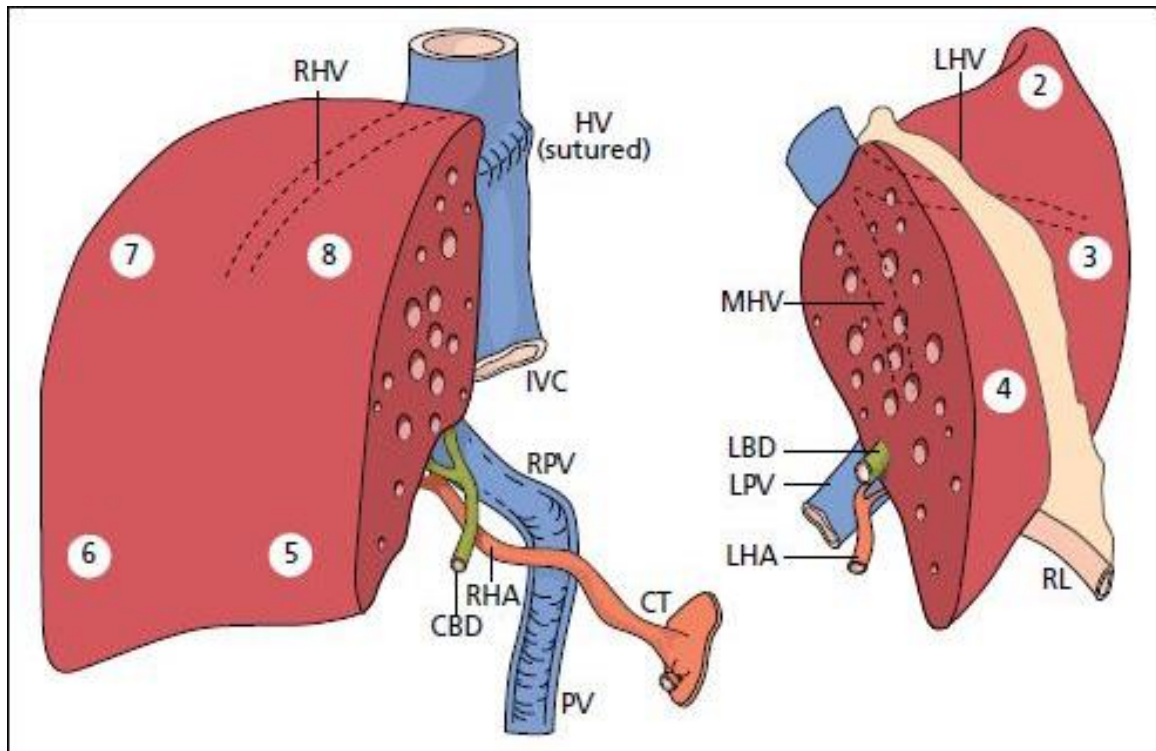
245 "Extended right lobe graft" in the text refers to segments, IV, V, VI, VII and VIII; "left-lateral section" refers  
246 to segments II and III. The smaller recipient would receive the left-lateral section, whereas the larger  
247 recipient would receive the extended right lobe graft.

248



249  
250  
251  
252  
253

**Figure 2.** Split for 2 “larger” recipients (either adult large pediatric patients); the difference from Figure 1 is that segment 4 goes with segments 2 and 3 to give similar-sized grafts. This corresponds to Scenario 3 in the text. In this figure Arabic numerals are used.



254  
255  
256  
257  
258  
259  
260

Fig. 2, Springer Science & Business Media.

**Appendices** (Data generated by OPTN analysts)

- 1) Of 113,394 deceased donor livers transplanted from 1/1/1995 - 12/31/2015, 1546 (1.36%) were split liver transplants. The criteria listed were adopted in November 2007; from 19 months pre-adoption

261 through 19 months post-adoption (April 2006 - June 2009), 2247 (10.3%) of 21,832 deceased donors  
262 met these criteria; during this same period, 218 (1.1%) of 19,644 livers transplanted were split liver  
263 transplants.  
264 2) Of 1546 donor livers split from 1/1/1995 - 12/31/2015, 1439 (93%) provided a liver allograft to a  
265 pediatric recipient. 6.8% of whole liver transplants were done in pediatric recipients. Additionally, from  
266 April 2006 - June 2009, a pediatric recipient was the primary candidate on the match run for 201  
267 (92%) of 218 split liver transplants.  
268 3) From 6/1/2001 - 12/31/2015, there were 151,250 adult registrations for liver transplantation; at listing,  
269 129,276 (85%) noted a willingness to accept a split liver. In 2015, 10,100 (90%) of 11,256 registrants  
270 noted a willingness to accept a split liver.  
271 #