Survival After Pediatric Liver Transplantation

Why Does Living Donation Offer an Advantage?

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**Hypothesis:** Living donor liver transplantation (LDLT) results in improved survival compared with deceased whole and split organ transplantation in children.

**Objective:** To evaluate the effect of LDLT on graft and patient survival in pediatric liver transplantation.

**Design:** Retrospective cohort.

**Methods:** Data included all pediatric recipients (aged <18 years) registered in the UNOS (United Network for Organ Sharing) database from October 1, 1987, to May 24, 2004. Covariates predictive of survival by univariate analyses were included in the Cox proportional hazards regression models in a blockwise fashion to determine predictors of survival.

**Results:** Kaplan-Meier graft and patient survival rates were improved in LDLT recipients compared with recipients of deceased whole and split organ transplantations (P<.01). In the initial model (model P<.001), prognostic factors for graft and patient survival included recipient age, race, origin of liver disease, certain pre-transplantation laboratory data, medical condition, multi-organ transplantation, re-transplantation, recipient-donor ABO blood compatibility, and cold and warm ischemia times. The addition of graft type to the initial covariate set did not significantly change the model (P=.21, covariate P=.09). However, most of the positive prognostic factors identified in the model were inherent characteristics of LDLT recipients and the LDLT procedure.

**Conclusions:** Graft and patient survival in the pediatric population is better with LDLT than deceased organ transplantation. Factors that contribute to this difference include recipients who are less ill, who have shorter cold and warm ischemia times, and those with a decreased need for re-transplantation but not the type of graft per se.


_A S ORIGINALLY DESCRIBED BY_ Starzl et al., liver transplantation was first performed in children. Orthotopic liver transplantation is the accepted treatment of end-stage liver disease in both children and adults. The prevalence of end-stage liver disease is increasing. Although children compose only 15% of the transplantation waiting list, children younger than 5 years have the highest waiting list mortality of all age groups. The need for small-sized grafts coupled with a critical organ shortage have necessitated identifying alternative graft sources for the pediatric population with end-stage liver disease. Living donor liver transplantation serves as an important alternative to deceased donor transplantation especially in those candidates with limited or delayed access to transplantation. Since the introduction of living donor and split-deceased grafts, several studies have reported decreased waiting list times and mortality. With these advances, significant ethical issues have been encountered by the transplantation community. Although LDLT provides a valuable resource for transplantation recipients, it also poses a finite risk to an otherwise healthy donor. Therefore, it is crucial that the transplantation community carefully select candidates for LDLT and evaluate outcomes.

In this study, we use national data from the Organ Procurement and Transplantation Network (OPTN) to examine the effect of donor type on outcomes in pediatric liver transplantation. The OPTN registry contains prospectively collected data.

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on all individuals listed for solid organ transplantation. The OPTN registry includes demographic information, pretransplantation clinical and laboratory data, transplantation data, and follow-up information. National data have significant power, and previous analyses of OPTN registry data have influenced both practices and policies within the transplantation community.

We hypothesize that LDLT leads to improved graft and patient survival compared with deceased donor whole and split organ transplantation in children with end-stage liver disease. Using the OPTN database, we sought to identify variables that would predict graft and patient outcome and to compare the outcomes achieved among the different donor types.

**METHODS**

**STUDY POPULATION**

All data were obtained from UNOS (United Network for Organ Sharing) Standard Transplant Analysis Research files, a registry maintained by UNOS that prospectively collects pretransplantation demographic information, pretransplantation clinical and laboratory data, transplantation data, and follow-up information on all individuals listed for solid organ transplantation in the United States. Data are collected at the time of listing, transplantation, 6 months after transplantation, and yearly thereafter for every living organ recipient. Based on OPTN data as of May 24, 2004, the study population included all liver transplantations performed since October 1, 1987, in pediatric patients (aged <18 years) with end-stage liver disease in the United States. These data were provided in a “de-identified” format.

**STATISTICAL METHODS**

Overall graft and patient survival were determined by Kaplan-Meier methods. Log-rank tests were performed to compare graft and patient survival stratified by the following pretransplantation characteristics: deceased donor whole grafts vs deceased donor split grafts vs living-donor grafts. Additional potential risk factors for graft and patient survival were identified from previous studies. These covariates included age; race; cause of end-stage liver disease; pretransplantation levels of creatinine, albumin, and total bilirubin; UNOS status and medical condition of the recipient; ABO blood compatibility; retransplantation; multiorgan transplantation; and era of transplantation. Log-rank tests were performed to ensure these variables as univariate predictors of graft and patient survival in our data set. Log-rank tests were also performed to compare graft and patient survival stratified by short vs prolonged cold and warm ischemia times. The effect of donor type on means of continuous variables was tested via analysis of variance with post hoc tests of pairwise effects. The distribution of categorical variables by organ type was analyzed by the \( \chi^2 \) test of proportions.

Prior to modeling, continuous variables were stratified as follows: age (infants, 0-2 years; children, 3-12 years; and adolescents >12 years), creatinine level (\(<1.5\) and \(\geq1.5\) mg/dL, \(<133\) and \(\geq133\) µmol/L), albumin level (\(<3.0\) and \(\geq3.0\) g/dL, \(<12\) and \(\geq12\) g/L), total bilirubin level (\(<2.5\) and \(\geq2.5\) mg/dL, \(<43\) and \(\geq43\) µmol/L), transplantation date (prior to and including December 31, 1994, or after December 31, 1994), cold ischemia time (\(<12\) hours and \(\geq12\) hours), and warm ischemia time (\(<30\) minutes and \(\geq30\) minutes). The OPTN disease classification for end-stage liver disease includes 72 disease codes for pediatric patients. For our analyses, we collapsed the OPTN diagnostic scheme into 5 diagnostic categories including biliary atresia, metabolic disease, hepatitis, tumor, and other causes. Each case was then assigned to 1 of 5 mutually exclusive diagnostic categories on the basis of diagnosis at the time of transplantation.

Variables that were predictive of outcome by univariate analysis, as defined by a statistical significance level of less than .05, were included in a Cox proportional hazards regression model to determine the independent effect of each covariate on graft and patient survival. To determine the explicit effect of graft source on graft and patient survival, a blockwise approach to Cox proportional hazards regression modeling was used. In the initial model, all of the covariates except graft source were entered, and model fit and covariate parameters were determined. The effect of the addition of donor source (living, deceased whole, or deceased split) to the model was then assessed as the test of change in the model fit, and covariate parameters were recomputed for the full model. Statistical significance was determined at the 2-tailed \( \alpha < .05 \). All statistical analyses were performed using SPSS version 11.0 (SPSS Inc, Chicago, Ill).

**RESULTS**

A total of 8771 liver transplantations were performed in the United States from October 1, 1987, to May 24, 2004, in pediatric patients (aged <18 years) with end-stage liver disease. Eighty-one percent of the recipients received a deceased donor whole graft (n=7149) compared with 9% (n=702) and 11% (n=920) of the recipients who received deceased donor split and living donor grafts, respectively. During the study period, 3107 allograft failures occurred with 1778 (57%) of these graft failures resulting in retransplantation and 1329 (43%) graft failures being associated with patient death. Mean \( \pm \) SD time to graft failure was \( 416 \pm 831 \) days. Thirty-seven percent of the deceased donor whole transplantations and 38% of deceased donor split transplantations resulted in graft failure compared with only 27% of the living donor grafts (pairwise \( P < .001 \)).

**RECIPIENT AND TRANSPLANTATION CHARACTERISTICS**

Several pretransplantation characteristics were significant univariate predictors of graft and patient survival by log-rank tests including age stratifications (infant, child, or adolescent), race, cause of liver disease, pretransplantation laboratory data (creatinine, albumin, and total bilirubin levels), medical condition (ie, not hospitalized, hospitalized non-intensive care unit or hospitalized ICU), UNOS urgency status (1/2A or 2B/3), multiorgan transplantation, and retransplantation (all \( P < .05 \)). Other covariates exerting significant effects on graft and patient survival included donor recipient ABO blood compatibility, cold ischemia time, and warm ischemia time (all \( P < .05 \)).

The effect of donor type on these characteristics was evaluated (Table). Living donor liver transplant recipients were younger and more often white than deceased donor whole and split organ transplant recipients (both \( P < .001 \)). The percentage of male recipients was similar between the 3 donor types. The cause of liver disease varied between the groups (\( P < .001 \)); however, biliary atresia was the most common indication for transplantation in all 3 donor type groups.
Living donor liver transplant recipients were not as ill as recipients of deceased donor organs as evidenced by a greater percentage of nonhospitalized patients, and patients having an UNOS status 2B or 3 at the time of transplantation (both \(P < .001\)). Living donor liver transplant recipients also had lower mean pretransplantation creatinine (\(P < .001\)) and total bilirubin levels (\(P = .03\)) than recipients of deceased donor organs. Multiorgan transplantation was highest in the deceased donor whole organ group at 7%; whereas, retransplantation was greatest in the deceased donor split organ recipients at 20%.

Although the proportion of patients with a recipient donor gender match did not vary between the groups, the ABO blood compatibility was greatest for LDLT recipients (98.4%). Both cold and warm ischemia times were lower in the LDLT group (both \(P < .001\)). Since 1994, the use of deceased donor split and living donor organs has increased significantly (\(P < .001\)).

### Table. Recipient and Transplantation Characteristics According to Donor Graft Type

<table>
<thead>
<tr>
<th>Variable</th>
<th>Deceased Donor Whole Organ (n = 7149)</th>
<th>Deceased Donor Split Organ (n = 702)</th>
<th>Living Donor Organ (n = 920)</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD, y</td>
<td>5.3 ± 5.7</td>
<td>3.2 ± 4.5</td>
<td>2.4 ± 4.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Sex, male</td>
<td>48</td>
<td>45</td>
<td>46</td>
<td>.21</td>
</tr>
<tr>
<td>Race, white</td>
<td>59</td>
<td>48</td>
<td>67</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Cause of liver disease</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Biliary atresia</td>
<td>45</td>
<td>52</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Metabolic disease</td>
<td>16</td>
<td>15</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Hepatitis</td>
<td>15</td>
<td>16</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Tumor</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>22</td>
<td>14</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>UNOS status (1/2A)</td>
<td>51</td>
<td>59</td>
<td>31</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Medical condition</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Not hospitalized</td>
<td>47</td>
<td>40</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Hospitalized, non-ICU</td>
<td>19</td>
<td>18</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Hospitalized, ICU</td>
<td>34</td>
<td>42</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Albumin level, mean ± SD, g/dL</td>
<td>3.1 ± 0.7</td>
<td>3.1 ± 0.8</td>
<td>3.1 ± 0.7</td>
<td>.96</td>
</tr>
<tr>
<td>Serum creatinine level, mean ± SD, mg/dL</td>
<td>0.7 ± 1.0</td>
<td>0.5 ± 0.6</td>
<td>0.4 ± 0.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Total bilirubin level, mean ± SD, mg/dL</td>
<td>12.7 ± 12.3</td>
<td>12.5 ± 12.0</td>
<td>11.6 ± 10.2</td>
<td>.03</td>
</tr>
<tr>
<td>Multigraft transplantation</td>
<td>7</td>
<td>1.6</td>
<td>0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Retransplantation</td>
<td>15</td>
<td>20</td>
<td>12</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Recipient-donor gender match</td>
<td>50</td>
<td>47</td>
<td>51</td>
<td>.23</td>
</tr>
<tr>
<td>Recipient-donor ABO blood compatibility</td>
<td>94.9</td>
<td>97.9</td>
<td>98.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>CIT, mean ± SD, h</td>
<td>9.9 ± 5.2</td>
<td>8.4 ± 4.8</td>
<td>6.1 ± 7.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>WIT, mean ± SD, min</td>
<td>55.5 ± 27</td>
<td>50 ± 27</td>
<td>46.4 ± 24</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Transplantation era</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pre-1995</td>
<td>93</td>
<td>2.4</td>
<td>4.6</td>
<td></td>
</tr>
<tr>
<td>(\geq 1995)</td>
<td>74</td>
<td>12</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CIT, cold ischemia time; ICU, intensive care unit; UNOS, United Network for Organ Sharing; WIT, warm ischemia time.

SI conversions: To convert serum creatinine to micromoles per liter, multiply by 88.4; total bilirubin to micromoles per liter, multiply by 17.1.

*Data are given as percentages unless otherwise indicated.

Multivariate Cox proportional hazards regression analysis identified the following variables as significant prognostic factors for graft failure in the initial model (model \(P < .001\)), which did not include graft type as a covariate: younger age (0-2 years), African American race, ICU admission, elevated pretransplantation serum creatinine level (\(\geq 1.5\) mg/dL \(\geq 133\) µmol/L)), elevated pretransplantation total bilirubin level (\(\geq 2.5\) mg/dL \(\geq 43\) µmol/L)), multiorgan transplantation, retransplantation, prolonged cold (\(\geq 12\) hours) and warm (\(\geq 30\) minutes) ischemia times, and transplantation era (pre-1995). In addition, the diagnoses of hepatitis, tumor, or other liver disease predicted worse graft outcome compared with biliary atresia and metabolic diseases. The addition of donor type to the initial model did not significantly improve the overall model fit (model change = 0.121), and donor type was not an indepen-
dent predictor of graft failure in the full model (independent effect of donor type, \( P = .39 \)).

With the exception of transplantation era that was not a statistically significant predictor of patient survival, a similar set of prognostic risk factors for patient death were identified in a second model (model \( P < .001 \)). Again, the addition of donor type to the initial second model did not result in a significant improvement in the model fit (model change \( P = .208 \); independent effect of donor type, \( P = .09 \)).

COMMENT

Despite an increasing number of patients with end-stage liver disease awaiting liver transplantation, the rate of organ donation remains relatively unchanged.9 This results in the critical shortage of organs, the rate limiting step in liver transplantation. While the number of children on the waiting list has doubled since 1993, the total number of adults on the waiting list has increased 6-fold in that same period.3 The large number of adults on the waiting list affects pediatric candidates’ access to organs. These facts stimulated the transplantation community to develop LDLT and split liver transplantation to increase the donor pool and help fill the gap between the availability and the demand for size-matched organs for pediatric recipients.10

The newer procedures of LDLT and split liver transplantation generate important ethical considerations. Although split liver transplantation increases the number of candidates receiving transplants, it has less favorable results for recipients than other graft sources.9 Living donor liver transplantation produces excellent results in children, but it poses a finite risk to the donor.11 Given these dilemmas, the results of this study may help guide decision making with regard to transplantation options for pediatric patients.

Living donor liver transplant recipients showed improved patient and graft survival compared with deceased donor whole and split organ transplant recipients in this study. These results conflict with 2 earlier reports that failed to demonstrate an overall benefit to LDLT recipients.12,13 Both studies were conducted at single centers with relatively few patients. Thus, the failure to show a significant difference may have resulted from a lack of power.

The results of the earlier studies also conflict with more recently published studies. In 2001, the Studies of Pediatric Liver Transplantation (SPLIT) Research Group14 reported an increased risk of graft loss for recipients of deceased donor split organs compared with deceased donor whole organs but no difference between recipients of living donor and deceased donor whole organs. In a comprehensive review of the Scientific Registry of Transplant Recipients from 1993 to 2002, Mage et al15 reported improved patient and graft survival in LDLT recipients compared with deceased donor grafts for recipients younger than 1 year. This trend was not shown in any other age group. Using the same database, Roberts et al16 showed a decreased risk of graft failure for LDLT recipients compared with deceased donor split and deceased donor whole grafts as well as lower mortality compared with recipients of deceased donor split grafts for recipients aged younger than 2 years. In a multivariate analysis of 285 pediatric transplant recipients, Gupta et al16 demonstrated that a living donor graft was independently associated with a decreased risk for chronic rejection compared with deceased donor grafts (odds ratio, 0.2; \( P = .001 \)).

To determine the independent effect of graft type on graft and patient survival and its specific influence on model fit, we performed a blockwise multivariate analysis in which all covariates except graft type were included in the first covariate set. Since these covariates were determined to significantly affect patient and graft survival by univariate analysis, each covariate included in the model represented a potential independent predictor of outcome. Despite its association with outcome by univariate analysis, graft type did not significantly improve the model fit when it was added to the initial multivariate model. Therefore, when all of the other covariates were included and controlled for, graft type per se did not exert a significant effect on graft or patient survival. Thus, the differences in outcome identified in the univariate analysis must be due to other recipient or transplantation procedure factors associated with the use of a particular graft type but not due to the graft type itself.

The Cox models identified several recipient characteristics that were significantly associated with graft and patient survival including recipient age; race; pretransplantation serum creatinine and total bilirubin levels; medical condition; multiorgan transplantation, and retransplantation. Between-group comparisons of each prognostic variable identified several key differences between recipients of LDLT and deceased donor organs. Similar to the results reported by Reding et al,17 LDLT recipients were younger (mean ± SD age, 2.4±4.0 years) than the deceased donor whole and split organ recipients (mean ± SD age, 5.3±5.7 and 3.2±4.5 years, respectively). Living donor liver transplant recipients were more often white and had a diagnosis of biliary atresia. These patients received transplants earlier in their illness as evidenced by a decreased percentage of ICU admissions and urgent status retransplantation compared with deceased donor organ recipients. Thus, transplantation of younger, less acute recipients no matter what the graft source contributes to their better graft and patient survival after transplantation.

Living donor liver transplantation was also associated with significantly lower cold and warm ischemia times compared with deceased donor whole and split organ transplantations. Both cold and warm ischemia times were identified as being independently associated with graft and patient outcome in the multivariate models. In 2001, Farmer et al12 and Broering et al13 reported an increased cold ischemia time associated with deceased donor split transplantation compared with LDLT. Although both studies failed to show a difference in survival between LDLT and deceased donor split transplantation, Farmer et al12 reported an increase in graft loss due to primary nonfunction in recipients of deceased donor split organs compared with LDLT recipients. They also
noted an increase in technical complications associated with deceased donor split transplantation. Given the lengthy study period, it was important to control for transplantation date in our analyses. Not surprisingly, transplantation era also proved significant in the multivariate model. Recipients who received transplantations after 1994 showed significantly improved graft survival after transplantation compared with recipients who underwent organ transplantations in an earlier era. In addition, the proportion of both LDLT and deceased donor split transplantations increased markedly in the post-1995 era.

We recognize both potential advantages and limitations to a retrospective study design that uses a large national database. Despite the immense breadth of the OPTN registry, some variables that may influence graft choice and/or patient outcome may not be captured in the database. In a retrospective design, confounders may exist that are not controlled for in the analyses. For example, the OPTN Standard Transplant Analysis Research files contain no center-specific information such as postoperative complications or immunosuppression regimens. However, in this national database, the large sample size provides sufficient power to detect meaningful associations. These associations may be missed by single-center studies owing to limitations in statistical power.

**CONCLUSIONS**

We determined that graft and patient survival in the pediatric population is better with LDLT compared with deceased donor whole or split organ transplantation but not owing to the graft type itself. Several factors contribute to this difference including recipients who are not critically ill, who have shorter cold and warm ischemia times, and who have fewer incidents of retransplantation with LDLT. Although LDLT poses risk to the donor, it is, as practiced, a valuable technique in pediatric transplantation to help overcome the critical organ shortage.

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**REFERENCES**

is used, they are also equally, if not more, influenced by the status of the recipient at the time of the transplantation procedure. Herein lies the difficulty of the data analysis as performed by Austin and colleagues. What they were able to identify was that essentially the different graft types were not used in the same patient cohorts. In other words, live donor transplantation was more likely to be performed on an elective basis in healthier, more stable patients. Therefore, it is not surprising that the results were improved in this group compared with a different graft type used frequently in sicker patients, often under emergency circumstances.

I have several questions for the coauthors. While the results presented suggest that LDLTs are associated with improved results compared with whole or split transplantations in the pediatric population, this has not been the case for adult-to-adult LDLT, where overall graft survival and patient survival is actually slightly worse than for cadaveric transplantation, and actually significantly worse in adult split liver transplantation. Do the authors have an explanation for this difference?

What have the authors concluded from these results? In other words, should split liver transplantation be abandoned in favor of LDLT? In our center we use split liver transplantation whenever possible but do this only under carefully controlled circumstances. This is only performed when the cadaveric donor is young and otherwise seems to represent an excellent donor, usually in a hemodynamically stable donor younger than 30 years old. We perform an in situ split procedure, similar to the technique used for LDLT. In addition, we sometimes move the brain-dead donor to our facility where our liver team is present in an effort to minimize cold ischemic times and we believe that an in situ split transplantation is associated with better results than back-table splitting of the cold nonperfused graft. Using this strategy, our results with split liver transplantation in pediatric patients have been equivalent to our LDLT results. In our opinion, the use of in situ splitting can allow for pediatric patients to receive excellent quality grafts and minimize the need for live donation and the potential risks to the donor in live donation.

Given that the donor graft per se was not a significant variable affecting the observed outcomes, does this mean that recipient variables play the largest role in outcome for liver transplantation? In other words, do the authors believe that the results are essentially equivalent between donor types?

Once again, this group of investigators has performed a careful analysis regarding an important question in the field of liver surgery, helping us all to better understand important variables associated with an area of complex patient care.

Dr Pinson: Dr Chapman asked about the difference in results between adults and pediatric LDLT. I can think of 3 reasons why there is a difference. First, there is the issue of the living related split liver graft being smaller for size in an adult than it is in a child. The relatively smaller liver mass in the adult-to-adult LDLT is not as capable of providing adequate function to support the recovery of the patient. There are several animal studies that describe this so-called small-for-size phenomenon. The second reason is that while there are a lot of vascular complications on the inflow side for both children and adults, there is a higher incidence of complications on the venous outflow side in adults than in children. The third reason has to do with the early period (the database goes back to 1987) we used some split organ transplantations in adults in sicker patients.

The answer to your second question, should we stop doing split organ transplants lies in the fact that LDLT and split organ transplantations and reduced size grafts all contribute to the supply of an appropriate sized graft, together providing almost 1 in 5 grafts for the group with the highest mortality on
the wait[ing] list, namely, children younger than 5 years, and of those roughly 19% to 20%, 8% are provided by split grafts. I would answer your question by saying "yes," we should continue to use split grafts as well as the live donor grafts.

Your third question was did we think the 3 types of transplantation grafts gave essentially the same outcomes, and the answer is in our data, which is when we use blockwise technique to look at the type of graft per se, we are unable to demonstrate a difference.

John J. Ryan, MD, Sioux Falls, SD: Am I correct in understanding that in the pediatric population there is acceptance for disease donor organs to be used and, if so (1) How is it established that the donor is hepatitis free, and is the recipient monitored? For example, by DNA measurement rather than antibody measurement in the posttransplant phase? (2) If a recipient of a diseased organ in the pediatric group, would it not be appropriate to perform an auxiliary heterotopic transplantation in that type of patient rather than have to redo which would be inevitable in the orthotopic position? Well, if we have a split donor diseased organ placed in a pediatric patient that is placed in the orthotopic position, thereby removing the recipients liver at the first operation, it is going to be inevitable in that patient’s lifespan that another organ will probably be needed, if a diseased organ is accepted. Would it not be better to have a split diseased organ placed in the auxiliary position, for example, in the pelvis, thereby having a virgin operation at the next time the patient needs a better liver in the orthotopic position?

Dr Pinson: Your first question had to do with what are the tests that are usually performed for donor evaluation to rule out various other disease entities such as hepatitis. The answer is the usual hepatitis profiles as well as other viral serologic tests are routinely performed. Oftentimes there are biopsies performed on the liver to rule out significant amounts of steatosis. On the recipient side these patients are followed up quite carefully, and were a patient to have any elevated transaminase levels outside the initial postoperative period, they would usually be evaluated with viral profiles.

The second question is why not use auxiliary transplantation in the pediatric patient group more routinely, and the answer is that there has been some work on auxiliary transplantation between 1 and 2 decades ago that demonstrates that the outcomes with auxiliary transplantation are not as good as they are with any of the types of the transplantation techniques that we have described herein.