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Meeting Report

Report of the Crystal City Meeting to Maximize the Use of Organs Recovered from the Cadaver Donor

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Introduction

A consensus meeting to develop guidelines that would improve the recovery and transplantation of organs from the cadaver donor was held on 28–29 March 2001, in Crystal City, Virginia, sponsored by the American Society of Transplant Surgeons and the American Society of Transplantation. The crisis in organ supply persists and the continuing shortage presents a compelling responsibility for the transplant community to maximize the use of organs procured from cadaver donors.

Nearly 100 participants included physician and surgeon members of the American Society of Transplantation (AST), American Society of Transplant Surgeons (ASTS), medical and executive directors of Organ Procurement Organizations (OPO), representatives from the Department of Health and Human Services (DHHS), the National Kidney Foundation (NKF), the International Society for Heart and Lung Transplantation (ISHLT), the Scientific Registry for Transplant Recipients University Renal Research and Education Association (URREA), and the United Network for Organ Sharing (UNOS).

Five work groups were assembled that focused upon maximizing the use of hearts, lungs, livers, kidneys, and cadaver donors with a history of malignancy or a serology testing positive for hepatitis C or B virus. The report is given by the deliberations of each work group.

The Kidney Work Group

The discard rate of kidneys procured from the cadaver donor in USA has been increasing to an alarming level of more than 15% of those kidneys recovered for transplantation. If the utilization of recovered kidneys over 45 years of age matched the rate of recovery and transplantation accomplished in Spain, it would increase the rate of donors per million in USA by 38%. Approximately 50% of kidneys from cadaveric donors over 60 years of age (older age donors) are not transplanted due to donor quality.

Enhancing the opportunity to transplant kidneys from the older age donor could help decrease the continuing disparity between the number of patients on the transplant waiting list and the number of patients receiving a transplant each year. The disincentives to transplanting older cadaver donor kidneys include their likely dysfunction immediately following transplantation because older donor kidneys have the longest mean preservation time (Figure 1). The relative risk of dialysis after transplantation is 1.5 times greater in recipients of kidneys from donors >55 years of age vs. <55 donor. Importantly however, only the 6-antigen-matched kidneys provide a net benefit (in terms of graft survival) to the recipients of kidneys from older donors (Figure 2). This outcome benefit of national sharing is not realized for older donor 0 MM kidneys. Refinement of distribution policies would encourage centers

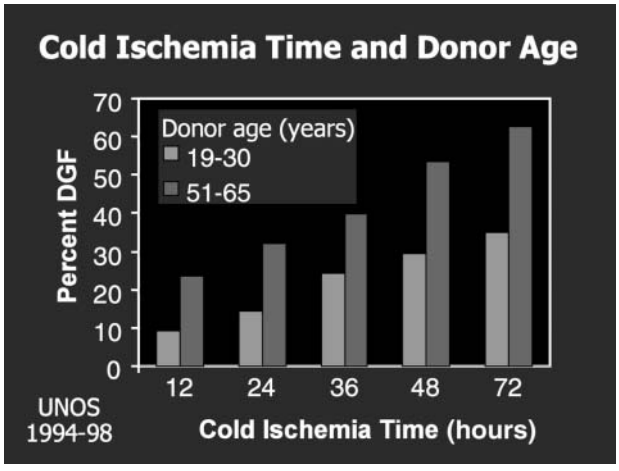

Figure 1: Older cadaver donor kidneys have the longest mean preservation time and the highest rate of delayed graft function (DGF).

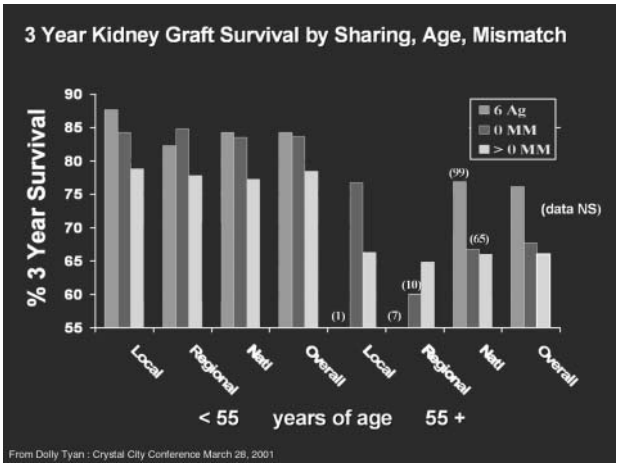

Figure 2: The outcome of HLA matched kidneys allocated locally, regionally and nationally from donors < and > than 55 years of age. There is no significant 0 mm benefit for a kidney recovered from a donor >55 years of age.

to be receptive to transplanting older donor kidneys by expediting placement to a list of pre-informed candidates who would accept such older donor kidneys.

The Kidney Work Group goals were to increase the utilization of older donor kidneys, improve patient outcomes by decreasing cold-storage times and delayed graft function; and thus, decrease hospital length of stay and costs.

The kidney proposal of the conference participants was to allocate older donor kidneys >60 years of age to a pre-informed group of patients based upon waiting time only. These recipients would be identified for the marginal donor kidney before organ procurement. UNOS could develop a standard policy whereby a local OPO could adopt the policy upon notification to UNOS of local OPO approval. Finally, allocation would occur at the level of the OPO, except for the identification of a 6-antigen-matched recipient nationally.

There was an additional objective to evaluate the use of biopsies in the decision to transplant a kidney from an older age donor. Currently, biopsies at the time of recovery assume an importance in kidney distribution that is not supported by available evidence correlating the biopsy findings to short- or long-term function following transplantation. Centers and OPOs would be encouraged to obtain wedge biopsies, when clinically indicated, to determine the utility of biopsies for long-term outcome.

The final consideration of the participants was to assess functional data using the Cockcroft-Gault formula. The proposal was to compare the Cockcroft value to biopsy findings determining the utility of either or both in predicting immediate and long-term function of the older age donor kidney. These data could be used to analyze the effect of this program upon the discard rate of kidneys recovered from the older age donor, comparing the 2 years after the OPO adoption of the proposal with the 2-year period immediately prior to its inception.

Table 1: The expanded kidney donor. The decision matrix using relative risk of graft failure >1.7 for donors older than 50 years of age, shown below, are now the UNOS approved expanded criteria by which kidney donors are defined as expanded and placed into the expedited system

Donor condition	Donor age categories				
	<10	10–39	40–49	50–59	≥60
CVA + HTN + Creat >1.5				X	X
CVA + HTN				X	X
CVA + Creat >1.5				X	X
HTN + Creat >1.5				X	X
CVA					X
HTN					X
Creatinine >1.5					X
None of the above					X

CVA = CVA was cause of death.
HTN = history of hypertension.
Creat >1.5 = creatinine >1.5 mg/dL.

This Crystal City Kidney proposal was modified subsequently by collaboration with the OPTN (UNOS) KP Committee (J. Wynn), the UNOS Organ Availability Committee (R. Metzger), and URREA (F. Port). The result of their interaction with the Crystal City kidney group was to set forth a definition of the marginal cadaver kidney donor not only by age, but also according to a relative risk of graft failure of >1.7 for donors >50 years of age, and at least two of the following factors: creatinine >1.5 mg/dL, a cerebral vascular accident as a cause of death, and hypertension when compared to a reference group of non-hypertensive donors between the ages of 10–39 whose cause of death was not CVA, and whose creatinine was <1.5 mg/dL (Table 1). The difference in outcome for kidneys recovered from donors with a relative risk of graft failure of >1.7 is shown in Figure 3.

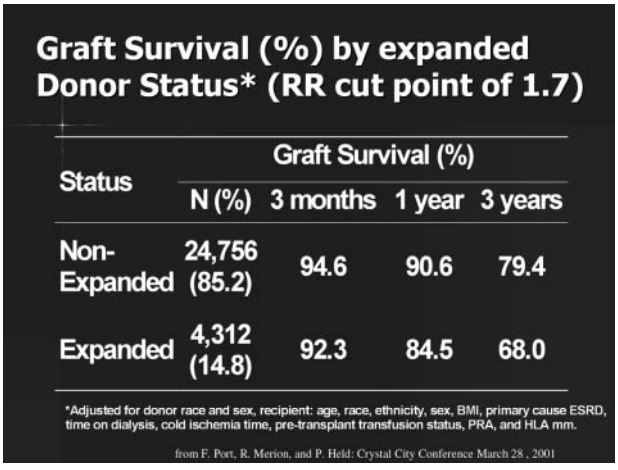

Figure 3: The difference in outcome for kidneys recovered from donors with a relative risk of graft failure of >1.7 (see Table 1).

The following proposal of the joint working group was subsequently approved by the UNOS Board on 15 November 2001. Kidneys procured from expanded criteria donors will be allocated preferentially to patients determined to be suitable candidates: first, for zero-antigen-mismatched patients among this group of patients with time limitations; and next, for all other eligible patients, locally, regionally, and nationally, based upon time waiting and not HLA matching. The UNOS Organ Center will attempt to place expanded criteria donor organs for the for zero-antigen-mismatched patients, according to the national list of patients waiting for expanded donor kidneys for a period of 2 h, after which time the UNOS Organ Center will notify the Host OPO that it may allocate the expanded criteria kidneys by the standard geographical sequence of local and regional allocation. OPOs would be required to identify potential recipients (i.e. perform a match run and start the process for notifying the appropriate transplant program(s) regarding the organ offer) for kidneys they procure from expanded criteria donors within 6 h post cross-clamp or offer the organs for eligible patients listed regionally and then nationally.

The Liver Work Group

There is an ethical imperative to address the ever-increasing list of patients waiting for a liver allograft; at the same time, there has been an under-utilization of existing technology and an inefficient use of current liver donor potential. The Liver Work Group identified multiple issues that could be considered for review: expand the use of non-heart-beating donors; broader use of marginal organs; more efficient placement of cadaveric organs; maximization of pre- and post-transplant survival; wider application of innovative technologies; and maximizing the use of split livers. Justification for a more aggressive use of expanded donors of all types is readily provided by the growing disparity between the donor and recipient pools for all organs. Faced with these and other complex study topics, the Liver Work Group chose to address split liver transplantation. While the incremental benefit may be limited in terms of the number of livers regained, the structural paradigm provided by the development of a policy to enhance the use of split livers would be useful in other areas for the expansion of allograft use.

It is estimated that 20% of the approximately 6000 cadaveric donor livers could be split for two recipients. Wasted grafts occur both in left lobe reductions and non-use of left lobe segments from adult donors. The explosion of recent use of living donors for both adults and children has driven further evolution of split technology, suggesting that SLT and LRT will ultimately be complementary therapies. The results of adult/infant split are equivalent to whole organ grafting.

The Liver Work Group concluded that splitting cadaveric livers for transplantation of two adults, while promising, was still experimental technology. For this reason, the Liver Work Group also concluded that the development of a national policy for splitting a single cadaveric liver for two adult recipients is premature. On the other hand, experience with splitting one cadaveric liver into a left lateral segment graft (LLSG) for a pediatric recipient and a right trisegment graft (RTSG) for an adult recipient was sufficient to conclude that this should be the standard of care for donors meeting the appropriate criteria for the split procedure (see Table 2). The Liver Work Group recognized the necessity of promoting this conclusion because there are still many liver transplant procedures performed for children where the cadaver liver graft is 'reduced' in size to obtain a graft small enough for the pediatric recipient, but the remaining liver segments are discarded without regard for utilizing this remaining segment. Furthermore, the Liver Work Group recognized that both patient and graft survival for LLSGs transplanted into pediatric recipients are comparable to whole organ transplantation, and patient and graft survival for RTSGs transplanted into adults are equivalent to whole organ adult transplantation (see Figures 4 and 5). Estimates of potential cadaveric grafts meeting criteria for split transplants suggest that if the 20% of donor livers suitable for split were realized, this would increase the total number of liver allograft recipients by 1000 per year. For these reasons, the Liver Work Group felt one important method for maximizing the use of cadaveric organs would be to recommend a national policy for splitting of appropriate donors into LLSG and RTSG whenever possible (see Figure 6), treating the cadaveric liver meeting split criteria (see Table 2) as a paired organ. The simultaneous double allocation would fol-

Table 2: Proposed Crystal City Criteria for split liver donation

- *Age > 10 and < 45*
- Hemodynamically stable (see recommendations from the Heart Work Group)
- ICU < 5 days
- LFT's < 5X, serum sodium < 170, Steatosis < 20%

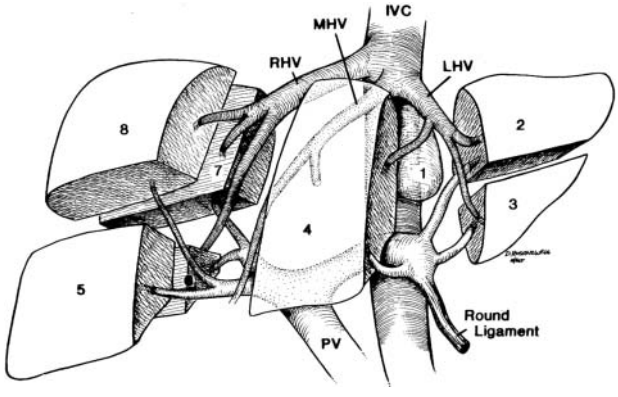

Figure 4: The anatomy of the liver as defined by Couinaud. The portal based functional anatomy made it possible to develop planes of transection which could preserve functional integrity of several anatomic territories defining functional grafts. Numbers indicate portal segments. MHV = middle hepatic vein, RHV = right hepatic vein, LHV = left hepatic vein, IVC = inferior vena cava. PV = portal vein.

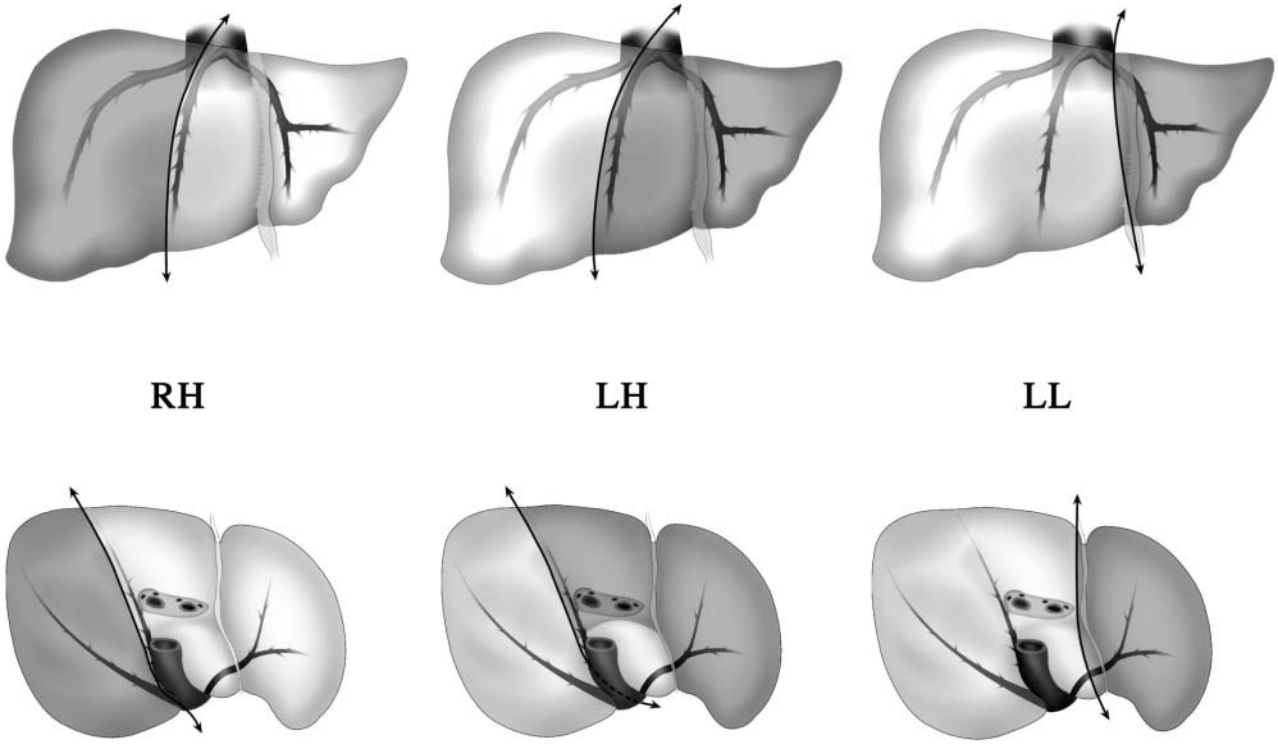

Figure 5: Planes of transection for splitting the liver are presented below showing the anterior surface (above) and the posterior surface (below). The first two drawings (RH and LH depict the anterior and posterior views of right and left lobes created by splitting the liver just to the right of the middle hepatic vein, the preferred technique for right lobe living donation). The drawings on the right, LL, demonstrate the anatomy of the right 'trisegmental' and left lateral split in which a liver is split to treat an adult and an infant. (With permission E. Salame).

low current policy, and patient and geographic sequences would remain intact.

The two accepting centers will need to communicate surgical responsibilities and any anatomical consideration with one another prior to the donor procedure. Teams with significant experience with the split technique should be encouraged to perform the *in situ* split and teach less experienced teams at the outset.

Split liver procedures will be monitored via UNOS reporting and all procedures will be entered into the ASTS split liver database which would be maintained by Jean Emond and Robert Merion and the ASTS informatics group. This will entail OPO reporting split procedures to UNOS and identifying centers receiving LLSG and RTSG. This development would then alert the ASTS registry to the existence of a split and generate queries until data supplied. The ASTS should establish training guidelines and standards for this procedure. The ASTS and UNOS Liver Committees will review donor demographic and clinical data and split recipient patient and graft survival data. One year after implementation, these Committees could assess the results of this policy and make recommendations regarding any needed changes.

The Expanded Donor (by CNS Malignancy and Hepatitis) Work Group

Organs procured from donors with positive viral serology and medical histories of malignancy are currently underutilized. These donors are considered marginal because transplantation of an organ from these donors might transmit disease and thereby compromise the well-being of the recipient. Inherent in cadaveric organ donation is the risk of unintended transmission of viral or neoplastic disease.

In USA, there are approximately 13 000 deaths per year as a result of Central Nervous System (CNS) tumors, yet only about 1.0% of those patients are organ donors. This leaves a significant donor potential, if the risks can be defined. A basic tenet should be that the transplant physician weighs that inherent risk against the possibility that the lack of an organ may result in the death of the recipient (because no organ was available for transplantation). This decision varies by organ type but defining the risk of disease transmission will enhance utilization of organs from these donors.

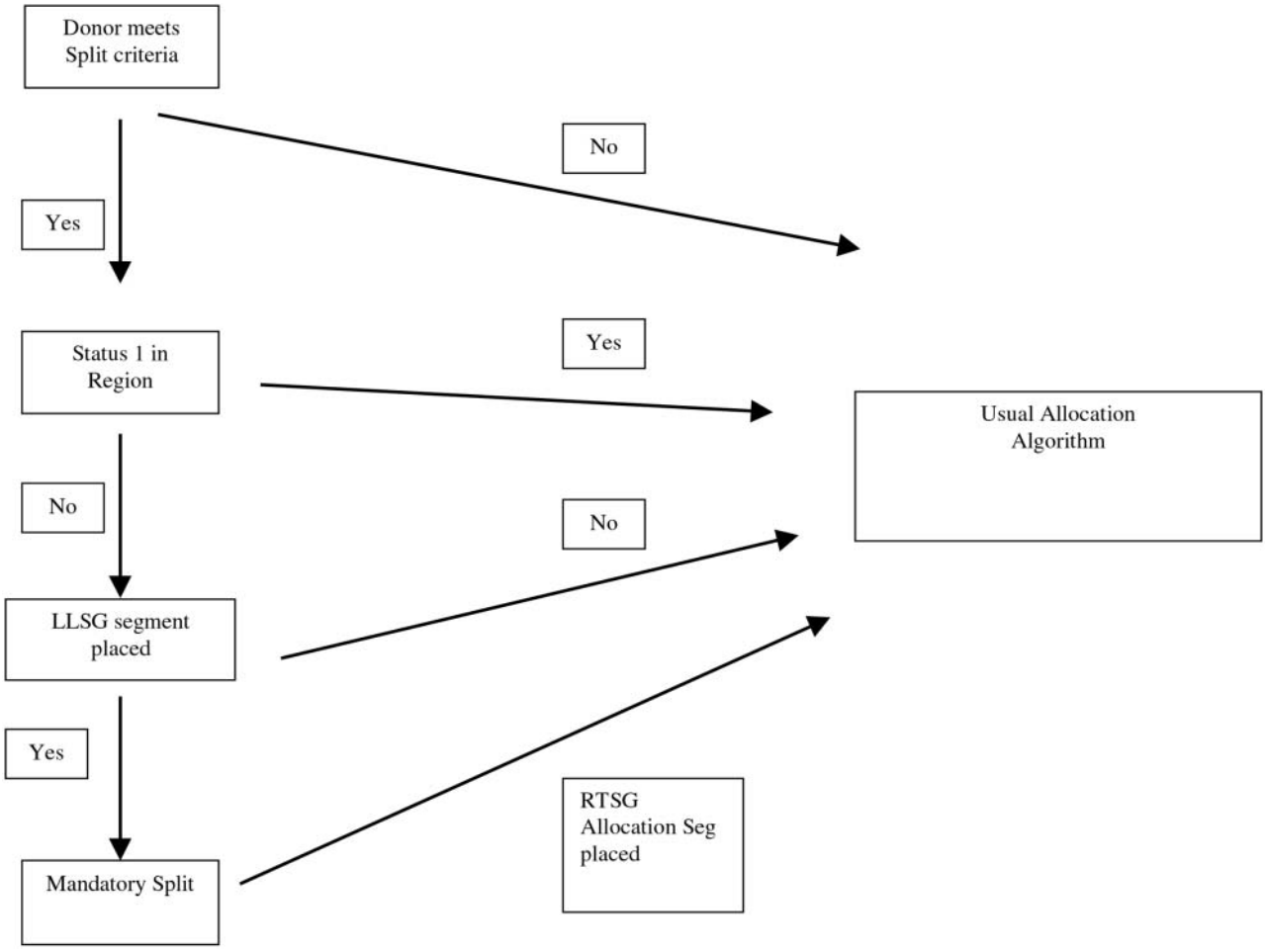

Figure 6: Crystal City Allocation Algorithm for splitting liver into Left Lateral Segment Graft (LLSG) and Right Trisegment Graft (RTSG). When a donor is identified that meets the split liver criteria, the split liver allocation algorithm would be activated: 1. If a status 1 patient is active in that UNOS region then the donor liver would be allocated to that recipient according to standard UNOS policy. 2. If there is no status 1 recipient or if the center with the status 1 recipient declines the whole liver offer, the OPO then identifies any potential LLSG recipients (usually by weight range) in that OPO and offers the LLSG to candidates in order on the waiting list prioritized by prevailing UNOS policy. 3. If the LLSG is accepted, the RTSG is offered to the next ranking recipient until it is accepted. 4. If the RTSG cannot be placed before the start of the donor procurement procedure, the RTSG graft is allocated to the LLSG accepting center.

CNS Tumors

When considering organ use from donors suffering from intracranial malignancies, there are a number of general guidelines. Most important is to consider the known biologic behavior of various CNS neoplasms and their propensity to spread outside of the cranial vaults. Repeated craniotomy as well as ventriculoperitoneal or ventriculojugular shunts have been associated with increased risk of metastasis.

A list was developed outlining the relative risks as determined by data and known biologic behavior of the tumors (see Table 3). High-risk tumors should be considered for life-threatened allograft recipients.

Serology Evaluation of an Organ Donor

Table 4 provides guidelines of reliability for the serologic testing, and Table 5 presents the known risks of viral transmission to allograft recipients.

If the serology reveals a determination of hepatitis B core Ab +, the simultaneous determination of a hepatitis B s Ab and histological findings consistent with hepatitis ± cirrhosis on liver biopsy, would confirm that the positive hepatitis B core Ab is a true positive. In addition, the class of hepatitis B core positivity, as IgM +, indicates recent infection. Finally, hepatitis B DNA may provide additional information regarding risk of disease transmission, although this use has *not* been

Table 3: Risk of CNS tumor transmission from cadaver donor to allograft recipient

Lowest risk:
- *Benign Meningiomas*
- Pituitary Adenomas
- Acoustic Schwannomas
- Craniopharyngiomas
- Astrocytoma Grade I
- Epidermoid Cysts, Colloid Cysts
- Low-Grade Oligodendromas
- Gangliogliomas, Gangliocytomas
- Pineocytomas, Ependymomas
- Well Differentiated Teratomas
- Papillomas
- Hemangioblastomas

Moderate risk:
- Astrocytoma (Grade II)
- Gliomatosis Cerebri

Highest risk:
- Anaplastic Astrocytoma (Grade III)
- Glioblastoma Multiforme
- Medulloblastoma
- Anaplastic Oligodendroglioma
- Pineoblastomas
- Chordomas
- Malignant Ependymomas
- Primary Cerebral Lymphomas

validated by data. The work group proposed that the ideal recipients for kidneys or thoracic organs from hepatitis B core Ab + donors might be those + for HepBsAb. The low risk of disease transmission suggests that a prophylactic treatment strategy may *not* be warranted. The recipient pool may be justifiably expanded considering the low risk of disease transmission and the availability of effective therapy (Lamivudine). The work group also recommended that all transplant candidates should undergo HepB vaccination. Serologic testing for hepatitis C virus (HCV) is based upon ELISA (EIA) which detects antibodies against HCV antigens. As the sensitivity of anti-HCV EIA has increased, specificity has decreased. In the event of a repeatedly reactive EIA, the recombinant immunoblot assay (RIBA) can help discriminate between a true and false positive result. There is *no* increase in short- (1 year) and medium- (5 year) term mortality and morbidity (incidence, timing, or severity of liver disease) associated with the transplantation of a liver from a hepatitis C Ab + donor vs. a hepatitis C Ab – donor into a *hepatitis C ± recipient*. Genotype is only predictive of response to therapy. Genotype does *not* predict disease severity. Repopulation occurs at equal frequency by donor and recipient genotype. Ideal recipients may be those positive for hepatitis C, although this has not been uniformly held by transplant centers. There is no adverse impact on graft or patient survival 3–5 years after transplantation of a kidney from a hepatitis C Ab + donor into a hepatitis C + recipient compared to a kidney transplanted from a hepatitis C Ab – donor.

The Heart Work Group

The shortage of available donor hearts severely limits clinical cardiac transplantation. For this reason, strict criteria have limited the number of patients placed on the USA waiting list to approximately 6000–8000 per year, though it is estimated that at least 25 000 patients per year would benefit from the procedure. Sub-optimal utilization of donor hearts has compounded the problem in USA. In a 1999 survey from the Association of Organ Procurement Organizations, the average donor yield from 55 regions was 39%, ranging from 19% to 62%.

The primary objectives of the Heart Work Group were to determine the accuracy of current methods to assess donor

Table 4: Reliability of serologic testing

	Sensitivity	Specificity	Comments
HBsAg	High	High	Confirmatory testing with antibody neutralization assay is routinely done False negatives may occur with mutant HBV strains (uncommon) False positives may occur immediately after HBV vaccination
HBcAb	High	Moderate	Significant false positive rates NO available confirmatory test#
HCVAb	High	Moderate	RIBA can improve specificity: performed by some but not all OPOs
HIVAb	High	High	

#Acquisition and consideration of additional data may be helpful in the interpretation of a positive result:
1. Risk factors (ethnicity and social behavior).
2. Titer of hepatitis B core antibody.
3. Result of HBsAb testing.
4. Characterization of HBcAb as IgM.
5. result of HCV Ab testing.
6. Histology of liver biopsy.

Table 5: Risk of viral transmission

	Donor serology	Risk of viral transmission
	HBsAb + recipient	HBsAb – recipient
HBsAg +	Liver: Insufficient data	Liver: High
	Non-liver: Insufficient data	Non-liver: High
HBcAb +	Liver: Low – Moderate[@]	Liver: Moderate – High
	Non-liver: Very Low	Non-liver: Low
HCVAb +	HCVAb + recipient	HCVAb – recipient
	Liver: High *	Liver: High
	Non-liver: Insufficient data[%]	Non-liver: High

@ Data indicate that the risk of viral transmission may be lower for recipients who are immune from previous HBV infection (HBsAb +/HbcAb +) compared to recipients who are immune from vaccination (HBsAb +/hbcAb –).

* Although there is evidence that the donor virus is transmitted to the recipient, repopulation after liver transplantation occurs with approximately even frequency by donor or recipient strain. Available data indicate *no* increase in short (1 year) and medium (5 year) term mortality and morbidity (incidence, timing, or severity of liver disease) associated with transplantation of a liver from a HCVAb + donor vs. a liver from an HCV Ab – donor into a hepatitis C + recipient.

% There are insufficient data regarding persistence of donor vs. recipient virus strains after transplantation to determine the true incidence of viral transmission. Available data indicate that transplantation of a kidney from an HCVAb + donor has *no* adverse impact on graft and patient survival (5 years) or the recipient's HCV disease compared to a kidney from an HCVAb – donor.

heart function prior to recovery and to provide recommendations to improve the successful utilization of cardiac donors. The first hypothesis of the heart group was that existing criteria for heart donor suitability can be broadened to increase utilization of marginal donors without compromising recipient outcomes. The second hypothesis was that intensive management of heart donors, including liberal use of pulmonary artery catheterization and hormonal resuscitation, would improve utilization of donors with left ventricular systolic dysfunction and/or hemodynamic instability. The complete recommendations of the Heart Work Group will be published separately.

The heart group proposed modified donor criteria, which have the potential to expand the available pool of cardiac donors. These criteria include donor age, size, left ventricular hypertrophy (LVH), mild valvular disease, and the evaluation of coronary artery disease (CAD). These modifications are described in Table 6. It is important to consider the interactions between the characteristics of the donor heart and the recipient as well as the degree of urgency for the recipient when considering marginal or nonstandard organs.

Although echocardiography is effective in screening for anatomical abnormalities of the heart, the use of a single echocardiogram to determine the physiologic suitability of a donor is not supported by evidence. An alternative approach, using a pulmonary artery catheter to guide the physiologic assessment and management of ventricular dysfunction, has been used with success in UK.

The heart group proposed that metabolic abnormalities, anemia, and excessive dosing of inotropes be corrected prior to obtaining an echocardiogram. Aggressive donor management, including pulmonary artery catheterization and hormonal resuscitation should be performed in all donors with an initial left ventricular ejection fraction less than 45%. If specific hemodynamic criteria can be achieved in these

Table 6: Crystal City modifications of existing heart donor criteria

Criteria	Modification(s)
Age	Donors >55 may be used selectively, though coexisting LVH and longer ischemic times may increase recipient mortality risks
Size	Despite an increased risk associated with small donors, a normal sized adult male (>70 kg) donor is suitable for most recipients
LVH	Mild LVH (wall thickness ≤ 13 mm by echocardiography and no LVH by ECG criteria) does not preclude recovery, particularly with shorter ischemic times
Valvular lesions	Certain lesions, such as mild or moderate mitral or tricuspid regurgitation, or a normally functioning bicuspid aortic valve may be amenable to 'bench' repair, prior to transplantation
Congenital lesions	Certain lesions, such as a secundum type ASD, may be amenable to 'bench' repair
Coronary angiography	a. Male donor age 35–45 years and female donor age 35–50 years: perform angiography if there is a history of cocaine use or ≥ 3 risk factors for CAD b. Male donor age 46–55 years and female donor age 51–55 years: angiography recommended c. Age >55 years: angiography strongly recommended
CAD	Donor hearts with mild coronary artery disease should be considered for recipients with relatively urgent need

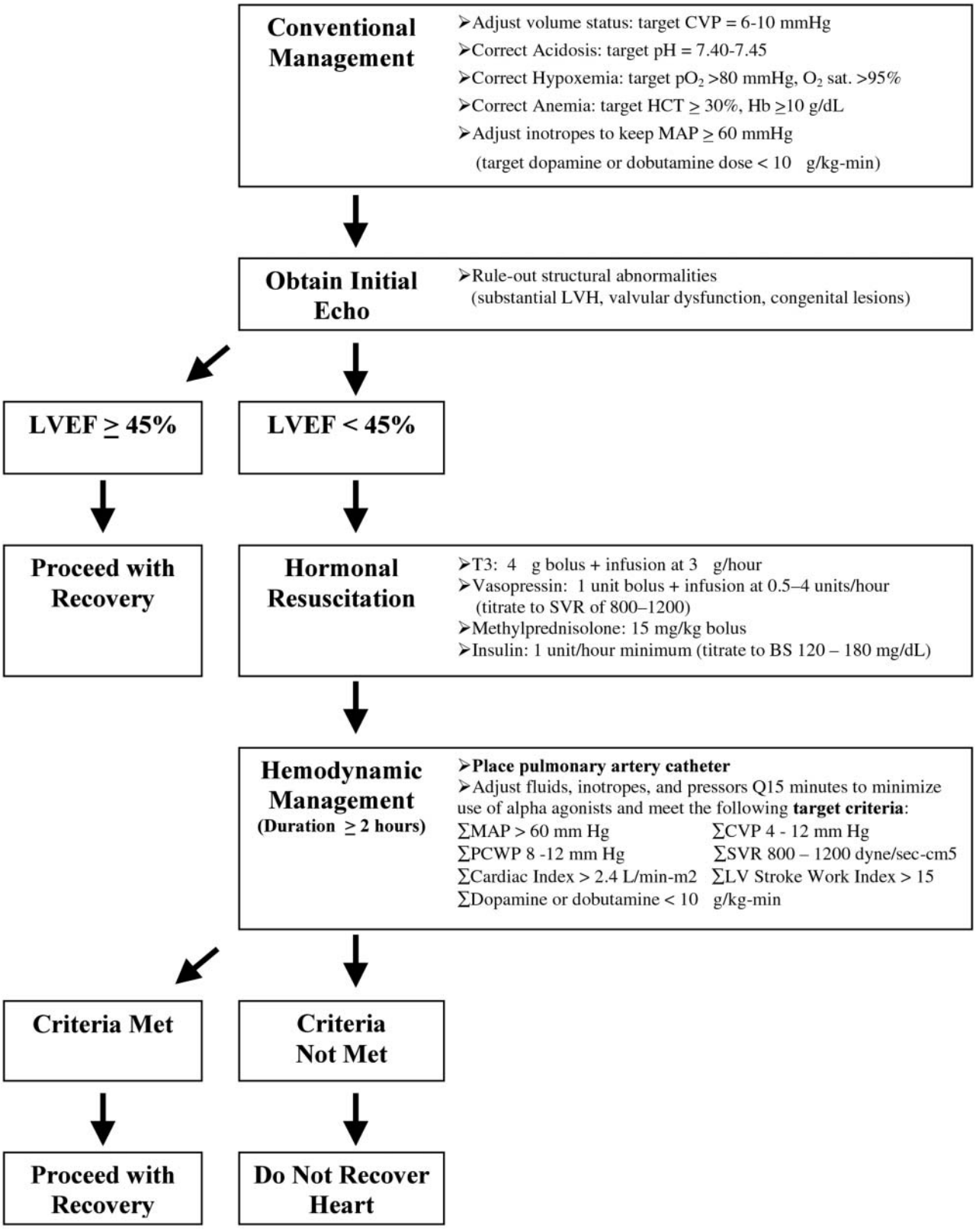

Figure 7: Crystal City recommendations for cardiac donor management, which have been adopted into the UNOS Critical Pathway.

Table 7: Current criteria for lung donation

- *PO2/FiO2 ratio >300, FiO2 = 1.0,*
- PEEP = 5 cm H_2O
- Clear chest X-ray
- Age < 55 years *
- Absence of chest trauma
- Absent aspiration, sepsis, or purulent secretions
- Smoking history of < 20 pack years
- Absent history of malignancy

* The Lung Work Group proposed new criteria to include virtually any donor with age up to 65 years and an absence of lung injury from smoking.

cases, it is appropriate to proceed with recovery. The heart group's specific recommendations for donor management are shown in Figure 7. These recommendations have been adopted into the UNOS Critical Pathway.

The Lung Work Group

The annual number of lung transplants in USA has fluctuated between 850 and 950 for the past 5 years, in a period when the number of thoracic organs recovered from cadaveric donors declined. As the number of patients waiting for lung transplantation continues to increase, there were about two deaths for every three patients who underwent lung transplantation in the year 2000. Variations in OPO practice have been evident by the rates of lung procurement ranging from 7 to 22% of potential donors. Patient selection, patient evaluation, and donor management were cited as important reasons for differences in the utilization of cadaveric lungs. Utilization rates in Canada are higher than in USA. In Australia, lungs from 50% of potential donors have been utilized without compromising recipient outcome. In USA, there is also a utilization variance between small and large centers; smaller centers are defined by fewer than 10 lung transplants per year. Programs transplanting more than 20–25 lungs per year tend to show much higher utilization rates. Wider application of broader criteria for donor selection and procurement is possible and can clearly increase the size of the donor pool. If uniform multidisciplinary donor management protocols were developed, increased lung utilization would follow. Table 7 presents the current criteria that are used to determine the suitability of a cadaver lung donor. The Lung Work Group proposed the new criteria to include virtually any donor with age up to 65 years, absence of lung injury from smoking, and absence of cancer with metastatic potential. The lung group recommended that the OPO coordinator work with the managing physician/thoracic transplant consultant to correct anemia and address fluid status by PA line data, and to employ the hormonal resuscitation as given by Heart Work Group (see Figure 7).

The optimization of donor management and selection criteria should increase the number of potential organ donors (see Table 8). The standardization and simplification of donor management and procurement protocols would benefit all transplant organs and all transplant patients, as the better the cardiopulmonary function of the donor, the better the organ function after transplantation. The Lung Work Group also emphasized the need to improve communication between OPO coordinators and lung transplant centers. The lung group suggested that a plan for regional organ procurement be developed as soon as possible, simplifying the number of transplant center contacts by an OPO and reduce critical delays in waiting for distant procurement teams to arrive when a local procurement team might be able to do the operation. The Lung Work Group also recognized the need to develop outcome research to determine whether prolonged ischemic time or other donor risks may be acceptable. For example, the capacity to augment edema fluid clearance in the lung may be maintained long after the current presumed 'limit' of 6 h. Finally, the development of alternative donors, such as non-heart-beating donors should be explored.

Table 8: Crystal City lung donor management recommendations

The airway:
Bronchoscopy
Frequent suctioning and aspiration precautions
Albuterol therapy for wheezing (may improve lung fluid clearance)

Mechanical ventilation:
Adequate oxygenation:
$pO_2 > 100$ mmHg, $FiO_2 = 0.40$ or O2 saturation > 95%
Adequate ventilation:
Maintain pH 7.35–7.45 and PCO_2 30–35 mmHg
PEEP + 5 cm H_2O
Tidal volume 10–12 mL/kg
Peak airway pressures < 30 mmHg

Fluid management and monitoring:
CVP at a minimum; PA catheter desirable
Arterial line and pulse oximetry
Judicious fluid resuscitation to ensure end-organ perfusion:
CVP 6–8 mmHg, PCW 8–12 mmHg
Urine output 1 cc/kg/h
Colloid as the fluid of choice for volume resuscitation:
Albumin with normal PT, PTT; FFP with coagulopathy;
Hemoglobin > 10 g/dL

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