Lung Procurement From Solid Organ Donors: Role Of Fluid Resuscitation In Procurement Failures

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Citation

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Abstract

Purpose: To determine the incidence of and factors leading to failed lung procu rement from solid organ donors at a university trauma and transplant center.

Methods: Retrospective review of medical and organ procurement organization (OP O) records of all solid organ donors at a university hospital over a 48-month p eriod. Student's t-test and Mann-Whitney U-test were applied for statistical an alysis when appropriate.

Results: Thirty-eight solid organ donors were identified over the 48-month peri od. A mean of 3.5 ± 0.2 solid organs were recovered per donor. Thirteen lungs w ere harvested from 9 donors for a lung procurement rate of 17.1% ($p<0.01$ vs. pr ocurement rates for liver [71.1%], heart [73.7%], and kidney [85.5%]). Successf ul lung donors were significantly younger (21 ± 4 vs. 35 ± 4 years [$p<0.05$]) an d had a shorter time from admission to determination of brain death (20 ± 4 vs. 80 ± 20 hours [$p<0.05$]) than non-donors. Reasons for rejection of lungs most f requently included infection (n=8), underlying lung disease (n=5), and progress ive in-hospital pulmonary dysfunction (n=9). Potential lung donors who develope d progressive pulmonary dysfunction had a marked and significant fluid balance (7000 ± 1000 vs. 300 ± 600 cc [$p<0.05$]) when compared to the donor group. No pa tient with progressive pulmonary dysfunction had fluid and vasopressor therapy guided by the use of a pulmonary artery catheter.

Conclusions: The inability to successfully procure lungs from solid organ donor s remains a significant limiting factor to lung transplantation. Younger patien ts who are quickly pronounced brain dead and proceed to organ procurement are m ost likely to become successful lung donors. While the reasons for failed lung procurement are multi-factorial and often unavoidable, the potential for iatrog enic injury to the lungs with over-aggressive fluid resuscitation while awaitin g the determination of brain death appears significant.

INTRODUCTION

Advancements in surgical technique, post-operative care, and immunosuppression have led to major advancements in solid organ transplantation. Over the last twenty years, transplantation has increasingly become an accepted treatment for a number of end-stage diseases [1].

Unfortunately, the exponential increase in patients on waiting lists awaiting transplantation has not been matched by a significant increase in the number of organ donors [2].

The shortage of suitable organs for donation is particularly critical in the field of lung transplantation [3]. The number of patients on lung transplant waiting lists nationally has grown

from 68 in 1988 to greater than 3200 as of April 21, 1999 2. In fact, nearly 500 patients died in 1998 while awaiting a lung transplant 2. Unfortunately, the majority of organ donors do not have lungs suitable for transplantation. The reasons for this appear multi-factorial, but there is a concern that the management of the potential organ donor, traditionally aimed at maintaining adequate hydration to ensure renal and hepatic function, may actually adversely affect the lungs.

This retrospective study was performed to determine the actual percentage of solid organ donors who are suitable lung donors. More importantly, from a performance improvement standpoint, we hoped to identify potentially preventable factors, which led to the rejection of donor lungs by the local organ procurement organization.

METHODS

A retrospective review of medical and organ procurement organization (OPO) records of all solid organ donors at a university hospital over a 48-month period was performed. Demographic data was abstracted, as were complications during the hospital stay and the cause of brain death. Time of presentation/admission to determination of brain death was calculated. Fluid balance and the use of pharmacological agents and pulmonary artery catheters were noted.

The specific reasons for lung procurement failure from solid organ donors were identified. In-hospital progressive pulmonary dysfunction (PPD) was defined as significant worsening of the A-a gradient during the hospital stay, usually with patchy bilateral infiltrates on CXR, but always without documented evidence of infection.

Results, when appropriate, are presented as the mean ± the standard error of the mean. Student's t-test and Mann-Whitney U-test were applied for statistical analysis when appropriate.

RESULTS

38 solid organ donors were identified over a 48-month study period. 25 of the donors (65.8%) died from traumatic injury, and 13 (34.2%) from a primary, non-traumatic, CNS event. The mean age of the donors was 31 ± 5 years. There were 30 male and 8 female donors.

133 solid organs were harvested and transplanted from 38 solid organ donors for an average of 3.5 ± 0.2 organs/donor. Procurement rates for individual organs are presented in Table 1. While more than 70% of potential kidneys, livers, and hearts were procured, only 17.1% of potential lungs were ultimately transplanted. This was statistically significant ($p<0.01$)

Figure 1

PROCUREMENT RATES		
	N	Procurement Rate
Lung	13	17.1%
Liver	27	71.1%*
Heart	28	73.7 %*
Kidney	65	85.5%*
* p<0.01 vs. Lung procurement rate.		

* $p<0.01$ vs. Lung procurement rate.

Reasons for rejection of lungs by the organ procurement organization are presented in Table 2. Infection, most often diagnosed by bronchoscopic sampling, resulting in the loss of 8 lungs. Underlying lung disease, most often seen in older donors, was the reason for rejection of 5 lungs. Surprisingly, the most common cause of lung unsuitability was progressive in-hospital pulmonary dysfunction. 31% of lungs rejected in this review suffered from this process.

Figure 2

REASONS FOR LUNG PROCUREMENT FAILURE		
	N	% of Failures
Progressive Pulmonary Dysfunction	9	31%
Infection	8	28%
Active	7	
History	1	
Underlying Lung Disease	5	17%
Family Refusal	2	7%
Direct Trauma	2	7%
Other	3	10%

A comparison of donors and non-donors is presented in Table 3. Successful lung donors were significantly younger than non-donors. In addition, the time from admission to the determination of brain death was significantly shorter for the donor group. No difference was noted in the mechanism of lethal insult, use of vasopressors, or presence of Diabetes Insipidus during the brain death stay.

Figure 3

COMPARISON OF DONORS AND NON-DONORS			
	Donor	Non-Donor	p Value
N	9	9	
Age (years)	21 ± 4	35 ± 4	<0.05
Time to Brain Death	20 ± 4	80 ± 20	<0.05
Determination (hours)			
Mechanism			
Penetrating Trauma	3 (33%)	14 (48%)	NS
Blunt Trauma	3 (33%)	5 (17%)	NS
Primary CNS	3 (33%)	10 (34%)	NS
Vasopressor Use	9 (100%)	24 (83%)	NS
Diabetes Insipidus	2 (22%)	7 (24%)	NS

Potential lung donors who developed progressive pulmonary dysfunction had a marked and significant fluid balance (7000 ± 1000 vs. 300 ± 600 cc [p<0.05]) during their short hospital stay when compared to the donor group. Despite a worsening A-a gradient, a significant fluid requirement, and the liberal use of vasopressors, no patient with progressive pulmonary dysfunction had therapy guided by the use of a pulmonary artery catheter. (Table 4)

Figure 4

Table 4: In-Hospital Progressive Pulmonary Dysfunction

	Donor	PPD	p Value
N	9	9	
Positive Fluid Balance (cc)	30 ± 600	7000 ± 1000	<0.05
Pulmonary Artery Catheter	1 (11%)	0 (0%)	NS

DISCUSSION

The inability to successfully procure lungs from solid organ donors remains a significant limiting factor to lung transplantation. From this review, it appears that young patients who are quickly pronounced brain dead and proceed to organ procurement are most likely to become successful lung donors. Potential organ donors are at significant risk for multiple complications, which may lead to pulmonary deterioration and an ultimate failure of lung procurement [4]. While the reasons for failed lung procurement are multi-factorial and often unavoidable, the potential for iatrogenic injury to the lungs with over-aggressive fluid resuscitation while awaiting the determination of brain death appears significant.

There are a number of possible steps, which may be taken to improve lung procurement rates. An increase in the total number of organ donors is the most obvious solution. It is estimated that only 20% to 30% of potential donors actually go on to organ donation [5,6]. Nationally, multiple efforts are in place to improve donation rates. Recent results suggest that these efforts may be having a modest effect 2. Once consent is obtained, aggressive medical management is necessary to prevent medical failures to organ donation (as high as 17% of potential organ donors in one recent review) 4.

Little can be done about premorbid pulmonary disease, direct trauma, or the high incidence of aspiration at the time of injury, all contraindications to lung donation. Acute pulmonary infection or colonization of the potential donor is common secondary to the presence of an endotracheal tube. In addition, poor pulmonary toilet, due to a loss of normal “cough reflexes” and a reluctance to suction (and stimulate) a patient with an increased ICP, only worsens this problem [7]. Unfortunately, it seems only a relaxation of standards for donor lungs would significantly impact on this aspect of the problem [8,9].

Interestingly, the time from admission to the determination of brain death may be a factor which intensivists can impact. We recently have decreased our brain death stay from 12 to 4.5 hours (with an associated decrease in patient charges) by utilizing cerebral blood flow scans to rapidly determine brain death [10,11]. Further research is needed to determine whether this will translate into an increase in the number of organs procured per donor and a decrease in medical failures to donation, although preliminary reports are favorable [12].

In patients who arrive at the hospital with suitable lungs, the incidence of progressive pulmonary dysfunction (PPD) is distressing. The etiology of this process cannot be determined from this study, especially since none of these patients had pulmonary artery catheters in place. PPD may represent ARDS, neurogenic pulmonary edema, or simply fluid overload [13,14,15]. As noted above, these patients were markedly fluid positive during their hospital stay. Even though they required significant amounts of fluid, had worsening A-a gradients, and most often required vasopressors for blood pressure support, not one of these patients had a pulmonary artery catheter in place to assist in volume management. In contrast, the lung donor group, while frequently requiring vasopressors for blood pressure support, did not require excessive amounts of fluid or have a marked worsening of their A-a gradients. Clearly this group did not appear to have an indication for invasive monitoring

with a pulmonary artery catheter.

Would the routine use of pulmonary artery catheters impact on the lung procurement rates from solid organ donors? The data presented here cannot answer that question. We currently place pulmonary catheters in potential organ donors to guide fluid and vasopressor therapy in the hopes of minimizing fluid overload, increasing lung procurement rates and maximizing the number of solid organs procured from each donor. We currently now harvest an average of 4.7 solid organs / donor from our intensive care unit 11. Still, prospective studies are needed to determine if this routine use of pulmonary artery catheters is justified in this patient population.

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