Does Donor Cardiopulmonary Resuscitation Time Affect Heart Transplantation Outcomes and Survival?

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Background. **Donor heart availability has limited the number of heart transplants performed in the United States, while the number of patients waiting for a transplant continues to increase. Optimizing the use of all available donor hearts is important to reduce waiting list deaths and to increase the number of patients who can ultimately undergo a successful heart transplant. Donor cardiopulmonary resuscitation (CPR) time has been proposed to be a selection criterion to consider in donor selection. This study examined whether the duration of donor CPR time affects recipient posttransplantation outcomes and survival.**

Methods. **The United Network of Organ Sharing database was retrospectively queried from January 2005 to December 2013 to identify adult patients who underwent heart transplantation. This population was divided into four groups: donors with no CPR, CPR of less than 20 minutes, CPR of 20 to 30 minutes, and CPR exceeding 30 minutes. Kaplan-Meier analysis was used to compare the recipient posttransplant survival between groups, and posttransplant outcomes were examined. Propensity matching was performed for comparison of posttransplant survival of recipients of donors who did and did not undergo CPR. Multivariable logistic regression analysis was performed to examine individual independent variables for death after transplant.**

Results. **During this period, 17,022 patients underwent heart transplantation. Of those, 16,042 patients received hearts from a donor with no CPR, 639 patients with donor CPR of less than 20 minutes, 154 patients with donor CPR 20 to 30 minutes, and 187 patients with donor CPR exceeding 30 minutes. The posttransplant survival at 1 year for each group was 89% vs 90% vs 88% vs 89% and at 5 years was 75% vs 74% vs 74% vs 72%, respectively, which was not significantly different among the groups. Recipient primary graft failure and rejection rates were similar among the groups. The multivariable regression model showed CPR duration was not an independent risk factor for posttransplant death.**

Conclusions. **Donor CPR does not significantly affect outcomes and survival after transplant. In an effort to optimize donor heart use, donor CPR time alone should not be used to rule out the acceptance of a potential donor heart.**

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Despite the advancement of mechanical circulatory support, heart transplant remains the gold standard for patients with end-stage congestive heart failure. The number of heart transplants in the United States has been limited by donor heart availability, while the number of heart failure patients and transplant waiting list patients continues to increase, along with the use of continuous-flow left ventricular assist devices (LVADs) as bridge-to-transplant (BTT) devices [1, 2]. Optimizing the use of all appropriate available donor hearts is becoming increasingly important to minimize waiting list deaths and to perform transplants in more patients with end-stage heart failure. The use of "marginal" or "extended-criteria" donor hearts has been proposed in an effort to increase the donor organ pool [3–5]. However, the standard "marginal" donor heart is not well defined.

Historically, donor cardiopulmonary resuscitation (CPR) time, especially donors with extended CPR time, has been proposed as a donor exclusion criterion because it is suspected to influence outcomes and survival after heart transplantation secondary to potential myocardial injury [6–10]. The exact duration of CPR time that may or may not affect transplant outcomes remains unknown [8–12]. In this study, we used the United Network for Organ Sharing (UNOS) database to examine whether the length of donor CPR time affects recipient post-transplantation outcomes and survival.

Material and Methods

Data and Study Population

Data were requested from the UNOS registry, after Institutional Review Board approval, for thoracic organ

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transplantation. Additional donor troponin data were requested from UNOS and merged into the standard UNOS database for analyses. The UNOS database was then queried to identify patients aged 18 years or older who underwent heart transplantation between 2005 and 2013. This resulted in 17,022 patients who were further classified in two groups by whether the donors did or did not receive CPR at any time point after the neurologic event and before procurement. The donors who received CPR were further divided by the duration of the CPR: CPR of less than 20 minutes, CPR of 21 to 30 minutes, and CPR exceeding 30 minutes. Outcomes for donor graft failure and rejection, as well as 1- and 5-year survival, were compared among the groups. Donor (Table 1) and recipient (Table 2) demographic factors and characteristics were examined.

Statistical Methods

Analysis of variance was used to compare the continuous variables among the groups and the Bonferroni *t* test was applied to identify differences within the groups. The χ^2 test was used to assess the differences between the categoric variables among the groups. Kaplan-Meier survival analysis was used to compare the posttransplant survival among the groups. A multivariate logistic regression model using donor factors was generated to identify factors independently associated with posttransplant death at 1 year.

To account for differences between the donor demographics for recipients of donors who did and did not receive CPR, a propensity-score analysis was performed to match the CPR group to the no-CPR group with ratio of 1:1. All donor factors with *p* value of 0.1 or less were included in a logistic regression model to generate a propensity score. The propensity score was used to match the CPR group (n = 812) to the no-CPR group (n = 819 matched patients). All statistical tests were performed using SAS 9.4 software (SAS Institute Inc, Cary, NC) at the 95% confidence level.

Results

Of the 17,022 patients who underwent heart transplantation during the study period, 16,042 patients received hearts from a donor with no CPR, 639 patients from a donor with a CPR time of less than 20 minutes, 154 patients from a donor with CPR time between 20 and 30 minutes, and 187 patients from a donor with a CPR time exceeding 30 minutes. Donor characteristics for the four groups are reported in Table 1.

More hearts from male donors were used for transplant in all four groups. The mean donor age for all groups was 31.5 ± 11.2 years, with no significant difference among the groups. There were no differences in donor ejection fraction, ischemic time, and inotrope requirement. Donors with CPR exceeding 30 minutes had a higher body mass index (BMI; 29.4 ± 7.5 kg/m^2), a higher proportion had a history of cocaine use (Table 1), and they had the highest creatinine (2.1 ± 2.02 mg/dL) and troponin I levels (1.72 ng/mL). In addition, as the CPR time increased, the donor creatinine and troponin I level also increased.

The incidence of head trauma as the cause of brain death was higher in donors without CPR. Donors with

Table 1. Heart Transplant Donor Characteristics

Donor Variables	No CPR (n = 16,042)	CPR <20 min (n = 639)	CPR = 21–30 min (n = 154)	CPR >30 min (n = 187)	*p* Value
Age, mean ± SD, y	31.6 ± 11.8	30.4 ± 10.9	31.6 ± 11.2	32.2 ± 11.1	0.07
Male gender,[a,b] %	72	69	64	64	0.009
BMI,[a,b] mean ± SD, kg/m^2	26.9 ± 5.5	27.5 ± 6.1	28.3 ± 6.6	29.4 ± 7.5	<0.0001
Diabetes,[b] %	3	4	4	6	0.07
History of					
Cocaine use,[b] %	14.1	14.5	16	29	<0.0001
Cigarette use, %	16	15	14	16	0.5
Inotrope, %	1.3	2.1	1.3	2.1	0.2
Vasopressin, %	61	61	55		
Ejection fraction[b]	0.616 ± 0.071	0.616 ± 0.79	0.615 ± 0.74	0.600 ± 0.74	0.15
CPR time, mean ± SD, min	NA	10.3 ± 6.1	26.6 ± 3.3	47.4 ± 14.6	<0.001
Ischemia time, mean ± SD, h	3.2 ± 1.0	3.1 ± 1.0	3.1 ± 0.9	3.2 ± 0.9	0.15
Troponin I,[b] median, ng/mL	0.28	0.60	0.61	1.72	0.002
Creatinine,[a,b,c] mg/dL	1.3 ± 1.2	1.5 ± 1.5	1.7 ± 1.8	2.1 ± 2.02	<0.0001
Cause of brain death[a,b,c]					<0.0001
Stroke, %	22	13	10	12	
Head trauma, %	59	50	29	15	
Anoxia, %	15	34	59	71	

[a] Significant difference (p <0.05) between no-CPR and CPR for 21–30 min group. [b] Indicates significant difference (p < 0.05) between no-CPR and CPR for >30-min group. [c] Indicates significant difference (p < 0.05) between no-CPR and CPR for <20-min group.

BMI = body mass index; CPR = cardiopulmonary resuscitation; SD = standard deviation; NA = not applicable.