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.

Table 2. Heart Transplant Recipient Baseline Characteristics and Posttransplant Outcomes[a]

Recipient 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	52.4 ± 12.6	51.8 ± 13.3	52.3 ± 13.7	52.3 ± 12.6	0.9
Male gender, %	75	77	71	72	0.2
BMI, mean ± SD, kg/m^2	26.9 ± 4.8	27.3 ± 4.7	27.7 ± 5.6	27.6 ± 4.8	0.02
Creatinine, mean ± SD, mg/dL	1.36 ± 0.9	1.37 ± 0.8	1.36 ± 0.8	1.39 ± 0.9	0.6
Pulmonary artery pressure, mean ± SD, mm Hg	28.3 ± 10.1	28.5 ± 10.1	27.9 ± 9.4	28.9 ± 9.9	0.7
PCWP, mean ± SD, mm Hg	18.8 ± 8.8	18.7 ± 8.5	18.0 ± 8.7	19.1 ± 8.6	0.6
Diabetes, %	26	27	22	24	0.6
Bilirubin, mean ± SD, mg/dL	1.17 ± 1.9	1.19 ± 2.02	1.00 ± 0.66	1.07 ± 0.88	0.7
CF LVAD,[b] %	21	22	26	27	0.07
UNOS status 1A,[b] %	51	55	55	58	0.03
Blood type, %					0.3
O	39	41	39	45	
A	42	40	41	40	
B	14	14	16	12	
AB	5	4	4	3	
Ventilator,[c] %	18	24	16	21	0.001
Cardiomyopathy, %					
Ischemic	36	35	34	30	0.4
Idiopathic	34	35	32	29	0.4
Acute rejection, %	16	18	14	18	0.8
Graft failure at most recent follow-up,[a] %	7	6	4	8	0.2
Renal failure requiring dialysis after transplantation,[b] %	10	10	12	15	0.1
Posttransplant survival at					0.9
30 days, %	96	96	96	95	
1 year, %	89	90	88	89	
5 years, %	75	74	74	72	

[a] Mean follow-up period 5.5 years. [b] Significant difference ($p < 0.05$) between no-CPR and CPR >30-min group. [c] Significant difference ($p < 0.05$) between no-CPR and CPR <20-min group.

BMI = body mass index; CF = continuous flow; CPR = cardiopulmonary resuscitation; LVAD = left ventricular assist device; PCWP = pulmonary capillary wedge pressure; SD = standard deviation; UNOS = United Network of Organ Sharing.

more than 30 minutes of CPR had a higher incidence of anoxic brain injury as the cause of brain death.

Table 2 reports the recipient characteristics within the four groups. A higher proportion of the recipients who received a donor heart with CPR exceeding 30 minutes were at UNOS 1A status. Recipients who received a donor heart with CPR time exceeding 30 minutes were also larger in size (average BMI of 27.6 ± 4.8 kg/m^2) and a higher proportion had LVAD placement.

The rejection rate, graft failure rate, renal failure rate, and short-term and long-term survival after transplant were not significantly different among the four groups. Table 3 reports the outcomes and survival of recipients with or without LVAD as BTT for all study groups. Posttransplant survivals and outcomes were similar among all groups with or without LVAD support as BTT.

Table 4 reports the multivariable logistic regression analysis of the donor characteristics for posttransplant death at 1 year. Troponin I level and donor CPR time were not independent risk factors for posttransplant death at 1 year. However, donor age was a significant predictor of death at 1 year after transplant. Figure 1 shows the Kaplan-Meier survival curves of the transplant recipients from the four groups. There difference in posttransplant survival among the groups was not significant ($p > 0.05$). Figure 2 shows the posttransplant survival of recipients, with or without LVAD support as BTT, who received donors with a different duration of CPR. The difference among the four groups was not significant ($p > 0.05$).

Figure 3 shows the proportion of all transplants performed with the heart of a donor who received CPR by year 2005 to 2013. Only 3.5% of heart transplants were performed with donors who received CPR in 2005 and increased to 8% in 2013. On average, only 6% (980 of 17,022 transplants) of the transplants between 2005 and 2013 were performed with a donor who had received CPR. Figure 4 shows the propensity-matched recipient posttransplant survival based on donor characteristics between recipients who received donor hearts with and without CPR. There was no significant difference ($p>0.05$) in posttransplant survival of recipients who received

Table 3. Posttransplantation Outcomes and Survival in Recipients With and Without Mechanical Circulatory Support

Recipient Variables	No CPR	CPR <20 min	CPR = 21–30 min	CPR >30 min	p Value
Without mechanical circulatory support, No.	10,604	402	99	116	
Acute rejection,[a] %	15	16	14	22	0.12
Graft failure at most recent follow-up, %	7	6	6	9	0.7
Posttransplant survival at					
30 days, %	96	95	96	96	0.5
1 year, %	89	89	89	91	
5 years, %	77	74	71	74	
With mechanical circulatory support, No.	3,371	143	40	51	
Acute rejection,[a] %	19	23	15	8	0.3
Graft failure at most recent follow-up, %	6	3	0	2	0.12
Posttransplant survival at					
30 days, %	95	97	94	95	0.5
1 year, %	88	92	88	89	
5 years, %	74	73	82	70	

[a] Significant difference ($p < 0.05$) between no-CPR group and CPR >30-min group.

CPR = cardiopulmonary resuscitation.

a donor heart with or without CPR despite a donor propensity-matched comparison.

Comment

In an effort to improve use of donor hearts and to further understand the factors that should be considered as part of the "marginal" donor characteristics, this study used the UNOS database to examined the effects of donor CPR time on posttransplant outcomes and survival. The analysis showed the presence and duration of donor CPR (including CPR >30 minutes) did not affect posttransplant outcomes or short-term and long-term survival. Recipient outcomes, including graft failure rate, rejection rate, and renal failure rate, were not significantly different among the groups.

This analysis also showed a higher proportion of UNOS status 1A patients received a donor heart with CPR exceeding 30 minutes. Despite the recipients being sicker, transplantation with a donor heart that received CPR exceeding 30 minutes did not affect outcomes after transplant. The donor propensity-matched comparison also demonstrated no significant difference in posttransplant survival between recipients who received organs from donors who received CPR and those who did not. Furthermore, extensive donor CPR duration (exceeding 30 minutes) did not affect posttransplant outcomes or survival for patients with and without LVAD support.

The multivariable regression model also showed donor CPR duration and peak troponin values were not an independent risk for death at 1 year after transplant. In this study, donors with extensive duration of CPR used for transplantation had a higher troponin, creatinine, BMI, and proportion with a history of cocaine use. Interestingly, despite these differences, there was no difference in the ejection fraction, ischemic time, and requirement of inotropes of the donors used for heart transplant. This would suggest that as long as the heart function has recovered and the troponin level normalized, the duration of CPR alone will not affect posttransplant outcomes or survival. This should also emphasize that a single donor characteristic, especially donor CPR time, should not be used as the sole justification to exclude the donor organ for transplantation, whereas other donor organ characteristics and risk factors (eg, cardiac function, left ventricular hypertrophy, inotrope used, etc.) should be considered.

The annual number of heart transplantations in United States has been limited by the supply of donor organs. Because the number of patients with advanced heart failure is rapidly increasing, the use of all available donor organs must be optimized to minimize waiting list deaths.

Table 4. Multivariate Logistic Regression Model for Posttransplant Mortality at 1 Year

Donor Factors	Point Estimate	95% Confidence Limits	
Peak troponin I	1	0.998	1.003
Age	1.015	1.009	1.021
BMI	1	0.988	1.012
Creatinine	1.022	0.975	1.072
Ejection fraction	1.004	0.995	1.014
CPR 0 vs >30 min	1.078	0.596	1.951
CPR <20 min vs >30 min	0.907	0.457	1.799
CPR 21–30 min vs >30 min	1.168	0.492	2.771
Cocaine use	1.212	1.000	1.47
Diabetes	0.959	0.829	1.109
Brain death			
Anoxia	0.693	0.369	1.3
Stroke	0.654	0.352	1.217
Trauma	0.638	0.345	1.182

BMI = body mass index; CPR = cardiopulmonary resuscitation.

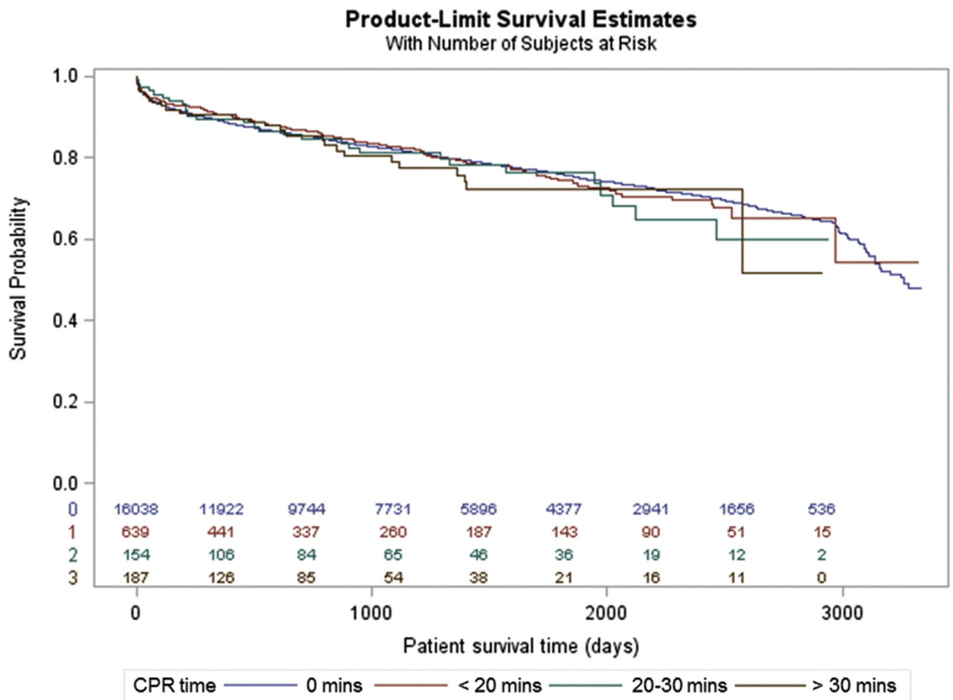

Fig 1. Survival after heart transplant of recipients of donors with no cardiopulmonary resuscitation (CPR), less than 20 minutes of CPR, 20 to 30 minutes of CPR, and greater than 30 minutes of CPR.

"Marginal" donor hearts have been used as a method to increase the donor pool [3–5]; however, the term "marginal" is not well defined. A number of studies have examined the effect of "marginal" donor characteristics on posttransplant recipient outcomes and survival [3–5]. A recently published article [13] showed no significant difference between waiting list survival time of patients with LVAD support as BTT and posttransplant survival of recipients who received donor hearts with the marginal characteristics of advanced age, ejection fraction of less than 0.45, hepatitis C positive, cocaine use, and BMI mismatch. Thus, the authors concluded that there may be

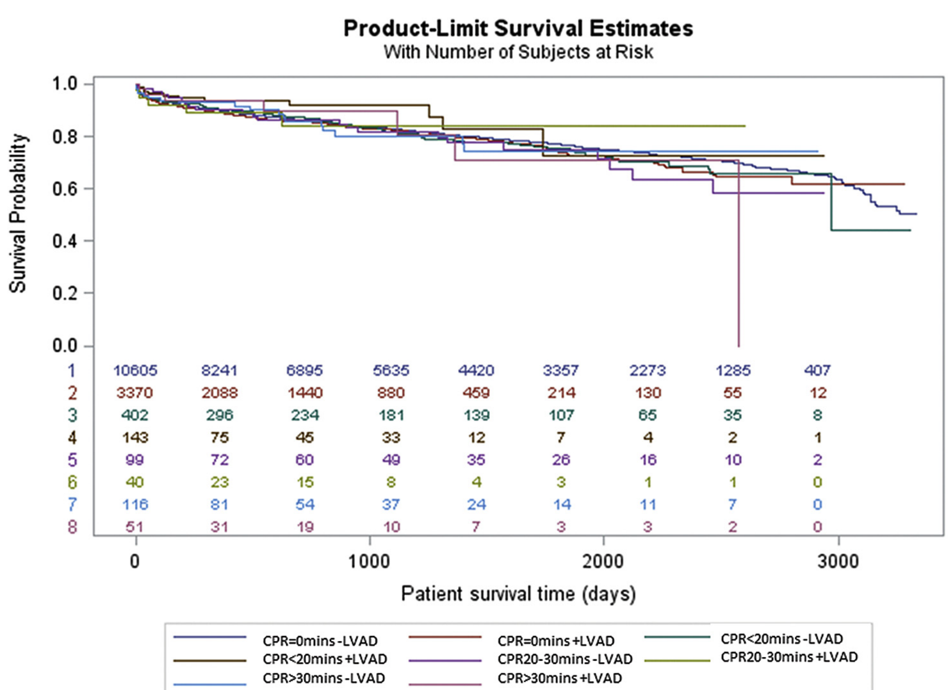

Fig 2. Posttransplant recipient survival with donor with no cardiopulmonary resuscitation (CPR), less than 20 minutes of CPR, 20 to 30 minutes of CPR, and greater than 30 minutes of CPR ($p = 0.5$) in recipients with (+) or without (–) left ventricular assist device (LVAD) support.

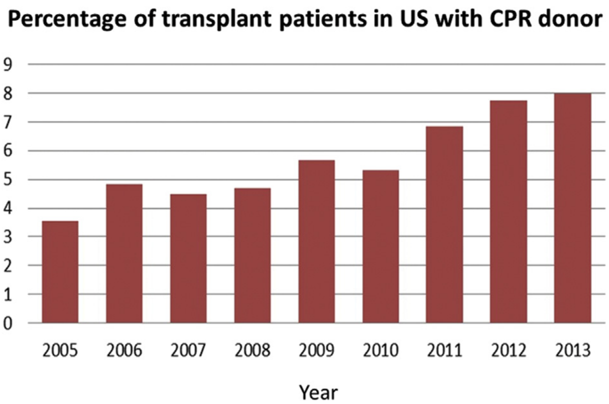

Fig 3. Percentage of transplants using donors who underwent cardiopulmonary resuscitation (CPR) during 2005 to 2013 in the United States (US).

clinical benefits for using LVAD support to allow time for better allocation of optimal donor hearts as opposed to transplantation with a marginal donor heart [13].

Cardiologists and cardiac surgeons have used donor CPR as a historical selection criterion to consider in donor exclusion. Donor cardiopulmonary arrest has been associated with poor transplant recipient outcomes and survival of other organs [6, 7]. Warm ischemia to the myocardium during cardiopulmonary arrest can potentially cause injury to the myocardium [9, 10, 14] and may lead to poor graft function and recipient survival after transplant. Because of this, there is a reluctance of transplant physicians to use donors with extensive CPR time.

The current Scientific Registry of Transplant Recipients (SRTR) risk-adjustment model did not include donor CPR time as a risk variable [15]. Previous studies have examined the heart transplantation outcome from cardiac arrest-resuscitation donors in children and adults [8, 11, 12]. L'Ecuyer and colleagues [8] and Ali and colleagues [11] both showed that the use of cardiac-arrested donor hearts did not affect posttransplant outcomes and survival. However, the effects of donor CPR duration and warm ischemic time on posttransplant survival remain unknown.

The question of whether donors with prolonged CPR time (>30 minutes) should be excluded for transplantation remains to be examined. This is particularly pertinent in the modern era, given that the donor pool is shifting to a higher proportion of donor deaths from anoxic encephalopathy where the incidence of prolonged CPR is higher. The specific duration of CPR that may cause irreversible myocardial injury will need to be better defined if CPR time is to be used as a selection factor for organ refusal.

Furthermore, entering the era of mechanical circulatory support, examining how the duration of warm ischemic time affects the post-transplant outcomes and survival of recipients with mechanical circulatory support before transplant is also important. The CPR time/warm ischemic time, along with the potentially longer ischemic time for LVAD patients, may affect outcomes. In contrast, patients with mechanical circulatory support tend to have better respiratory status and pulmonary pressure. As such, whether the use of a donor heart with extensive CPR may do better in a LVAD patient than in a non-LVAD patient remains unknown. As the UNOS

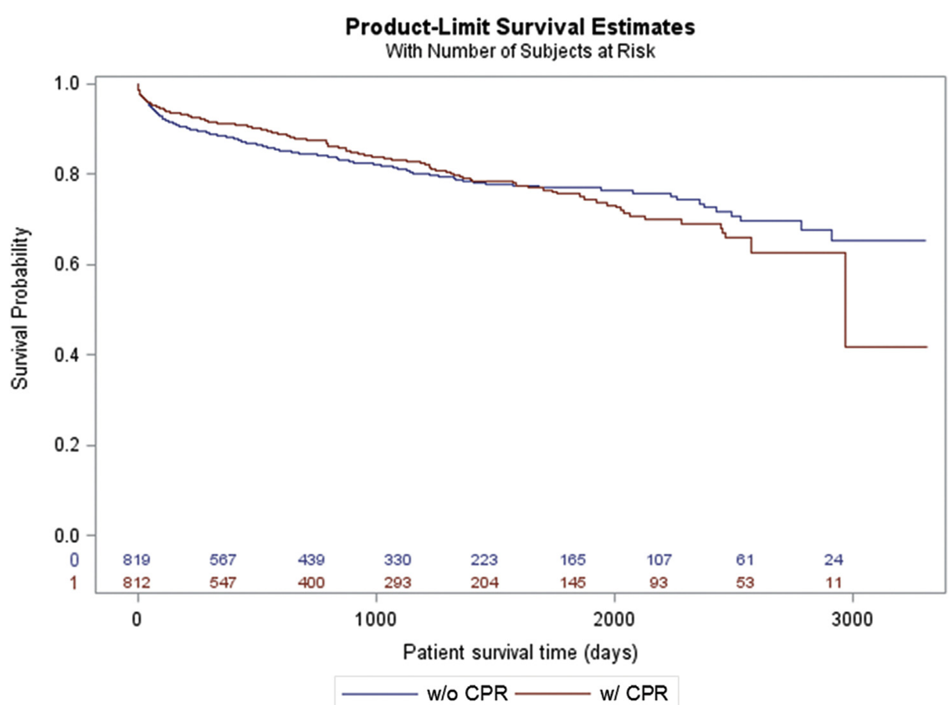

Fig 4. Propensity-matched post-transplant survival between groups with cardiopulmonary resuscitation (w/CPR) and without CPR (w/o CPR; p = 0.2).

allocation scoring is changing to reflect the increased use of LVAD, the use of donors with extensive CPR time in patients stably supported with an LVAD will warrant further examination.

The critical duration of ischemia that leads to irreversible myocardial cell damage is not well defined. Previous studies have shown irreversible injury after 20 minutes, depending on various conditions [9]. Similar to our result, L'Ecuyer and colleagues [8] showed that a donor CPR duration greater than 30 minutes did not affect posttransplantation outcomes and survival in the pediatric population. In a single-center study, Ali and colleagues [11] showed, with an average CPR time of 15 minutes, the use of donors with CPR does not affect posttransplant survival. In our study, the posttransplant survival remained the same even with the use of donor with extensive CPR time (>30 minutes).

Previous studies have shown "preconditioned" hearts have less accumulation of metabolic waste and less depletion of adenosine 5′-triphosphate secondary to the prior synthesized antioxidant enzymes during subsequent ischemic events [16, 17], for example, during storage and transportation for transplantation. We suspect the ischemic "preconditioning" in donor hearts after prolonged CPR may have a protective effect on the donor organ from the subsequent ischemic time after organ procurement and before transplantation.

Limitations

Our study is a retrospective database study and is therefore limited by selection bias. As an example, all donor organs in this analysis were used for transplant and were highly selected. The UNOS database does not include donors who underwent CPR but were not used for transplantation; hence, their characteristics remain unknown. Furthermore, the exact amount of CPR time reported to UNOS is assumed to be well-documented and accurate. Location and personnel data where CPR was performed are also not available from the UNOS database. Hence, it is unknown whether the personnel performing the CPR on site, or at the admitting hospital, have an effect on the effectiveness of the CPR or the degree of myocardial injury.

Conclusions

The duration of donor CPR does not affect posttransplant outcomes and survival. In an effort to optimize use of available donor hearts, donor CPR time can be considered as a less relevant factor for donor selection, even with extensive CPR duration, as long as cardiac function has returned toward normal and the heart is not jeopardized by ischemic time during transplantation.

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References

1. Go AS, Mozaffarian D, Roger VL, et al. Executive summary: heart disease and stroke statistics—2014 update: a report from the American Heart Association. Circulation 2014;129:399–410.
2. Colvin-Adams M, Smith JM, Heubner BM, et al. OPTN/SRTR 2012 annual data report: heart. Am J Transplant 2014;14(Suppl 1):113–38.
3. Russo MJ, Davies RR, Hong KN, et al. Matching high-risk recipients with marginal donor hearts is a clinically effective strategy. Ann Thorac Surg 2009;87:1066–70; discussion 1071.
4. Kransdorf EP, Stehlik J. Donor evaluation in heart transplantation: the end of the beginning. J Heart Lung Transplant 2014;33:1105–13.
5. Felker GM, Milano CA, Yager JE, et al. Outcomes with an alternate list strategy for heart transplantation. J Heart Lung Transplant 2005;24:1781–6.
6. Keitel E, Michelon T, dos Santos AF, et al. Renal transplants using expanded cadaver donor criteria. Ann Transplant 2004;9:23–4.
7. Wilson DJ, Fisher A, Das K, et al. Donors with cardiac arrest: improved organ recovery but no preconditioning benefit in liver allografts. Transplantation 2003;75:1683–7.
8. L'Ecuyer T, Sloan K, Tang L. Impact of donor cardiopulmonary resuscitation on pediatric heart transplant outcome. Pediatr Transplant 2011;15:742–5.
9. Granger DN, Korthuis RJ. Physiologic mechanisms of postischemic tissue injury. Annu Rev Physiol 1995;57:311–32.
10. Pérez López S, Otero Hernández J, Vázquez Moreno N, Escudero Augusto D, Alvarez Menéndez F, Astudillo González A. Brain death effects on catecholamine levels and subsequent cardiac damage assessed in organ donors. J Heart Lung Transplant 2009;28:815–20.
11. Ali AA, Lim E, Thanikachalam M, et al. Cardiac arrest in the organ donor does not negatively influence recipient survival after heart transplantation. Eur J Cardiothorac Surg 2007;31:929–33.
12. Quader MA, Wolfe LG, Kasirajan V. Heart transplantation outcomes from cardiac arrest-resuscitated donors. J Heart Lung Transplant 2013;32:1090–5.
13. Schumer EM, Ising MS, Trivedi JR, Slaughter MS, Cheng A. Early outcomes with marginal donor hearts compared with left ventricular assist device support in patients with advanced heart failure. Ann Thorac Surg 2015;100:522–7.
14. Hearse DJ, Garlick PB, Humphrey SM. Ischemic contracture of the myocardium: mechanisms and prevention. Am J Cardiol 1977;39:986–93.
15. Scientific Registry of Transplant Recipients. SRTS Risk adjustment model documentation: waiting list and posttransplant outcomes. Available at: http://www.srtr.org/csr/current/modtabs.aspx. Accessed November 6, 2015.
16. Carr CS, Grover GJ, Pugsley WB, Yellon DM. Comparison of the protective effects of a highly selective ATP-sensitive potassium channel opener and ischemic preconditioning in isolated human atrial muscle. Cardiovasc Drugs Ther 1997;11:473–8.
17. Remote Preconditioning Trialists, Healy DA, Khan WA, Wong CS, et al. Remote preconditioning and major clinical complications following adult cardiovascular surgery: systematic review and meta-analysis. Int J Cardiol 2014;176:20–31.

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DISCUSSION

DR AHMET KILIC (Columbus, OH): Thank you to the Association for the opportunity to discuss this manuscript. And thank you, Erin, to you and your colleagues for providing me with the manuscript ahead of time to review. All these discussions we have been having this morning are very timely as they point out the increased realization that we are underutilizing potentially viable organs. In fact, it is so timely that the newest Scientific Registry of Transplant Recipients (SRTR), the latest release from just a couple months ago, takes the donor equation from just two variables, which used to be just age and the cause of death, and now has over 30 different factors that are used to predict the outcomes in heart transplantation. Interestingly, cardiopulmonary resuscitation (CPR) is not one of them nor is the time of CPR duration.

In this context, I do have two questions. The first one is that your study may represent somewhat of a selection bias, because these were all judged to be suitable for transplantation, so we did not capture all the organs that were not used. Maybe more of an insight could be gained if you did a subgroup analysis on patients that underwent maybe extended CPR, maybe exceeding 45 minutes or 60 minutes, and likewise, in patients maybe whose hemodynamics did not return to normal and reported on the outcomes with these organs used for transplantation.

The second question is more of an abstract question. We all realize the underutilization of organs, and we realized in the first presentation today that maybe there is a little bit of a difference statistically in 5-year outcomes between "marginal" donors and "good" donors, but overall there is still a survival near 75% in 5 years with a heart transplant coming from donors labeled as "marginal." I hate to use that term because they are good organs.

Despite all of the scrutiny that we have discussed today—ranging from extracorporeal membrane oxygenation (ECMO) outcomes, readmissions, and transplant outcomes—we need to come together as an association to continue to utilize these organs and perhaps even push the envelope further. If so, should we have an asterisk as an alternate list of either high-risk recipients and/or donors? I look forward to your insights.

DR SCHUMER: To address your first question, we did look at donors who had CPR time exceeding 60 minutes; however, there were only 18 of them. We ran the survival analysis. Again, there was no difference in survival. I think that is a great point. We also would love to obtain the data for those organs that were not transplanted, because I think that might actually give a more informative answer to the question.

As far as the SRTR algorithm, I think it may help to accept more organs, but it is really up to the accepting physician to look at the algorithm. We really need to define what is a "marginal" organ, and then that marginal organ may not be marginal for every patient; it depends on the recipient as well. And so I think we really need to determine the optimal organ for the optimal patient.

DR KILIC: Thank you for those answers. I will just add another person to your cohort of over 60 minutes. I had a 101-minute donor CPR time that we accepted on an left ventricular assist device (LVAD), blood type O recipient, and he left the hospital in 2 weeks. So I think it is really the art of medicine, of appropriate recipient and donor matching, more than anything else, and these are all just excellent points for discussion. Thank you.

DR JOSEPH B. ZWISCHENBERGER (Lexington, KY): The message is profound just like some of the earlier presentations: Do not give up! So in your perusal of the data, do you know how to advise a clinician when to stop; because your message is, do not stop?

DR SCHUMER: I think that is a great question and one that is very hard to answer. There is no way to predict who is going to recover their heart function after CPR. Sixty minutes seems like an extended period; however, we just heard of a case report of somebody who underwent 101 minutes. So I do not really have a very good answer to your question, but I think it is important to be more aggressive with our donors in order to transplant more organs.

DR ZWISCHENBERGER: I look forward to your presentation next year telling us how far we can go and never, never give up.

DR SCHUMER: Thank you.

DR UMRAAN AHMAD (St. Louis, MO): I enjoyed your talk. The thing for me is, one, we always live by three rules that we can accept one of the three, and that was age of the donor, downtime, or ischemic time. But a lot of what I did for turning down organs was I would be facing a patient who was stable on a ventricular assist device (VAD), and most of my patients were stable on a VAD, and so a lot of the organs I turned down, hearts, I knew were going to other people, but I did not feel bad about it because I had a patient stable on a VAD, doing well, but I was looking for the best possible organ that I could get them that 15-year number we are reaching for now. So it is just interesting to hear people's comments.

DR SLAUGHTER: We all face that dilemma. I think that in general you are probably doing the right thing for the patient, and I would be interested in what everyone else thinks. But the problem you run into then is all of a sudden all your patients are waiting 1 year to 3 years to get transplanted and your program next door is still transplanting people within a year. So in the SRTR data you start to look bad, but your outcomes are as good at 1 to 3 years and actually may be better at 5 to 10 years. But when they do those rolls at 1 to 3 years, all of a sudden you have this prolonged wait on the transplant waiting list and they start giving you a phone call. So I do not know the right answer. I think it is getting harder and harder, because we all are under intense scrutiny, and it does only take one or two bad outcomes and all of a sudden your 1-year survival is off just a touch and then you revert to being extremely conservative, and that is equally bad. And this idea of maybe having an asterisk or something like that probably would be helpful for patients and programs, but I would defer to everyone else as well. But those are real-life problems.

DR AHMAD: I guess what I have always seen in my career is there is January risk and then there is December risk. You get to the end of the year and we have taken our risk for the year and now it is the beginning of the year.