ORIGINAL RESEARCH

Outcomes of Adult Heart Transplantation Using Hepatitis C–Positive Donors

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Background—This study evaluated the impact of hepatitis C–positive (HCV+) donors on outcomes of heart transplantation in the United States.

Methods and Results—Adults undergoing isolated heart transplantation in the United States between January 1, 2016, and December 31, 2018, were included. The primary outcome was 1-year post-transplant survival. Multivariable Cox regression and 2:1 propensity matching were used to compare outcomes between transplants with HCV+ and hepatitis C–negative (HCV−) donors. A subanalysis was performed to evaluate the impact of nucleic acid amplification test positivity on outcomes. Of 7889 isolated heart transplants performed during the study period, 343 (4.4%) used HCV+ donors. Overall unadjusted 1-year posttransplant survival was not statistically different between HCV− versus HCV+ donors (91.1% versus 90.2%; *P*=0.86), a finding that persisted after risk adjustment (hazard ratio, 1.05; 95% CI, 0.70–1.58; *P*=0.80). Propensity matching resulted in 675 well-balanced patients (437 HCV− and 238 HCV+). Overall 1-year posttransplant survival was not statistically different in propensity-matched analysis (89.8% HCV− versus 89.2% HCV+; *P*=0.88). Rates of 1-year drug-treated rejection (21.1% versus 22.1%; *P*=0.84), postoperative dialysis (11.4% versus 14.7%; *P*=0.22), and stroke (4.6% versus 2.1%; *P*=0.10) were also not statistically different between HCV− and HCV+ groups, respectively. Outcomes were not statistically different between nucleic acid amplification test–negative and nucleic acid amplification test–positive HCV+ donors.

Conclusions—Adult heart transplants using HCV+ donors, including those that are nucleic acid amplification test positive, can be performed without an adverse impact on 1-year survival. Wider implementation of protocols for using HCV+ donors and an assessment of longer-term outcomes including seroconversion rates will be important in maximizing the effect of HCV+ donors on national donor shortages. **(*J Am Heart Assoc*. 2020;9:e014495. DOI: 10.1161/JAHA.119.014495.)**

Key Words: heart failure • heart transplantation • hepatitis C • rejection

Although adult heart transplantation can be lifesaving for many patients with end-stage heart failure with excellent short- and long-term survival, its use is limited by a persistent donor shortage.[1] Using hepatitis C–positive (HCV+) donors may be one strategy to help combat the organ shortage for heart transplantation. An earlier report of the UNOS (United Network for Organ Sharing) registry demonstrated inferior survival with the use of HCV+ donors in heart transplantation, with a greater likelihood of death attributable to liver disease and coronary allograft vasculopathy.[2] This was likely related to the use of interferon-based therapy for hepatitis C, and enthusiasm for using HCV+ donors dissipated as a result. Recently, there has been a resurgence of interest in cardiac transplantation using HCV+ donors with the advent of direct-acting antiviral drugs, with low reported rates of seroconversion and acceptable posttransplant survival in small series.[3,4] The aim of this study was to evaluate national outcomes of adult heart transplantation using HCV+ donors.

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Accompanying Tables S1 through S3 and Figures S1, S2 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.119.014495

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Methods

Study Population

The authors declare that all supporting data are available within the article and its online supplementary files. Adult patients aged 18 years or older undergoing isolated heart transplantation in the United States between January 1, 2016, and December 31, 2018, were included in the study. Pediatric

Clinical Perspective

What Is New?

- This is a large, multicenter study evaluating modern outcomes of heart transplantation using hepatitis C–positive donors.
- Posttransplant survival, rejection rates, and complications were similar between hepatitis C–positive and –negative donors.

What Are the Clinical Implications?

- Adult heart transplantation can be performed using hepatitis C–positive donors without an adverse impact on outcomes.
- Further research is needed on specific protocols as well as longer-term outcomes and seroconversion rates to maximize the potential effect and use of these donors.

patients and those undergoing multiorgan transplantation were excluded. The UNOS registry was used to identify all eligible heart transplants performed during the study period. The institutional review board approved this study. The requirement for informed consent for this study for each individual subject was waived.

Data Analysis

The primary stratification was heart transplants performed using HCV+ versus hepatitis C–negative (HCV−) donors. HCV+ was defined as having a positive antibody to HCV, with further substratification based on nucleic acid amplification test (NAT) positivity. Baseline characteristics, including donor, recipient, recipient-donor matching, and transplant-related variables, were compared between HCV+ and HCV− donor transplants.

The primary outcome was overall 1-year survival following heart transplantation. All causes of mortality were included in the survival analysis. Kaplan–Meier survival curves were generated and compared using the log-rank test. A multivariable Cox regression analysis was also performed to evaluate the independent effect of HCV+ donor use on posttransplant survival. The multivariable model was constructed using variables that were supported with previously published literature or were associated with posttransplant survival in univariate Cox regression analysis with an exploratory P value of <0.05. Eligible variables were incorporated into the model in a forward and backward stepwise fashion using the likelihood ratio test and Akaike's information criteria in a nested model approach to maximize the explanatory power of our model. Variables with >15% missing data were excluded from the model, as the model was constructed using casewise deletion. The proportional hazards assumption was tested using Schoenfeld residuals and complementary log-log plots for each covariate.

Secondary outcomes included drug-treated rejection within 1 year of transplantation. All forms of rejection, including antibody-mediated rejection, were included in this outcome. Rates of new-onset postoperative dialysis and postoperative stroke were also compared. For the latter 2 secondary outcomes, *postoperative* was defined as occurring during the index hospitalization following transplantation. Length of hospitalization following heart transplantation was an additional secondary outcome.

Propensity matching was performed to account for baseline differences. This was done using a greedy matching algorithm with 2:1 nearest neighbor matching without replacement and a caliper of 0.01 of the standard deviation of the propensity score. A subanalysis was performed, limiting the patients to those transplanted only at centers that used HCV+ organs. This was done with both the unmatched and propensity-matched populations to compare outcomes at these centers using HCV+ versus HCV− donors. Another subanalysis evaluated outcomes of heart transplants using NAT+ versus NAT− HCV+ donors.

Categorical data are presented as number and percentage and compared using the chi-square test. Normally distributed continuous data are presented as mean with standard deviation and compared with the Student t test. Nonparametric continuous data are presented as median with interquartile range and compared with the Wilcoxon rank-sum test. All statistical analyses were performed with version 14 STATA software (StataCorp, College Station, TX).

Results

Baseline Characteristics of the Study Population

There were 7889 isolated heart transplants performed in adults in the United States during the study period at 128 centers. Of these, 343 (4.4%) were performed using HCV+ donors at 36 centers. By year of transplant, the percentage of centers performing heart transplants that used HCV+ donors increased from 8.5% in 2016, to 13.2% in 2017, to 29.4% in 2018. Only 15 (4.4%) of the recipients receiving HCV+ donors had a history of treated HCV, with the remaining 328 (95.6%) being HCV−. At baseline, there were significant differences between HCV+ versus HCV− donors (Table S1). HCV+ donors were older and were more likely to be white and blood type O, with drug overdose as the mechanism of death. HCV+ donors also had a lower proportion with inotrope use and a higher terminal serum creatinine.

There were also baseline recipient differences (Table S2). More recipients of HCV+ donors were blood type O. In addition, recipients of HCV+ donors had higher serum creatinine, and more were bridged with the HeartMate 3

(Abbott, Inc, Plymouth, MN) ventricular assist device. Transplants performed using HCV+ donors had a higher percentage of race matching between the donor and recipient (Table S3). Recipients of HCV+ donors had shorter wait list time, with a greater distance between the donor hospital and transplant center along with longer cold ischemic time (Table S3).

Outcomes Before Propensity Matching

The overall 1-year posttransplant recipient survival was similar between HCV− (91.1%) and HCV+ (90.2%) donors (*P*=0.86) (Figure S1). In multivariable analysis, the use of an HCV+ donor was not associated with posttransplant survival (hazard ratio, 1.05; 95% CI, 0.70–1.58; *P*=0.80) (Table 1). The rate of 1-year drug-treated rejection was similar (HCV−, 19.6% versus HCV+, 21.6%; *P*=0.60). The rate of new-onset postoperative dialysis was comparable (HCV−, 11.2% versus HCV+, 13.7%; *P*=0.16). The rate of postoperative stroke was also comparable (HCV−, 2.9% versus HCV+, 2.0%; *P*=0.35). Length of hospitalization was similar in HCV− (median, 16 days; interquartile range, 11–23 days) and HCV+ cases (median, 16 days; interquartile range, 12–24 days) (*P*=0.36). Similar

Table 1. Multivariable Cox Regression Analysis for Posttransplant Mortality in the 675 Propensity-Matched Patients

Covariate	Hazard Ratio	95% CI	*P* Value
Hepatitis C–positive donor	1.05	0.70–1.58	0.80
Donor age (increasing, per year)	1.01	1.01–1.02	<0.001
Recipient age (increasing, per year)	1.02	1.01–1.02	<0.001
Etiology of heart failure			
Nonischemic dilated cardiomyopathy	Reference	Reference	Ref.
Ischemic cardiomyopathy	1.12	0.95–1.32	0.17
Congenital heart disease	2.36	1.59–3.51	<0.001
Restrictive cardiomyopathy	1.60	1.15–2.24	0.006
Valvular heart disease	0.90	0.44–1.86	0.78
Failed primary heart transplant	1.93	1.26–2.97	0.003
Hypertrophic cardiomyopathy	0.89	0.53–1.49	0.65
Other etiology	0.83	0.47–1.48	0.53
Diabetes mellitus	1.22	1.05–1.43	0.01
Serum creatinine (increasing, per 1 mg/dL)	1.05	1.00–1.11	0.07
Serum bilirubin (increasing, per 1 g/dL)	1.08	1.06–1.10	<0.001
Mechanical ventilation	1.83	1.05–3.20	0.03
Bridge with ECMO	2.74	1.59–4.72	<0.001
Bridge with ventricular assist device			
None	Reference	Reference	Ref.
Left ventricular assist device	1.21	1.04–1.42	0.01
Right ventricular assist device	5.53	2.25–13.6	<0.001
Biventricular assist device	3.62	2.27–5.76	<0.001

ECMO indicates extracorporeal membrane oxygenation.

Table 2. Comparison of Baseline Donor Characteristics Between Hepatitis C–Negative and Hepatitis C–Positive Donors After Propensity Matching

	Hepatitis C Negative (n=437)	Hepatitis C Positive (n=238)	*P* Value
Age, y (IQR)	32 (24–42)	33 (27–38)	0.42
Female, n (%)	136 (31.1)	73 (30.7)	0.90
Race, n (%)			0.13
White	352 (80.6)	197 (82.8)	
Black	50 (11.4)	21 (8.8)	
Hispanic	31 (7.1)	16 (6.7)	
Asian	3 (0.7)	0 (0)	
Other	1 (0.2)	4 (1.7)	
Body mass index, kg/m^2 (IQR)	26 (23–31)	26 (24–31)	0.98
Blood type, n (%)			0.45
A	146 (33.4)	78 (32.8)	
AB	26 (6.0)	11 (4.6)	
B	64 (14.7)	27 (11.3)	
O	201 (46.0)	122 (51.3)	
Cytomegalovirus positive	231 (53.0)	123 (51.9)	0.79
Mechanism of donor death, n (%)			<0.001
Trauma	106 (24.3)	44 (18.5)	
Cerebrovascular	66 (15.1)	13 (5.5)	
Drug overdose	91 (20.8)	154 (64.7)	
Other	174 (39.8)	27 (11.3)	
Diabetes mellitus	19 (4.4)	8 (3.4)	0.54
Inotrope use	157 (35.9)	81 (34.0)	0.62
Terminal serum creatinine, mg/dL (IQR)	1.00 (0.73–1.72)	1.10 (0.80–1.77)	0.13
Left ventricular ejection fraction, % (IQR)	60 (57–65)	60 (56–65)	0.43

IQR indicates interquartile range.

Table 3. Comparison of Baseline Recipient Characteristics Between Heart Transplants Using Hepatitis C–Negative and Hepatitis C–Positive Donors After Propensity Matching

	Hepatitis C Negative (n=437)	Hepatitis C Positive (n=238)	*P* Value
Age, y (IQR)	58 (48–64)	57 (48–64)	0.91
Female, n (%)	118 (27.0%)	62 (26.1%)	0.79
Race, n (%)			0.65
White	291 (66.6)	162 (68.1)	
Black	101 (23.1)	49 (20.6)	
Hispanic	33 (7.6)	20 (8.4)	
Asian	12 (2.8)	6 (2.5)	
Other	0 (0)	1 (0.4)	
Body mass index, kg/m^2 (IQR)	26 (23–31)	26 (24–31)	0.98
Blood type, n (%)			0.45
A	146 (33.4)	78 (32.8)	
AB	26 (6.0)	11 (4.6)	
B	64 (14.7)	27 (11.3)	
O	201 (46.0)	122 (51.3)	
Cytomegalovirus positive, n (%)	236 (54.0)	121 (50.8)	0.43
Etiology of heart failure, n (%)			0.72
Nonischemic dilated cardiomyopathy	245 (56.1)	128 (53.8)	
Ischemic cardiomyopathy	132 (30.2)	70 (29.4)	
Congenital heart disease	12 (2.8)	8 (3.4)	
Restrictive cardiomyopathy	15 (3.4)	14 (5.9)	
Valvular heart disease	5 (1.1)	3 (1.3)	
Failed primary heart transplant	10 (2.3)	6 (2.5)	
Hypertrophic cardiomyopathy	9 (2.1)	7 (2.9)	
Other etiology	9 (2.1)	2 (0.8)	
Diabetes mellitus, n (%)	124 (28.4)	60 (25.2)	0.38
Serum creatinine, mg/dL (IQR)	1.19 (0.97–1.40)	1.21 (1.00–1.49)	0.17
Total bilirubin, mg/dL (IQR)	0.60 (0.40–0.90)	0.70 (0.50–1.00)	0.24
Mechanical ventilation, n (%)	0 (0)	1 (0.4)	0.18
Intra-aortic balloon pump, n (%)	47 (10.8)	23 (9.7)	0.66
ECMO, n (%)	0 (0)	0 (0)	0.99
Bridge with ventricular assist device, n (%)			0.73
None	237 (54.2)	130 (54.6)	
Left ventricular assist device	188 (43.0)	105 (44.1)	
Right ventricular assist device	2 (0.5)	0 (0)	
Biventricular assist device	4 (0.9)	1 (0.4)	
Total artificial heart	6 (1.4)	2 (0.8)	
Type of left ventricular assist device, n (%)			
HeartMate 2	80 (18.3	31 (13.0)	0.08
HeartWare	81 (18.5%)	45 (18.9)	0.91
HeartMate 3	1 (0.2)	3 (1.3)	0.10

Continued

Table 3. Continued

	Hepatitis C Negative (n=437)	Hepatitis C Positive (n=238)	*P* Value
Other durable device	32 (7.3)	26 (10.9)	0.11
Temporary device	3 (0.7)	1 (0.4)	0.66
Most recent panel reactive antibody, % (IQR)	0 (0–8)	0 (0–10)	0.95

ECMO indicates extracorporeal membrane oxygenation; IQR, interquartile range.

results were obtained when excluding recipients with a history of treated HCV. The most common causes of death among HCV+ donor recipients were multiorgan failure (n=5), cardiogenic shock (n=3), and sepsis (n=2).

Propensity-Matched Analysis

Propensity matching yielded 437 HCV− and 238 HCV+ donors. The baseline donor characteristics were not statistically different except for a higher proportion with drug overdose as a mechanism of death in the HCV+ cohort (Table 2). Recipient and donor-recipient matching characteristics were not statistically different in the propensity-matched analysis (Tables 3 and 4). Although distance between donor hospital and transplant center was longer in the HCV+ matched cohort, the cold ischemic time was not statistically different between groups after matching (Table 4). In total, propensity matching resulted in well-balanced groups that had <10% standardized mean difference across all covariates, including mechanism of death (Figure S2).

There were no statistical differences in overall 1-year survival in the propensity-matched analysis between HCV− (89.8%) and HCV+ (89.2%) donor transplants (*P*=0.88) (Figure). One-year drug-treated rejection rates were statistically comparable (HCV−, 21.1% versus HCV+, 22.1%; *P*=0.84). Rates of new-onset postoperative dialysis (HCV−, 11.4% versus HCV+, 14.7%; *P*=0.22) as well as postoperative stroke (HCV−, 4.6% versus HCV+, 2.1%; *P*=0.10) were not statistically different, nor was length of hospital stay between HCV− (median, 16 days; interquartile range, 12–25 days) and HCV+ transplants (median, 15.5 days; interquartile range, 11.5–24 days) (*P*=0.94).

Subanalysis Limited to Centers Performing Heart Transplants With HCV+ Donors

Of the 128 centers performing heart transplants during the study period, 36 (28.1%) used HCV+ donors. When limiting the analysis to centers performing HCV+ donor transplants, there were 3466 heart transplants performed with HCV− donors from these centers during the same study period. There were no statistical differences in 1-year survival between HCV− and HCV+ donors at these centers (91.0% versus 90.2%, respectively; *P*=0.85). There were 223 HCV− and 238 HCV+ donor transplants performed in the propensity-matched analysis when the analysis was limited to these 36 centers. Again, the 1-year survival was not statistically different (HCV−, 89.7% versus HCV+, 89.2%, *P*=0.87).

Subanalysis Evaluating the Impact of NAT+ Donor Use

NAT status was known in 331 (96.5%) HCV+ donor cases. In all, 194 (58.6%) were NAT+ HCV+ donors. There were no

Table 4. Comparison of Baseline Recipient-Donor Matching and Transplant-Related Characteristics Between Heart Transplants Using Hepatitis C–Negative and Hepatitis C–Positive Donors After Propensity Matching

	Hepatitis C Negative (n=437)	Hepatitis C Positive (n=238)	*P* Value
Sex matched, n (%)	335 (76.7)	187 (78.6)	0.57
Race matched, n (%)	256 (58.6)	143 (60.1)	0.70
HLA matched (≥3 antigens), n (%)	34 (7.8)	20 (8.4)	0.84
Blood type matched, n (%)	389 (89.0)	205 (86.1)	0.27
Cytomegalovirus status matched, n (%)	213 (48.9)	132 (55.7)	0.09
Days on wait list, n (IQR)	98 (28–281)	89 (21–298)	0.36
Donor hospital to transplant center distance, miles (IQR)	154 (35–331)	261 (98–436)	<0.001
Cold ischemic time, h (IQR)	3.5 (2.8–3.9)	3.5 (3.0–4.0)	0.18

HLA indicates human leukocyte antigen; IQR, interquartile range.

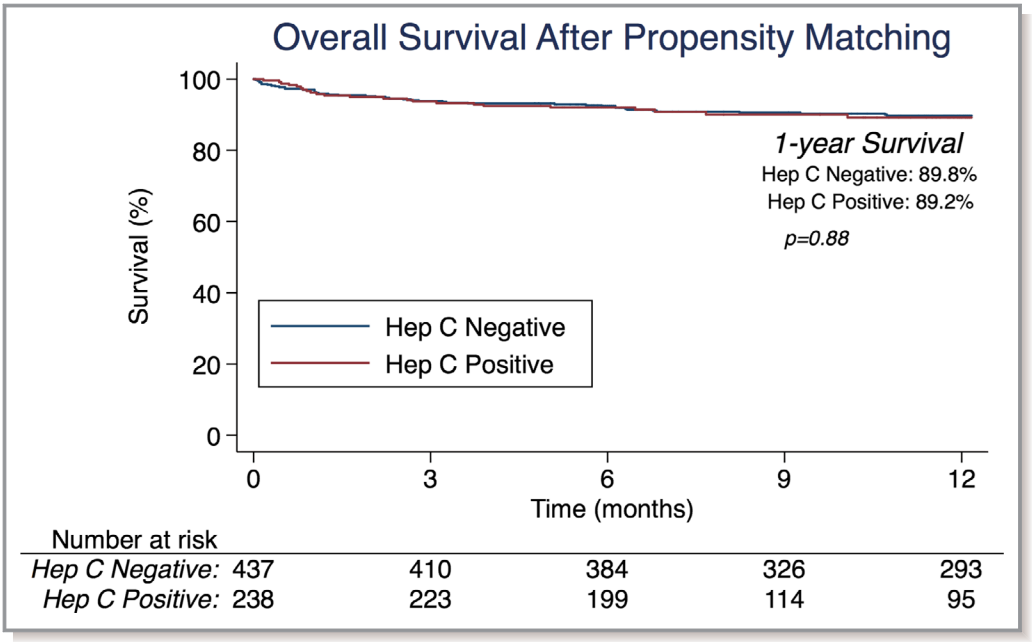

Figure. Overall 1-year survival in the propensity-matched heart transplants performed using hepatitis C–negative vs. hepatitis C–positive donors.

statistical differences in 1-year survival when comparing NAT− HCV+ and NAT+ HCV+ donors (86.9% versus 91.9%, respectively; *P*=0.16). There were also no differences in 1-year drug-treated rejection (NAT−, 18.8% versus NAT+, 25.4%; *P*=0.41), new-onset postoperative dialysis (NAT−, 17.5% versus NAT+, 11.9%; *P*=0.15), or postoperative stroke (NAT−, 2.2% versus NAT+, 2.1%; *P*=0.94). When directly comparing NAT+ HCV+ donors to HCV− donors, 1-year survival was again statistically comparable (91.9% versus 91.1%, respectively; *P*=0.37), as were rates of each of the secondary outcomes of rejection, dialysis, and stroke (each *P*>0.05).

Discussion

An earlier report that analyzed the UNOS registry for heart transplants performed between 1994 and 2003 in the United States demonstrated a 1-year mortality rate for transplants using HCV+ donors that was over double that observed in HCV− donors.[2] This led many groups to abandon using HCV+ donors for heart transplantation. The recent resurgence in interest in using HCV+ donors largely stems from the development of highly effective direct-acting antiviral agents that have revolutionized the treatment of hepatitis C.[5]

A single-center study reported outcomes of heart transplantation in 8 recipients of HCV+ donors and demonstrated that immediate 4-week treatment with a direct-acting antiviral agent resulted in an undetectable viral load in all patients with 100% survival at 6 months with no treatment-related serious adverse events.[3] Another single-center analysis evaluated heart transplant outcomes in 13 recipients of HCV+ donors, of which 12 were HCV− and 1 had a history of treated HCV.[4] In the 12 HCV− recipients, 9 (69%) developed HCV viremia after transplantation and received direct-acting antiviral agent therapy, with 8 demonstrating cure and 1 patient dying during treatment from a pulmonary embolism. All cases of recipient seroconversion were in transplants using NAT+ HCV+ donors. Another single institution experience of 10 HCV− recipients undergoing heart transplantation with HCV+ donors demonstrated that 9 patients achieved a sustained virologic response at 12 weeks, with the last patient having a positive crossmatch and dying from rejection and multiorgan failure.[5]

Our current analysis provides a nationwide, larger cohort analysis with heart transplantation using HCV+ donors in the modern era and demonstrates that it can be performed safely with no adverse impact on 1-year survival. In this current snapshot, it appears that 28% of centers are using HCV+ donors. Although this certainly represents a steep increase from earlier years, one could argue that there is room for broader implementation and use of HCV+ donors.

The potential pool of HCV+ donors is substantial and largely reflective of the rising opioid epidemic in the United States.[6] An analysis of heart transplants performed between 2010 and 2017 in the United States showed that 11% were from donors that overdosed on drugs, and these donors were more likely to be HCV+.[7] Discarded donor organs from drug overdose were ≈6-fold more likely to be HCV+.[7] Another study of 64 HCV+ donor heart transplants demonstrated that

only 5% of donor HCV+ hearts were accepted for transplantation in the United States despite similar posttransplant survival.[8]

Although our study is supportive of using HCV+ donors for heart transplantation, there are additional factors that should be studied further. Protocols for following and treating seroconversion in HCV− recipients should be evaluated and refined. Granularity regarding seroconversion rates, anti-HCV therapy initiation and timing, and adverse side effects from therapy are not provided in the UNOS registry but are essential to understanding the impact of HCV+ donor use in heart transplantation. In particular, it is unclear if treatment of all HCV− recipients transplanted with an HCV+ donor should be initiated in advance, particularly with NAT+ donors, or if treatment should be initiated with the first NAT positivity in the recipient.

Another important aspect that should be further studied is longer-term survival beyond 1-year. Donor HCV positivity has been associated with the development of allograft coronary artery disease.[9,10] One study demonstrated a 3-fold greater odds of developing any vasculopathy and over 9-fold greater risk of developing advanced vasculopathy with the use of HCV+ donors.[9] An analysis of heart transplants using HCV+ donors in the more recent era demonstrated that 10% and 25% of recipients developed grade 1 coronary allograft vasculopathy by 6 months and 1 year, respectively, although no patients required percutaneous or surgical revascularization.[11]

Interestingly, in our analysis, the rates of drug-treated rejection within 1 year were comparable between HCV− and HCV+ donors both in the unmatched and propensity-matched analysis. A prior UNOS registry analysis demonstrated that the 4 factors that significantly predicted the risk of drug-treated rejection in 1 year following heart transplantation included younger recipient age, non-Asian recipient race, female recipient, and <3 human leukocyte antigens matched between the recipient and donor.[12] All of these variables were comparable between HCV− and HCV+ cohorts in our study. Reported risk factors for antibody-mediated rejection include elevated panel reactive antibody, bridge with ventricular assist device, and redo heart transplant, factors that were also comparable between the cohorts in the current analysis.[13–15]

Limitations

This is a retrospective analysis and therefore has inherent limitations related to the study design. Granular aspects of HCV-related variables such as HCV genotype, anti-HCV therapy initiation and protocols, and rates of seroconversion were not available in the UNOS registry. Because of the recent resurgence of HCV+ donors in heart transplantation, longer-term follow-up was not available for this study period. Details regarding surveillance of donor organs after transplantation including the development of cardiac allograft vasculopathy were not available in the database. There may be data not contained within the UNOS registry that are predictive of outcomes that were not adjusted for in this analysis. Finally, there was a limited number of patients, particularly in the propensity-matched analysis, which subjects the analyses to type II statistical error. Further validation in larger cohorts is therefore warranted.

Conclusions

This study evaluated outcomes of adult heart transplantation using HCV+ donors in 343 patients in the United States in the modern era. The major finding was that 1-year posttransplant survival was comparable to HCV− donors. This suggests that heart transplants using HCV+ donors, including those that are NAT+, are safe and portend excellent survival to patients with end-stage heart failure. Currently, 28% of centers are performing cardiac transplants using HCV+ donors. Refining management protocols related to HCV+ donor heart transplantation, along with education and expansion of these protocols to centers currently not using this potentially large pool of donors, appears warranted.

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Disclosures

Dr Kilic is on the Medical Advisory Board for Medtronic, Inc. Dr Gleason is on the Medical Advisory Board for Abbott, Inc. The remaining authors have no disclosures to report.

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SUPPLEMENTAL MATERIAL

Table S1. Comparison of baseline donor characteristics between hepatitis C negative and hepatitis C positive donors before propensity matching.

	Hepatitis C Negative (n=7,546)	Hepatitis C Positive (n=343)	P Value
Age (years)	31 (IQR 23-40)	33 (IQR 28-39)	<0.001
Female	2,324 (30.8%)	105 (30.6%)	0.94
Race			<0.001
White	4,836 (64.1%)	288 (84.0%)	
Black	1,230 (16.3%)	25 (7.3%)	
Hispanic	1,223 (16.2%)	23 (6.7%)	
Asian	130 (1.7%)	0 (0%)	
Other	127 (1.7%)	7 (2.0%)	
Body Mass Index (kg/m^2)	27 (IQR 23-31)	26 (24-31)	0.76
Blood Type			0.001
A	3,062 (40.6%)	116 (33.8%)	
AB	416 (5.5%)	13 (3.8%)	
B	1,141 (15.1%)	43 (12.5%)	
O	2,927 (38.8%)	171 (49.9%)	
Cytomegalovirus Positive	4,606 (61.4%)	186 (54.6%)	0.01
Mechanism of Donor Death			<0.001
Trauma	3,473 (46.1%)	61 (17.8%)	
Cerebrovascular	1,326 (17.6%)	18 (5.3%)	
Drug Overdose	1,209 (16.0%)	222 (64.7%)	
Other	1,534 (20.3%)	42 (12.2%)	
Diabetes Mellitus	292 (3.9%)	11 (3.2%)	0.53
Inotrope Use	2,862 (38.1%)	108 (31.8%)	0.02
Terminal Serum Creatinine (mg/dL)	1.00 (IQR 0.76-1.50)	1.10 (IQR 0.80-1.73)	0.002
Left Ventricular Ejection Fraction (%)	60 (IQR 56-65)	60 (IQR 57-65)	0.57

Table S2. Comparison of baseline recipient characteristics between heart transplants utilizing hepatitis C negative and hepatitis C positive donors before propensity matching.

	Hepatitis C Negative (n=7,546)	Hepatitis C Positive (n=343)	P Value
Age (years)	57 (IQR 46-64)	58 (IQR 48-64)	0.07
Female	2,046 (27.1%)	95 (27.7%)	0.81
Race			0.51
White	4,847 (64.6%)	236 (69.2%)	
Black	1,678 (22.4%)	68 (19.9%)	
Hispanic	669 (8.9%)	26 (7.6%)	
Asian	265 (3.5%)	9 (2.6%)	
Other	49 (0.7%)	2 (0.6%)	
Body Mass Index (kg/m^2)	28 (IQR 24-31)	27 (IQR 24-31)	0.63
Blood Type			0.001
A	3,062 (40.6%)	116 (33.8%)	
AB	416 (5.5%)	13 (3.8%)	
B	1,141 (15.1%)	43 (12.5%)	
O	2,927 (38.8%)	171 (49.9%)	
Cytomegalovirus Positive	4,163 (55.2%)	166 (48.4%)	0.01
Etiology of Heart Failure			0.68
Non-Ischemic Dilated Cardiomyopathy	4,098 (54.3%)	182 (53.1%)	
Ischemic Cardiomyopathy	2,297 (30.4%)	101 (29.5%)	
Congenital Heart Disease	225 (3.0%)	11 (3.2%)	
Restrictive Cardiomyopathy	264 (3.5%)	19 (5.5%)	
Valvular Heart Disease	80 (1.1%)	4 (1.2%)	
Failed Primary Heart Transplant	159 (2.1%)	9 (2.6%)	
Hypertrophic Cardiomyopathy	233 (3.1%)	10 (2.9%)	
Other Etiology	190 (2.5%)	7 (2.0%)	
Diabetes Mellitus	2,098 (27.8%)	87 (25.7%)	0.40
Serum Creatinine (mg/dL)	1.17 (IQR 0.94-1.42)	1.21 (IQR 1.00-1.50)	0.02

Total Bilirubin (mg/dL)	0.70 (IQR 0.40-1.00)	0.70 (IQR 0.50-1.00)	0.25
Mechanical Ventilation	70 (0.9%)	5 (1.5%)	0.32
Intra-Aortic Balloon Pump	617 (8.2%)	37 (10.8%)	0.09
ECMO	86 (1.1%)	3 (0.9%)	0.65
Bridge with Ventricular Assist Device			0.46
None	3,744 (49.9%)	177 (53.8%)	
Left Ventricular Assist Device	3,581 (47.7%)	147 (44.7%)	
Right Ventricular Assist Device	12 (0.2%)	0 (0%)	
Biventricular Assist Device	67 (0.9%)	3 (0.9%)	
Total Artificial Heart	107 (1.4%)	2 (0.6%)	
Type of Left Ventricular Assist Device			
HeartMate 2	1,683 (22.3%)	41 (12.0%)	<0.001
HeartWare	1,412 (18.7%)	64 (18.7%)	0.98
HeartMate 3	110 (1.5%)	14 (4.1%)	<0.001
Other Durable Device	440 (5.8%)	28 (8.2%)	0.07
Temporary Device	79 (1.1%)	3 (0.9%)	0.80
Most Recent Panel Reactive Antibody (%)	0 (IQR 0-9)	0 (IQR 0-4)	0.17

ECMO, extracorporeal membrane oxygenation

Table S3. Comparison of baseline recipient-donor matching and transplant-related characteristics between heart transplants utilizing hepatitis C negative and hepatitis C positive donors before propensity matching.

	Hepatitis C Negative (n=7,546)	Hepatitis C Positive (n=343)	P Value
Sex Matched	5,788 (76.7%)	271 (79.0%)	0.32
Race Matched	3,874 (51.3%)	210 (61.2%)	<0.001
HLA Matched (3 or more antigens)	970 (12.9%)	42 (12.2%)	0.74
Blood Type Matched	6,523 (86.4%)	295 (86.0%)	0.82
Cytomegalovirus Status Matched	4,019 (53.6%)	184 (54.0%)	0.89
Days on Waitlist	105 (IQR 30-310)	79 (IQR 20-257)	0.006
Donor Hospital to Transplant Center Distance (miles)	78 (IQR 12-244)	260 (IQR 95-439)	<0.001
Cold Ischemic Time (hours)	3.0 (IQR 2.3-3.7)	3.5 (IQR 2.9-4.0)	<0.001

HLA, human leukocyte antigen

Figure S1. Overall 1-year survival following heart transplants performed using hepatitis C negative (HCV-) versus hepatitis C positive (HCV+) donors, before propensity-matching.

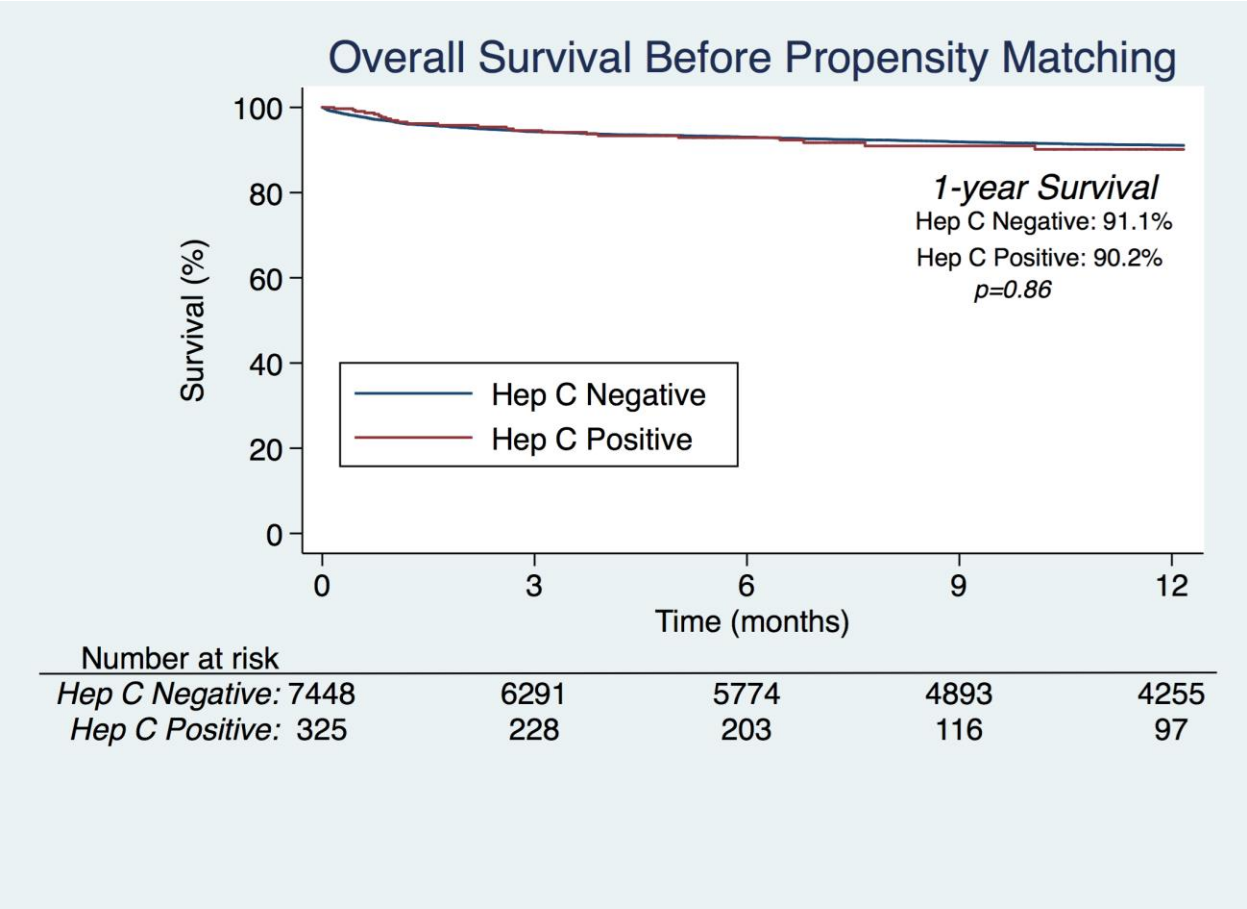

Figure S2. Standardized mean differences across covariates before and after propensity-matching.