Original Article

Characteristics and Outcomes of Patients With Myocarditis Listed for Heart Transplantation

Chantal A. ElAmm, MD*; Sadeer G. Al-Kindi, MD*; Guilherme H. Oliveira, MD

***Background*—**Myocarditis can cause dilated cardiomyopathy resulting in end-stage heart failure requiring advanced therapies. There is little contemporary information on the clinical progression, need for mechanical circulatory support, and outcomes of orthotopic heart transplantation of these patients.

***Methods and Results*—**We queried the UNOS database (United Network for Organ Sharing) for all adults listed for orthotopic heart transplantation (2000–2015) with a listed diagnosis of myocarditis. Comparative and survival analyses were performed. Of 45 941 adults listed for orthotopic heart transplantation during this period, we identified 299 patients (0.7%) with the diagnosis of myocarditis. Compared with patients with nonischemic cardiomyopathy (NICM) and ischemic cardiomyopathy (ICM), myocarditis patients were younger (myocarditis 43.4±14.2 years, NICM 49.8±12.4 years, and ICM 57.5±8.0 years; $P<0.001$) and more frequently listed as status 1A (myocarditis 44% versus NICM 21% versus ICM 21%; $P<0.001$), with significantly higher need for mechanical ventilation (myocarditis 11% versus NICM 2% versus ICM 4%; $P<0.001$), biventricular mechanical circulatory support (myocarditis 19% versus NICM 2%, versus ICM 2%; $P<0.001$), and extracoroporeal membrane oxygenation (myocarditis 5% versus NICM 0.4% versus ICM 1%; $P<0.001$). Additionally, patients with myocarditis had higher likelihood of delisting for clinical improvement (hazard ratio, 2.49 [95% confidence interval, 1.63–3.79] versus ICM and hazard ratio, 2.12 [95% confidence interval, 1.40–3.22] versus NICM; $P<0.001$). Despite higher allosensitization, patients with myocarditis had similar post-transplant rejection, retransplantation, and survival rates compared with other groups.

***Conclusions*—**Patients with the diagnosis of myocarditis listed for orthotopic heart transplantation are younger, sicker, and recover more frequently but require more biventricular mechanical circulatory support. Heart transplantation survival is comparable to that of patients with other types of heart failure. **(*Circ Heart Fail*. 2016;9:e003259. DOI: 10.1161/CIRCHEARTFAILURE.116.003259.)**

Key Words: cardiomyopathy ■ heart failure ■ myocarditis ■ transplantation ■ viruses

Myocarditis is a multifactorial, lymphocyte-mediated inflammatory process of the heart most commonly caused by viruses.[1,2] It has a variable clinical presentation and can be defined by either clinical or histopathologic criteria, making true incidence difficult to determine.[3,4] It has been estimated that myocarditis accounts for 9% to 16% of nonischemic cardiomyopathies (NICM).[5] Heart failure (HF) related to myocarditis carries mortality rates of 56% at 4.3 years[6] and may lead to end-stage HF requiring advanced therapies. Heart transplantation (HT) is required in 1% to 8% of patients with myocarditis.[7]

See Clinical Perspective

Utilization of mechanical circulatory support (MCS) and HT outcomes in patients with myocarditis remain incompletely defined because most available information is derived from relatively small series and isolated case reports.[8–10]

We, therefore, sought to use a large, contemporary, nationwide database to better understand the clinical characteristics, natural history, MCS needs, and HT outcomes of patients with end-stage HF from myocarditis listed for HT.

Methods

Data Source

Deidentified data were obtained from UNOS (United Network of Organ Sharing) and the Organ Procurement and Transplantation Network contracted with Health Resources and Services Administration. UNOS records compulsory transplantation information on listed patients in all centers across the United States. Data are collected at different time points: at listing, before transplantation,

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From the Advanced Heart Failure and Transplant Center, Harrington Heart and Vascular Institute, University Hospitals Cleveland Medical Center, Case Western Reserve University School of Medicine, OH.

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*Drs ElAmm and Al-Kindi contributed equally to this work.

Correspondence to Guilherme H. Oliveira, MD, Advanced Heart Failure and Transplant Center, Harrington Heart and Vascular Institute, University Hospitals Cleveland Medical Center, Case Western Reserve University, 11100 Euclid Ave, LKS 3012, Cleveland, OH 44106. E-mail guiherme.oliveira@uhhospitals.org

and continually after transplantation. The UNOS registry includes data on patient demographics, causes of cardiomyopathy, devices present, causes of removal from wait list, hemodynamics, and other peritransplantation and long-term data. The registry is continuously audited with rigorous quality control.[11] The version used in this study recorded patient listings and follow-up until September 30, 2015. Data included in the UNOS are extracted from the transplant candidate registration form, which is filled at listing; transplant recipient registration form, which is filled at the time of transplantation; and transplant recipient follow-up form, which is filled at follow-up.

Patient Population

We identified all patients ≥18 years of age, listed for HT with a primary diagnosis of myocarditis between January 2000 and September 2015. Additional cases were identified in the diagnosis free text variable. We compared their baseline characteristics, MCS utilization, and post-transplant outcomes to those of patients with ischemic and other nonischemic causes of HF. We excluded patients with congenital, valvular, and restrictive heart disease and those with hypertrophic cardiomyopathy and retransplantation.

Statistical Analyses

All analyses were performed using Statistical Package for Social Sciences (SPSS, version 19.0; SPSS Inc, Chicago, IL). Categorical variables are presented as percentages and compared using Pearson χ^2 test. Continuous variables are presented as mean and SD or median and 25th–75th percentiles, as appropriate. Comparisons were performed using Student *t* test (2 normal variables), 1-way ANOVA (>2 non-normal variables), Mann–Whitney *U* test (2 non-normal variables), and Kruskal–Wallis test (>2 non-normal variables), as appropriate. No assumptions were used for missing data. Survival analyses were done using Kaplan–Meier method with log-rank test and adjusted survival using Cox proportional-hazard model. All tests are 2 sided. $P<0.05$ is considered statistically significant. Institutional review board approval was not required because only deidentified data sets were used for this analysis.

Results

Demographic Characteristics

Of the 45 941 adults listed for orthotopic heart transplantation (OHT) from 2000 to 2015, we identified 299 patients (0.7%) with a diagnosis of myocarditis and compared them with 15 321 patients with NICM, and 16 686 with ischemic cardiomyopathy (ICM; Table).

Patients with myocarditis were younger (mean age: 43.4±14.0 years versus NICM 49.8±12.4 years and ICM 57.5±8.0 years; $P<0.001$) and less predominantly men (myocarditis 55.2% versus NICM 72.5% versus ICM 86.8%; $P<0.001$). Myocarditis patients were more often listed as status 1A (myocarditis 44.4% versus NICM 20.8% versus ICM 21.2%; $P<0.001$), had a significantly greater requirement for mechanical ventilation (myocarditis 10.6% versus NICM 2.4% versus ICM 4.2%; $P<0.001$), and were less likely to have implantable cardioverter-defibrillators (myocarditis 42.8% versus NICM 70.4% versus ICM 68%; $P<0.001$).

Out of 68 patients with myocarditis and biventricular support (biventricular MCS or ECMO), 46 patients (68%) were listed as status 1A compared with 31.1% without biventricular support at listing ($P<0.001$). However, patients with myocarditis without biventricular support still were more likely to be listed as 1A than those with other HF types (myocarditis 31% versus NICM 21% versus ICM 21%; $P<0.001$).

Wait List Outcomes

Of 299 myocarditis patients, 194 patients (65%) received OHT, 32 patients (11%) died while waiting, 17 patients (6%) were delisted for deterioration, 23 patients (8%) were delisted for improvement, 18 patients (6%) had other or unknown outcomes, and 15 patients (5%) remained on the wait list. Patients with myocarditis spent less time on the waitlist (myocarditis 2.0 months versus NICM 4.2 months versus ICM 4.2 months; $P<0.001$).

There were no differences in wait-list mortality or delisting between sexes (log rank $P=0.22$) or between pre- and post–continuous-flow MCS eras (pre 2008 versus post 2008; $P=0.62$). Compared with ICM and NICM, patients with myocarditis had higher likelihood of being delisted for improvement (harzard ratio, 2.49 [95% confidence interval, 1.63–3.79] versus ICM and hazard ratio, 2.12 [95% confidence interval, 1.40–3.22] versus NICM) but had similar rates of mortality and death or delisting for deterioration (Figure 1).

Mechanical Circulatory Support

Overall, 33% of myocarditis patients required MCS (left ventricular assist device, biventricular assist devices, or total artificial heart), compared with 17.5% of NICM and 17.1% of ICM patients; $P<0.001$). Isolated left ventricular assist device use was less common in myocarditis (myocarditis 15.2% versus NICM 16.9% versus ICM 16.5%), whereas biventricular support (biventricular assist devices or total artificial heart) use was more often required in myocarditis patients than in those with NICM and ICM (20.2% versus 2% versus 1.8%; $P<0.001$). The use of intra-aortic balloon pump (myocarditis 9.0% versus NICM 4.7% versus ICM 6.5%; $P<0.001$) and ECMO (myocarditis 4.7% versus NICM 0.4% versus ICM 0.8%; $P<0.001$) were also more frequent (Table).

Heart Transplantation Outcomes

Recipients with diagnosis of myocarditis had significantly higher panel-reactive antibodies than ICM and NICM patients ($P<0.001$) but similar Human Leukocyte Antigen mismatch ($P=0.085$). Rejection rates were comparable before discharge (myocarditis 9.5% versus NICM 9.7% versus ICM 8.9%; $P=0.039$) and at 1 year (myocarditis 24.4% versus NICM 26.4% versus ICM 23.9%; $P=0.002$; Table).

One-, 5-, and 15-year survival was 89%, 78%, and 56% for patients with myocarditis, compared with 90%, 77%, and 44% for those with NICM ($P=0.62$) and 88%, 74%, and 31% for patients with ICM ($P=0.061$; Figure 2).

Retransplantation rates were similar between myocarditis and NICM (log rank $P=0.71$) and ICM (log rank $P=0.12$). Among myocarditis patients, post-transplant survival was not different between sexes ($P=0.40$) or MCS era (pre 2008 versus post 2008; $P=0.35$).

Discussion

In this study, we report the largest contemporary cohort of patients listed for OHT with the diagnosis of myocarditis, unveiling new findings and confirming previous knowledge regarding this unique population.

Table. Characteristics of Patients by Type of HF

	Myocarditis (n=299)	NICM (n=15321)	ICM (n=16686)	*P* Value
Age, y	43.4±14.2	49.8±12.4	57.5±8.0	**<0.001**
Male sex	165 (55%)	11104 (73%)	14486 (87%)	**<0.001**
Ethnicity				**<0.001**
White	232 (78%)	8798 (57%)	13426 (81%)	
Black	46 (15%)	3647 (30%)	1636 (9.8%)	
Hispanic	9 (3.0%)	1301 (8.5%)	1068 (6.4%)	
Asian	10 (3.3%)	376 (2.5%)	424 (2.5%)	
Other/multirace	2 (0.7%)	199 (1.3%)	132 (0.8%)	
Diabetes mellitus	32 (11%)	3611 (24%)	6029 (37%)	**<0.001**
ICD	123 (42%)	10649 (70%)	11112 (68%)	**<0.001**
BMI, kg/m^2	26.5±5.0	27.6±5.4	27.7±4.6	**<0.001**
UNOS status at listing				**<0.001**
1A	131 (44%)	3190 (21%)	3543 (21%)	
1B	88 (29%)	6245 (41%)	5554 (33%)	
2	66 (22%)	5466 (36%)	7180 (43%)	
7	14 (4.7%)	420 (2.7%)	409 (2.5%)	
Blood group				**<0.001**
A	114 (38%)	5411 (35%)	6994 (42%)	
B	41 (14%)	2181 (14%)	2116 (13%)	
AB	16 (5.4%)	667 (4.4%)	784 (4.7%)	
0	128 (43%)	7062 (46%)	6792 (41%)	
IABP at listing	27 (9.0%)	718 (4.7%)	1089 (6.5%)	**<0.001**
ECMO at listing	14 (4.7%)	68 (0.4%)	126 (0.8%)	**<0.001**
Inotropes at listing	107 (36%)	5,679 (37%)	5,275 (32%)	**<0.001**
Ventricular assist device				**<0.001**
LVAD	43 (15%)	2408 (17%)	2566 (17%)	
BIVAD	54 (19%)	226 (1.6%)	253 (1.6%)	
TAH	3 (1.1%)	52 (0.4%)	34 (0.2%)	
Ventilator	32 (11%)	362 (2.4%)	706 (4.2%)	**<0.001**
HLA mismatch				0.077
0–2	6 (3.6%)	306 (3.6%)	341 (3.7%)	
3–4	64 (38%)	3094 (36%)	3552 (38%)	
5–6	99 (59%)	5164 (60%)	5424 (58%)	
Most recent PRA% class I	12.0±25.6	6.7±18.3	5.3±15.8	**<0.001**
Most recent PRA% class II	6.7±18.3	4.5±15.2	3.4±12.9	**<0.001**
Time on waitlist, mo	2.0 (0.6–7.4)	4.2 (0.2–41)	4.2 (0.2–44.8)	**<0.001**
Graft ischemic time, h	3.1±0.9	3.1±1.0	3.2±1.06	**<0.001**
Length of stay, d	13.5 (10.0–20.0)	14.0 (10.0–20.0)	14.0 (10.0–22.0)	**<0.001**
Rejection before discharge				**0.039**
Yes, treated	16 (9.5%)	748 (9.7%)	703 (8.9%)	
Yes, not treated	15 (8.9%)	435 (5.6%)	516 (6.5%)	
No	137 (82%)	6517 (85%)	6693 (85%)	
Rejection episode within 1 y	38 (24%)	2015 (26%)	1944 (24%)	**0.002**

Bold text is statistically significant. BMI indicates body mass index; BIVAD, biventricular assist devices; ECMO, extracorporeal membrane oxygenation; HLA, Human Leukocyte Antigen; IABP, intra-aortic balloon pump; ICD, implantable cardioverter-defibrillator; ICM, ischemic cardiomyopathy; LVAD, left ventricular assist device; NICM, nonischemic cardiomyopathy; PRA, panel-reactive antibody; TAH, total artificial heart; and, UNOS, United Network of Organ Sharing.

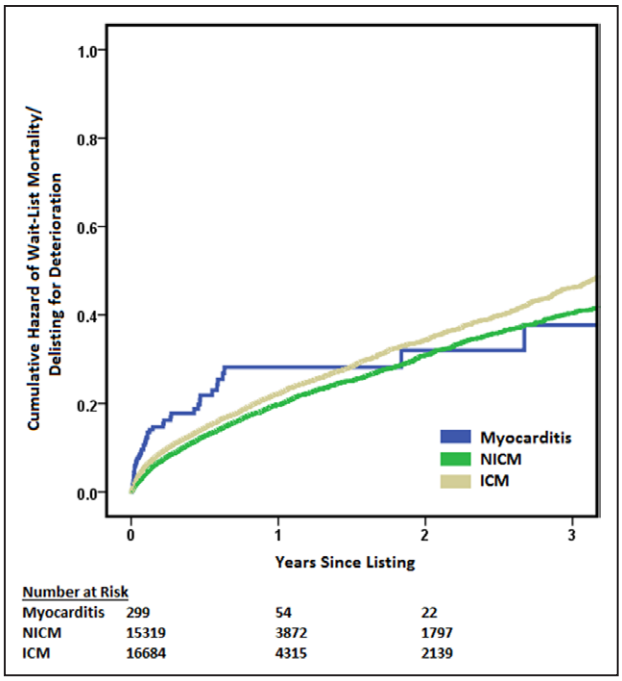

Figure 1. Wait-list mortality or delisting by type of heart failure. ICM indicates ischemic cardiomyopathy; and NICM, nonischemic cardiomyopathy.

We found that myocarditis accounts for <1% of patients who receive heart transplantation, which is consistent with previous estimates in the literature of 1% to 8%.[7] However, our report indicates that patients with myocarditis have unique characteristics that distinguish them from other advanced HF patients. For example, we show that advanced HF from myocarditis occurs mostly in young male patients. These age and sex differences are consistent with previous reports, where myocarditis has been shown to affect younger patients[12–14] and to be linked to male sex hormones.[6,15]

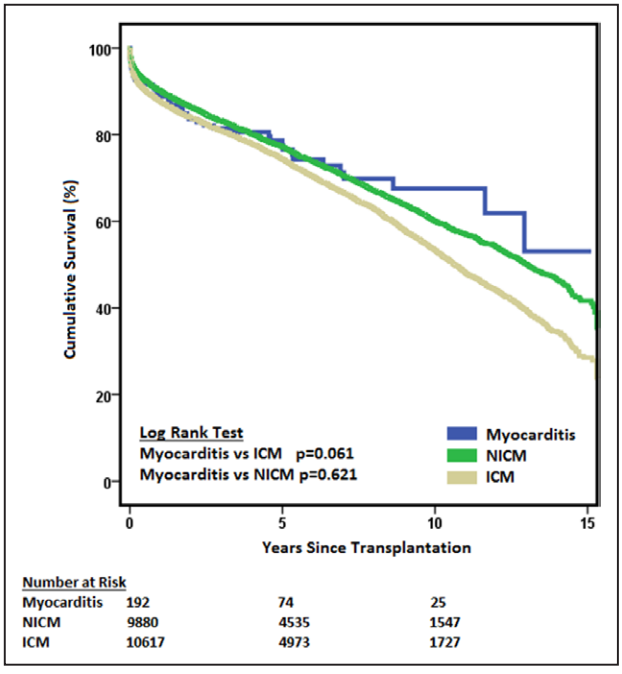

Figure 2. Post-transplant survival by type of heart failure. ICM indicates ischemic cardiomyopathy; and NICM, nonischemic cardiomyopathy.

The diagnosis of myocarditis was associated with higher acuity at listing, evidenced by a 10-fold higher requirement for biventricular MCS, 5-fold higher requirement for ECMO, and 3-fold higher requirement for ventilator need. Accordingly, myocarditis patients were more frequently listed as status 1A with less time for optimization of heart failure therapy and implantable cardioverter-defibrillators placement. Our data confirm that myocarditis affects both ventricles,[14,16] and therefore, patients require uni- and biventricular MCS more frequently,[17] similar to toxic cardiomyopathies, such as chemotherapy-induced cardiomyopathy.[18]

We also describe the natural history of myocarditis patients in the transplant waitlist and confirm a higher likelihood of recovery.[12,16] In our series, ≈7% of listed patients were delisted for recovery, twice as much as other HF types. This suggests that it is essential that patients with myocarditis—especially those with durable MCS—be monitored closely for signs of recovery, possibly by using intensified weaning protocols, even after listing for OHT. It is important to note, however, that the natural history is different among different types of myocarditis. For example, patients with giant cell myocarditis have been shown to have low recovery rates and most will have progressive disease requiring advanced therapies.[19]

We also investigated transplantation outcomes in myocarditis patients, which historically has been controversial because of fears of increased rejection and death after transplantation. In fact, some small studies have reported ≤2.2-fold increased risk of rejection and lower 1 year survival (58% versus 82%) compared with age- and sex-matched controls.[7,20] Previously, O'Connell et al[21] queried the UNOS database from 1968 to 1993 and reported the outcomes of 142 myocarditis patients to be similar to that of patients with other HF types. Similarly, a recently published single-center, retrospective experience concluded that patients with myocarditis had survival comparable to patients transplanted for other indications.[8] In this study, we confirm that patients with myocarditis have post-transplant survival similar to other HF patients, despite being younger and having higher panel-reactive antibodies, both well-established predictors of poorer survival.[22]

These reports also suggest that MCS with durable ventricular assist devices may provide a good alternative to transplantation in patients with acute myocarditis, especially in view of higher rates of recovery compared with other cardiomyopathies. However, careful assessment of right ventricular function is crucial when patients with myocarditis are considered for durable MCS, especially given the high rates of right ventricular support utilization in this series. Because the data presented here are obtained from a transplantation database, little is known about the outcomes of continuous-flow MCS in patients with myocarditis, and future studies from larger MCS registries may provide more granular information with regard to recovery and outcomes.

Limitations

We acknowledge multiple limitations of this study. In general, registries provide large numbers of patients at the expense of accuracy and granularity. Therefore, data accuracy is unverifiable and of poorer quality than data derived from prospective studies. As a result, one of the main limitations of this report concerns the accuracy of the diagnosis of myocarditis. Because the registry does not offer biopsy information, we cannot be sure of how many of these cases were confirmed by histology and had de facto myocarditis, although myocarditis can be diagnosed based on clinical criteria.[3] Additionally, because the clinicians reporting to UNOS are highly trained heart failure and transplant specialists, it is likely that the accuracy of this diagnosis is higher than that in the real-world scenario. Also, because most transplant centers are highly proficient in endomyocardial biopsies, it is possible that a considerable number of these diagnoses were indeed based on histology. Finally, we speculate that given the multitude of putative HF diagnoses in the UNOS reporting form, it is likely that clinicians would only choose the diagnosis of myocarditis when there was a fair amount of diagnostic certainty. More pertinent, perhaps, is the fact that the diagnosis of myocarditis may have been severely underestimated because many patients with dilated cardiomyopathies may have had unrecognized myocarditis.

The retrospective nature of this study predisposes to biases and confounding factors that statistical adjustments cannot completely avoid. For example, we cannot draw inferences on the natural history of all patients with myocarditis, but only those sick enough to require listing for transplantation, introducing significant referral bias. Because this database cannot provide clinical granularity, little insight is possible into treatment or diagnostic modalities used in these patients. Similarly, because there is no information pertaining to the pathogenesis of myocarditis, we cannot make inferences on treatment, presentation, or outcomes of different types of myocarditis. In addition, because UNOS reporting contains the diagnosis of viral cardiomyopathy, it is possible that some myocarditis could have been interchangeably reported as viral cardiomyopathy and vice versa. Finally, there are limited data on rejection and late transplant outcomes, including types or grades of rejection and cardiac allograft vasculopathy. This may be especially relevant considering that transplanted myocarditis patients have been reported to have increased frequency of late acute cellular rejection[8] but not cardiac allograft vasculopathy.[8]

Conclusions

Patients listed for OHT with a diagnosis of myocarditis are younger, present more acutely, and recover more frequently but require more uni- and biventricular MCS. Despite higher allosensitization, heart transplantation rejection and survival are similar to that of patients with other types of HF.

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Disclosures

None.

References

1. Cooper LT Jr. Myocarditis. *N Engl J Med*. 2009;360:1526–1538. doi: 10.1056/NEJMra0800028.
2. Blauwet LA, Cooper LT. Myocarditis. *Prog Cardiovasc Dis*. 2010;52:274–288. doi: 10.1016/j.pcad.2009.11.006.
3. Sagar S, Liu PP, Cooper LT Jr. Myocarditis. *Lancet*. 2012;379:738–747. doi: 10.1016/S0140-6736(11)60648-X.
4. Cooper LT Jr, Keren A, Sliwa K, Matsumori A, Mensah GA. The global burden of myocarditis: part 1: a systematic literature review for the Global Burden of Diseases, Injuries, and Risk Factors 2010 study. *Glob Heart*. 2014;9:121–129. doi: 10.1016/j.gheart.2014.01.007.
5. Caforio AL, Pankuweit S, Arbustini E, Basso C, Gimeno-Blanes J, Felix SB, Fu M, Heliö T, Heymans S, Jahns R, Klingel K, Linhart A, Maisch B, McKenna W, Mogensen J, Pinto YM, Ristic A, Schultheiss HP, Seggewiss H, Tavazzi L, Thiene G, Yilmaz A, Charron P, Elliott PM; European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. Current state of knowledge on aetiology, diagnosis, management, and therapy of myocarditis: a position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. *Eur Heart J*. 2013;34:2636–2648, 2648a. doi: 10.1093/eurheartj/eht210.
6. Mason JW, O'Connell JB, Herskowitz A, Rose NR, McManus BM, Billingham ME, Moon TE. A clinical trial of immunosuppressive therapy for myocarditis. The Myocarditis Treatment Trial Investigators. *N Engl J Med*. 1995;333:269–275. doi: 10.1056/NEJM199508033330501.
7. Höyer S, Berglin E, Pettersson G, Edvardsson N, Waagstein F. Cardiac transplantation in patients with active myocarditis. *Transplant Proc*. 1990;22:1450.
8. Yoshizawa S, Kato TS, Mancini D, Marboe CC. Outcome of patients having heart transplantation for lymphocytic myocarditis. *Am J Cardiol*. 2013;112:405–410. doi: 10.1016/j.amjcard.2013.03.042.
9. Moloney ED, Egan JJ, Kelly P, Wood AE and Cooper LT, Jr. Transplantation for myocarditis: a controversy revisited. *J Heart Lung Transplant*. 2005;24:1103–1110.
10. Mody KP, Takayama H, Landes E, Yuzefpolskaya M, Colombo PC, Naka Y, Jorde UP, Uriel N. Acute mechanical circulatory support for fulminant myocarditis complicated by cardiogenic shock. *J Cardiovasc Transl Res*. 2014;7:156–164. doi: 10.1007/s12265-013-9521-9.
11. Daily OP, Kauffman HM. Quality control of the OPTN/UNOS Transplant Registry. *Transplantation*. 2004;77:1309; author reply 1309–1309; author reply 1310.
12. McCarthy RE 3rd, Boehmer JP, Hruban RH, Hutchins GM, Kasper EK, Hare JM, Baughman KL. Long-term outcome of fulminant myocarditis as compared with acute (nonfulminant) myocarditis. *N Engl J Med*. 2000;342:690–695. doi: 10.1056/NEJM200003093421003.
13. Kytö V, Sipilä J, Rautava P. The effects of gender and age on occurrence of clinically suspected myocarditis in adulthood. *Heart*. 2013;99:1681–1684. doi: 10.1136/heartjnl-2013-304449.
14. Ginsberg F, Parrillo JE. Fulminant myocarditis. *Crit Care Clin*. 2013;29:465–483. doi: 10.1016/j.ccc.2013.03.004.
15. Schwartz J, Sartini D, Huber S. Myocarditis susceptibility in female mice depends upon ovarian cycle phase at infection. *Virology*. 2004;330:16–23. doi: 10.1016/j.virol.2004.06.051.
16. Gupta S, Markham DW, Drazner MH, Mammen PP. Fulminant myocarditis. *Nat Clin Pract Cardiovasc Med*. 2008;5:693–706. doi: 10.1038/ncpcardio1331.
17. Chen YS, Yu HY, Huang SC, Chiu KM, Lin TY, Lai LP, Lin FY, Wang SS, Chu SH, Ko WJ. Experience and result of extracorporeal membrane oxygenation in treating fulminant myocarditis with shock: what mechanical support should be considered first? *J Heart Lung Transplant*. 2005;24:81–87. doi: 10.1016/j.healun.2003.09.038.
18. Oliveira GH, Dupont M, Naftel D, Myers SL, Yuan Y, Tang WH, Gonzalez-Stawinski G, Young JB, Taylor DO, Starling RC. Increased need for right ventricular support in patients with chemotherapy-induced cardiomyopathy undergoing mechanical circulatory support: outcomes from the INTERMACS Registry (Interagency Registry for Mechanically Assisted Circulatory Support). *J Am Coll Cardiol*. 2014;63:240–248. doi: 10.1016/j.jacc.2013.09.040.
19. Cooper LT Jr, Berry GJ, Shabetai R. Idiopathic giant-cell myocarditis–natural history and treatment. Multicenter Giant Cell Myocarditis Study Group Investigators. *N Engl J Med*. 1997;336:1860–1866. doi: 10.1056/NEJM199706263362603.

20. O'Connell JB, Dec GW, Goldenberg IF, Starling RC, Mudge GH, Augustine SM, Costanzo-Nordin MR, Hess ML, Hosenpud JD, Icenogle TB. Results of heart transplantation for active lymphocytic myocarditis. *J Heart Transplant*. 1990;9:351–355; discussion 355.
21. O'Connell JB, Breen TJ, Hosenpud JD. Heart transplantation in dilated heart muscle disease and myocarditis. *Eur Heart J*. 1995;16(suppl O):137–139.
22. Stehlik J, Edwards LB, Kucheryavaya AY, Benden C, Christie JD, Dipchand AI, Dobbels F, Kirk R, Rahmel AO, Hertz MI; International Society of Heart and Lung Transplantation. The Registry of the International Society for Heart and Lung Transplantation: 29th official adult heart transplant report–2012. *J Heart Lung Transplant*. 2012;31:1052–1064. doi: 10.1016/j.healun.2012.08.002.

CLINICAL PERSPECTIVE

Myocarditis can cause dilated cardiomyopathy, which may progress to require advanced therapies. Heart transplantation for patients with myocarditis has been a controversial issue owing to myocardial recovery without transplantation and reports of increased post-transplant rejection. However, there is little contemporary data on the clinical progression and transplantation outcomes in these patients. In this large study of the UNOS registry (United Network of Organ Sharing), we show that myocarditis was the primary cause of transplantation in <1% of adults listed for heart transplantation. These patients are listed at higher priority and have higher incidence of biventricular failure, requiring more uni- and biventricular mechanical support. Patients with myocarditis also had a higher likelihood of recovery and delisting while on the waitlist. Despite higher allosensitization, patients who underwent heart transplantation for myocarditis had excellent short- and long-term outcomes.

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