Published in final edited form as:

J Heart Lung Transplant. 2015 February ; 34(2): 266–269. doi:10.1016/j.healun.2014.09.046.

Reliability of transthoracic echocardiogram interpretation in potential adult heart transplant donors

Kiran K. Khush, MD, MAS^a, John Nguyen, RN^b, Benjamin A. Goldstein, PhD^c, Dana P. McGlothlin, MD^d, and Jonathan G. Zaroff, MD^d

^aDivision of Cardiovascular Medicine, Department of Medicine, Stanford University School of Medicine, Palo Alto, California

^bCalifornia Transplant Donor Network, Oakland, California

^cDepartment of Biostatistics and Bioinformatics, Duke University School of Medicine, Durham, NC

^dKaiser Northern California Division of Research, Oakland, California

Heart transplantation is greatly limited by a scarcity of donor organs. Despite this critical organ shortage, only one third of available donor hearts are recovered for transplantation. Although there are many potential reasons for non-use of a donor heart, 25% to 50% of organs are declined due to reported echocardiographic abnormalities.¹

Echocardiographic assessment of potential hearts for transplantation was first reported in 1988² and is now performed on almost all potential heart donors. The ubiquitous use of transthoracic echocardiography (TTE) for cardiac donor evaluation has raised the concern that an error of interpretation may cause a viable organ to be discarded, prompting the consideration of centralized expert interpretation of donor TTEs.³ The question of whether centralized TTE interpretation yields more reliable measurements of donor heart structure and function, however, has never been systematically assessed. We therefore aimed to compare the reliability of core versus community donor TTE interpretation in a contemporary cohort of potential adult organ donors.

Approval for this study was obtained from the California Transplant Donor Network (CTDN). The medical records of all adult brain-dead organ donors managed by CTDN who were considered for heart donation (age 18 to 59 years, no known coronary or structural heart disease) from 2011 to 2012 were reviewed to determine whether a TTE had been performed, in which case the digital images were requested from the donor hospital with the local cardiologist's interpretation.

Once 100 donor echocardiograms had been obtained, the following data were extracted from community interpretation reports: left ventricular ejection fraction (EF); internal diameter in diastole and systole (LVIDd, LVIDs); end-diastolic septal and posterior wall dimensions

Disclosure statement

The authors have no conflicts of interest to disclose.

Supplementary data

Supplementary data associated with this article can be found in the online version at www.jhltonline.org.

(LVSD, LVPWd); and pattern of LV regional wall motion abnormalities (RWMA). Seventy TTEs were selected to represent a mix of “normal” (normal LV systolic function, no structural heart disease) and “abnormal” studies. These were uploaded into Digisonics Digiview echocardiographic analysis software in the core laboratory at Kaiser Northern California Division of Research. All personal identifiers and study dates were removed to ensure blinding. Each of the 70 studies was assigned a unique study ID. Twenty-nine TTEs that represented a mix of normal and abnormal studies were then duplicated, to test intra-rater reliability, for a total of 99 unique study IDs.

The 99 selected TTEs were independently interpreted by two core reviewers. Detailed methods of core TTE interpretation and statistical analyses are presented in the Supplementary Material (available online at www.jhltonline.org).

Mean donor age was 35.5 years (range 24.5 to 50 years). The most common cause of death was head trauma (47%), followed by cerebrovascular causes (41%). The mean time from brain death to TTE acquisition was 21 hours (range 17.7 to 24.6 hours).

Of the 70 donor hearts studied, 11 were considered unsuitable for transplant by CTDN and were not offered, 16 were offered for transplant but not accepted, 40 were accepted for transplant, and 3 hearts were initially accepted but not recovered due to an aborted transplant. Of the 11 hearts considered unsuitable for transplant, 5 had left ventricular hypertrophy (LVH) and 3 had LV dysfunction by community interpretation; one of these TTEs was classified as normal by both core reviewers. Of the 16 hearts offered but not accepted for transplant, 4 were declined due to LV dysfunction or RWMA and 3 for LVH, based on community interpretation; 2 of these TTEs were subsequently interpreted as normal by core review.

Table 1 summarizes the mean differences between core and community TTE measurements. There was no significant difference in LV wall thickness between core and community readers. The core readers reported smaller end-diastolic dimensions, on average, than community readers. The magnitude of this difference, however, was relatively small (0.15 to 0.19 cm). We did find significant differences in LVEF measurements between core and community reviewers, particularly for studies with depressed LV systolic function. Overall, community readers reported lower LVEF values than core readers. Figure 1 shows the Bland–Altman plots comparing core and community values for LV wall thickness and ejection fraction.

When LV wall thickness was classified as normal (≤ 1.1 cm) or abnormal, we found modest inter-rater reliability, with slightly greater agreement between the two core reviewers ($\kappa = 0.54$) compared with core vs community ($\kappa = 0.48$ for Core 1-community and Core 2-community). Overall, core reviewers were more likely to report LVH than were community reviewers.

There was great variability in interpretation of RWMA. Of the 70 echocardiograms examined, Core 1 reported an apical-sparing pattern of RWMA, as described in neurocardiogenic injury⁴ in 9 studies, and global hypokinesis in 7 studies. Core 2 reported an apical-sparing pattern in 3 studies (2 of which were described similarly by Core 1), and

diffuse hypokinesis in 6 studies. Community cardiologists reported an apical-sparing pattern in 4 studies (2 of which were described similarly by Core 1, no overlap with Core 2) and global hypokinesis in 4 studies. Overall, interpretation was most likely to concur in the setting of global LV dysfunction, with little agreement between core and community cardiologists with respect to regional patterns.

Intra- and inter-rater reliability within and between the two core readers was high, whereas measurement differences between core and community tended to be greater. For example, there was a 5% absolute difference in LVEF measurements within a given reviewer, 6% across the two core reviewers, and 9% and 10% between the two core and community readers.

The optimal way to evaluate donor hearts is a matter of debate, but most protocols are based on a consensus report that highlights the use of echocardiography.⁵ Unfortunately, the accuracy of TTE interpretation can vary. We therefore performed this study to quantify intra- and inter-rater agreement in donor echocardiogram interpretation between two core cardiologists with expertise in donor TTE interpretation, and a pooled sample of cardiologists at local hospitals. We found no significant difference between core and community LV wall thickness measurements. There were significant differences in LV dimensions; in general, core measurements were approximately 0.1 to 0.3 cm smaller than community measurements. The most notable finding from our study was a discrepancy between core and community assessment of LV systolic function. Precise quantification of LVEF is not crucial in hearts with normal systolic function, but is very important in the assessment of hearts with compromised function, when a few percentage points may determine whether or not a heart is accepted for transplantation. Core EF measurements were, on average, higher than community reads. Also, as demonstrated by Bland–Altman plots (Figure 1), there was more consistency in LVEF assessment between the two core reviewers than core vs community measurements for donor hearts with LV dysfunction. In our cohort, two donor hearts that were not accepted for transplant due to LV dysfunction were subsequently interpreted as normal by core review. In cases where acquisition of diagnostic quality echocardiographic images is difficult, such as in donors with chest trauma, use of myocardial contrast echocardiography may enable more accurate assessment of LV function.⁶

In conclusion, we compared core and community interpretation of LV structure and function, and several significant differences were found, particularly in the evaluation of donor hearts with LV dysfunction. These results provide data supporting the use of real-time expert interpretation of donor echocardiograms, particularly when a donor heart may be declined for transplantation based on abnormal TTE findings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank Rebecca Menza for assistance with study design, and the California Transplant Donor Network for access to the donor data and echocardiograms required for this study. This work was supported by the National Heart, Lung, and Blood Institute (K23HL091143 to K.K.K.) and the National Institute of Diabetes and Digestive and Kidney Diseases (K25DK097279 to B.A.G.).

References

1. Khush KK, Menza R, Nguyen J, et al. Donor predictors of allograft use and recipient outcomes after heart transplantation. *Circ Heart Fail*. 2013; 6:300–9. [PubMed: 23392789]
2. Gilbert EM, Krueger SK, Murray JL, et al. Echocardiographic evaluation of potential cardiac transplant donors. *J Thorac Cardiovasc Surg*. 1988; 95:1003–7. [PubMed: 3287011]
3. Venkateswaran RV, Bonser RS, Steeds RP. The echocardiographic assessment of donor heart function prior to cardiac transplantation. *Eur J Echocardiogr*. 2005; 6:260–3. [PubMed: 15992708]
4. Khush KK, Kopelnik A, Tung P, et al. Age and aneurysm position predict patterns of left ventricular dysfunction after subarachnoid hemorrhage. *J Am Soc Echocardiogr*. 2005; 18:168–74. [PubMed: 15682055]
5. Zaroff JG, Rosengard BR, Armstrong WF, et al. Consensus conference report: maximizing use of organs recovered from the cadaver donor: cardiac recommendations, March 28–29, 2001, Crystal City, Va. *Circulation*. 2002; 106:836–41. [PubMed: 12176957]
6. Bhatia VK, Senior R. Contrast echocardiography: evidence for clinical use. *J Am Soc Echocardiogr*. 2008; 21:409–16. [PubMed: 18329848]

Figure 1.

Bland–Altman plots comparing core and community values for three echocardiographic measurements of interest: LVSD (left ventricular septal wall dimension); LVPWd (left ventricular posterior wall dimension); and LVEF (left ventricular ejection fraction). In these plots, the differences between the two measurements (y-axis) are plotted against the averages of the two measurements (x-axis), while the horizontal dotted line is set at zero (no difference). Dots close to the dotted line represent small differences between core and community measurements (or between the two core measurements), whereas dots far from the dotted line represent large measurement differences. Note the large measurement

differences between core and community left ventricular ejection fraction (LVEF) measurements for echocardiograms with left ventricular dysfunction (LVEF <50%).

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 1

Mean Differences in Measurements Between Core and Community Readers

	Core 1 vs Core 2	p-value	Core 1 vs community	p-value	Core 2 vs community	p-value
LVPWd (cm)	-0.035	0.076	0.029	0.580	-0.004	0.939
LVSD (cm)	0.015	0.503	-0.033	0.131	-0.018	0.448
LVIDd (cm)	0.034	0.511	0.154	0.035	0.193	0.005
LVIDs (cm)	0.194	0.005	0.115	0.688	0.312	0.000
LVEF (%)	-2.243	0.015	-2.211	0.070	-4.602	0.000

Negative results occurred when mean community value was lower than mean core value; positive results occurred when community value was higher than core. LVEF, left ventricular ejection fraction; LVPWd, left ventricular posterior wall dimension; LVSD, left ventricular septal wall dimension; LVIDd, left ventricular internal diameter in diastole; LVIDs, left ventricular internal diameter in systole.