Elevated Troponin? Take Heart and Reconsider!

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Heart transplantation is a very effective treatment option for patients with many end-stage cardiac pathologies. Unfortunately, a shortage of donor organs limits the number of patients who benefit from this intervention, and many patients still die while awaiting transplantation. Per the Scientific Registry for Transplant Recipients, the estimated overall heart transplant wait-list mortality for 2013 was 10.7 deaths per 100 wait-list years. Given this, there has been great interest in identifying the donor risk factors that are significantly associated with adverse recipient outcomes, to safely expand donor heart utilization and to ensure that organs are not unnecessarily rejected.

When evaluating donor organs, there are a number of well-defined exclusion criteria, such as use of high-dose inotropic support during donor management, positive hepatitis/HIV serologies, obstructive coronary artery disease, and irreversible left ventricular systolic dysfunction. However, there are a number of donor risk factors that are evaluated on a case-by-case basis. Among these are elevated donor troponin I levels. Previous studies have shown that troponin I may be a reliable surrogate of donor heart function, and this biomarker has therefore been used to help select optimal organs. What is often not taken into consideration is the fact that donor troponin levels are influenced by a number of clinical variables, including mode of death and renal function. The Table lists the most commonly cited reasons for nonacceptance of donor hearts for transplantation.

Studies investigating recipient outcomes after using hearts from donors with elevated troponin I have had mixed results. Initial studies concluded that elevated donor troponin I levels were associated with decreased left ventricular ejection fraction, possibly predisposing to worse recipient outcomes, although that end point was not specifically evaluated. Shortly thereafter, Potapov et al found that recipients of hearts from donors with elevated troponin I or T had a higher odds of developing primary graft failure. In a follow-up study, this group found that elevated donor cardiac troponin T and procalcitonin were independently associated with early graft failure. Although the study cohorts were small, and the criteria for primary graft failure have since been revised, this was the longstanding belief for a number of years. Interestingly, one subsequent study suggested that elevated donor troponin levels may be protective against future recipient complications, such as development of cardiac allograft vasculopathy. More recently, our group showed that modestly elevated donor cardiac troponin I levels are not associated with increased recipient mortality after cardiac transplantation. Since then, other studies have shown that elevated donor troponin I levels are not associated with increased incidence of acute rejection or graft dysfunction in the transplant recipient. Similar findings have also been noted in the pediatric literature, although median troponin levels were much lower at ≈0.1 ng/mL. Most recently, Szarszoi et al used the newer high-sensitivity cardiac troponin T assay to study recipient incidence of primary graft dysfunction after receiving hearts from donors with elevated high-sensitivity cardiac troponin T. They found no significant difference in high-sensitivity cardiac troponin T levels between patients who developed primary graft failure and those who did not. One possible explanation for the change in findings in recent years is the reduction in mortality because of improvements in perioperative care. Generally, however, hearts from donors with elevated troponin I are subjected to more stringent selection criteria and often excluded from transplantation.

In this issue of Circulation: Heart Failure, the study by Madan et al used the national United Network for Organ Sharing database to investigate recipient outcomes after transplantation using hearts from donors with variably elevated levels of troponin I. The authors concluded that elevated donor troponin levels in patients with preserved left ventricular systolic function were not associated with primary graft dysfunction, the development of cardiac allograft vasculopathy, or increased mortality.

The study has a number of strengths that should be highlighted. First, it is the most comprehensive (with a cohort of ≈11 000 recipients) study investigating recipient outcomes using donors with elevated troponin. It is also relevant to our current practice because it includes data from contemporary years (2007 to 2014). Improvements in surgical and perioperative management and immunosuppressive therapies have led to significantly improved survival after heart transplantation in the current era, which may mitigate the effect of using higher-risk donor hearts. Additionally, the authors used hard definitions for primary graft dysfunction, minimizing ambiguity. Finally, the authors appropriately adjusted for a large number of donor and recipient characteristics that may be potential confounders, strengthening their findings significantly.

Although the study has many strengths, there are important caveats to consider. The first of these is the variability of troponin measurements. The authors selected the highest reported...
troponin value during donor management for their analyses. However, it is important to consider the implications of an elevated troponin in various clinical scenarios. For example, an elevated troponin after brain stem herniation or cardiopulmonary resuscitation, which often results in catecholamine release followed by myocardial injury, may not be equivalent to a donor with stable hemodynamics and persistently elevated troponin. Furthermore, different organ procurement organizations have different protocols for donor management, including laboratory evaluation before offering organs, so the reported values may reflect differences in donor management and the timing of blood draws. In addition, different donor hospitals use various troponin assays with variable sensitivity. Therefore, the use of a single troponin value, without other temporal or clinical standardization, should be interpreted with caution.

Another point to consider is the possibility of selection bias. Only those organs accepted for transplant were included in this analysis. It is likely that those donors with elevated troponin levels had other favorable features (i.e., young age, lack of additional comorbidities) that ultimately led to acceptance of their hearts for transplantation. Thus, the outcome of marginal or high-risk donor hearts with elevated troponin levels remains unknown because many of these organs were likely discarded.

Although this article concludes that troponin elevation in donors with intact systolic function does not portend poor recipient outcomes, there is still need for further investigation. Given the variability of troponin levels over time, it may be more insightful to follow trends (i.e., rise, decline, or persistent elevation) rather than a single value. The timing of troponin levels relative to donor cardiopulmonary resuscitation and brain stem herniation should be considered with respect to heart utilization and recipient outcomes. It may also be worthwhile to study the association between elevated troponin levels and recipient outcomes in donors with left ventricular dysfunction (ejection fraction <55%, excluded from this study) because decisions about acceptance of these hearts for transplantation are much more difficult than acceptance of a heart with normal function. Regardless, this article should go a long way toward reassuring transplant centers when evaluating heart offers from donors with normal cardiac function in the setting of elevated troponin levels. Hopefully this will represent a concrete step toward safely expanding donor heart utilization.

**Disclosures**

Dr Khush is the principal investigator of a National Institutes of Health–sponsored multisite study that aims to establish evidence-based criteria for donor heart selection (R01HL125303). The other authors report no conflicts.

**References**

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