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A Rare Case of Stenosis at the Inferior Vena Cava to Right Atrium Anastomosis after Bicaval Orthotopic Heart Transplantation

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Abstract: Stenosis at either the superior or inferior caval anastomosis is a rare complication of orthotopic heart transplantation (OHT) and is unique to the bicaval surgical technique. The severity of stenosis dictates the degree of clinical significance, varying from asymptomatic to congestive end-organ injury and hemodynamic instability from impaired preload. Due to differences in the anatomic location of organ congestion, the clinical presentation also depends on which of the 2 anastomoses is involved. In this article, the authors describe a case of stenosis at the inferior vena cava to right atrium anastomosis, which was diagnosed intraoperatively during OHT after weaning from cardiopulmonary bypass. Transesophageal echocardiography provided an accurate and timely diagnosis of this complication, which allowed for immediate surgical correction. Surprisingly, a large, native Eustachian valve was found to be obstructing the anastomosis. Resection of the valve relieved the previously significant narrowing across the anastomosis. This case highlights the importance of thorough intraoperative transesophageal echocardiographic evaluation of graft anastomoses during OHT, as well as an understanding on the part of the echocardiographer of the specific surgical techniques employed during OHT.

Introduction: The surgical approach to orthotopic heart transplantation (OHT) can be broadly classified into two separate techniques. The traditional biatrial approach conjoins left and right atrial recipient and donor cuffs instead of separate vena cava and pulmonary vein anastomoses, thus reducing the requirement of creating eight separate anastomoses down to four.[1] More recently, many surgeons have transitioned from a biatrial to a bicaval technique in an effort to preserve the anatomic and physiologic integrity of the donor right atrium (RA). The bicaval approach involves fashioning separate inferior vena cava (IVC) and superior vena cava (SVC) anastomoses, which preserves right atrial size and geometry, while also avoiding sinus node injury. This method has proven superior over the biatrial technique across a variety of measures, including perioperative mortality, tricuspid valve regurgitation, and arrhythmias.[1, 2] However, potential downsides of the bicaval technique include slight increases in ischemic graft time, as well as a small risk of caval stenosis at either the superior or inferior anastomosis.[1] Here, we describe a case of OHT by the bicaval approach in which the early recognition of stenosis at the IVC anastomosis by intraoperative transesophageal echocardiography (TEE) allowed for an immediate surgical correction, thus averting the potential risks of multiorgan failure and secondary risks of reoperation.

Case Presentation: A 45-year-old male with a history of familial nonischemic restrictive cardiomyopathy presented for OHT. The induction of general anesthesia, sternotomy, and commencement of cardiopulmonary bypass (CPB) proceeded without complications. The donor heart was inserted in the usual bicaval fashion. Implantation began with the left atrial anastomosis, followed by the pulmonary artery, aortic, and finally the IVC and SVC anastomoses. All anastomoses were completed with a standard, continuous running monofilament suture; no technical difficulties were encountered in the process. After weaning from CPB support, initial clinical assessment demonstrated excellent cardiac performance, with

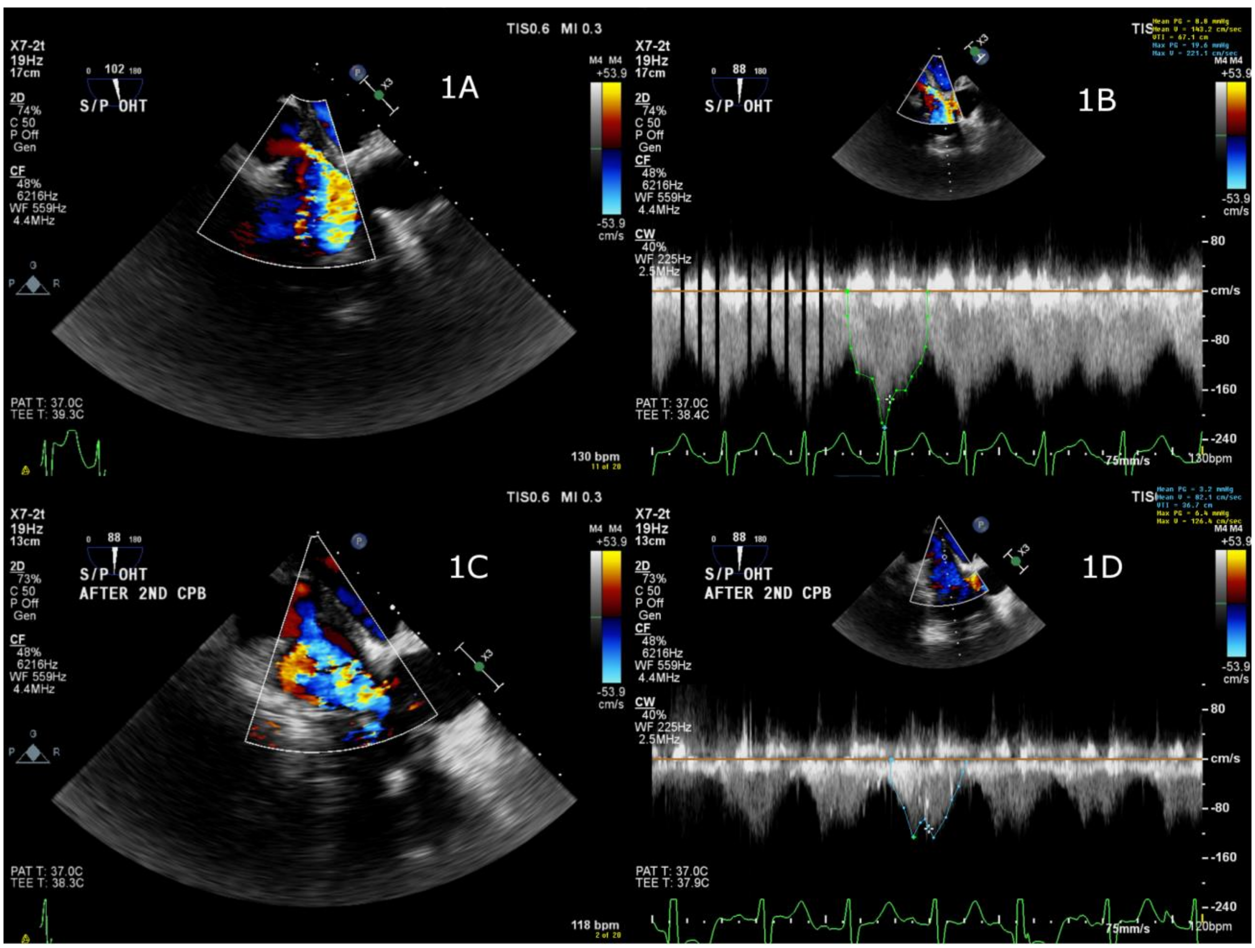

Figure 1. TEE images from a modified bicaval view. **Panel 1A**: Color doppler analysis after the first CPB run, demonstrating flow acceleration across the IVC anastomosis. A prominent Eustachian valve is also visible. **Panel 1B**: Continuous wave doppler analysis after the first CPB run, demonstrating significant stenosis across the IVC anastomosis (peak gradient 19.6 mmHg, mean gradient 8.8 mmHg). **Panel 1C**: Color doppler analysis after the second CPB run, demonstrating a significant reduction in flow acceleration across the IVC anastomosis. **Panel 1D**: Continuous wave doppler analysis after the second CPB run, demonstrating a significant reduction in stenosis across the IVC anastomosis (peak gradient 6.4 mmHg, mean gradient 3.2 mmHg).

normal biventricular function and sinus rhythm. However, filling pressures remained low despite considerable volume resuscitation, and significant vasopressor doses were required to maintain adequate mean arterial pressures.

Further assessment by color doppler TEE demonstrated flow acceleration from the IVC into the RA (Figure 1A), and continuous wave (CW) doppler measurements revealed a gradient through the anastomosis of approximately 19 mmHg (Figure 1B). After reinstitution of CPB and right atriotomy, assessment of the IVC anastomosis demonstrated the presence of a large (2.5 centimeter) Eustachian valve from the native heart that was obstructing flow from the IVC into the RA. A substantial area of the valve was resected. Thereafter, a 26 milimeter hegar dilator was able to be easily admitted into the IVC via the RA, confirming resolution of the IVC-RA anastamotic narrowing. The patient was again weaned from CPB. TEE now demonstrated resolution of flow acceleration across the anastamosis by color doppler (Figure 1C), and only a mild gradient was calculated by CW doppler (Figure 1D). In addition, "pull back" pressure measurements with a catheter withdrawn from the IVC into the RA demonstrated no gradient at all. The hemodynamics and filling pressures were significanjtly improved compared to the first attempt to wean from CPB. After ensuring adequate hemostasis, the patient's chest was closed and he was transferred to the intensive care unit in critical but stable condition. He subsequently progressed through an uncomplicated postoperative course and overall recovery. Outpatient follow up has confirmed excellent graft function and quality of life.

Discussion: Stenosis at either caval anastomosis after OHT is very rare[2], particularly when a native Eustachian valve is involved. To our knowledge, the only other reported case of this specific mechanism of stenosis was described in a neonate who underwent OHT, but required re-operation on postoperative day 3 to resect an obstructing Eustachian valve due to persistent hypotension.[3] In this case, the diagnosis was made postoperatively with an echocardiogram demonstrating a dilated IVC with underfilled right and left ventricles, but was otherwise unremarkable. Other etiologies for IVC-RA stenosis after OHT have also been reported, with variable presentations and subsequent interventions. In one case of an adult undergoing OHT, a hemostatic suture at the IVC-RA anastomosis proved to be the culprit for stenosis.[4] The pathology was diagnoased 12 hours postoperatively by TEE after the patient developed severe hepatic and renal failure, and required urgent reoperation to repair the anastamosis. A different patient who had undergone combined heart-lung transplantation presented with bilateral lower extremity edema on postoperative day 5, as well as a continuous murmur at the right lung base that increased with inspiration. Echocardiography demonstrated turbulent flow at the IVC-RA junction, and right heart catheterization from a femoral venous approach demonstrated a gradient of 13 mmHg across the anastomosis. Here, the mechanism for stenosis remained uncertain, but it was effectively treated by transcatheter balloon dilation on postoperative day 17, thus avoiding the risks of reoperation.[5]

Our case represents the first report of an intraoperative diagnosis of a stenotic IVC-RA anastomosis by TEE at the time of OHT, which allowed for immediate surgical repair. The timely diagnosis and subsequent intervention prevented the potential morbidity from multiple organ failure and reoperation as were described in the above references. Intraoperative TEE played an essential role in making this potentially challenging diagnosis. While SVC-RA stenosis classically presents with relatively specific clinical signs of “SVC syndrome,” the congestion from IVC-RA stenosis causes end-organ injury of the abdominal viscera and hypotension from impaired preload, neither of which is an infrequent finding after OHT.[4] The differential diagnosis for this clinical picture after OHT is broad, and more likely involves low cardiac output, vasoplegia, or congestion from right-ventricular dysfunction. TEE is an incredibly useful tool for making an accurate assessment in this clinical situation.

In addition to TEE, we have also demonstrated that a gradient across the IVC-RA anastomosis after OHT can be further assessed intraoperatively by the direct placement of a catheter into the IVC through a purse string suture in the RA, and transducing pressure measurements during “pull back” under TEE or fluoroscopic guidance. Alternatively, this can be performed through femoral venous access with RA-IVC “pull back,” as described above.

Conclusion: Overall, this case emphasizes the importance of intraoperative TEE to provide early recognition of IVC-RA stenosis after OHT, allowing for immediate surgical intervention. Based on previous reports, our timely diagnosis and repair likely prevented serious injury related to congestive end-organ damage and hemodynamic instability from impaired preload, and also averted the risks associated with re-operation. This case highlights the importance of thorough intraoperative TEE evaluation during OHT. Specifically, echocardiographers must go beyond the standard perioperative TEE exam to also evaluate each anastomosis, and proper interpretation of these findings requires a detailed understanding of the specific surgical technique employed for OHT.

There are no published standards to specifically guide the echocardiographic assessment of caval anastomoses after heart transplantation. In theory, there should be no pressure gradient by spectral doppler across either caval anastomosis, nor should there be turbulent flow demonstrated by color doppler imaging. If TEE assessment suggests evidence of flow acceleration by either of these approaches, we recommend that direct “pull back” pressure measurements be performed, as described above. This practice is particularly important in the setting of hemodynamic instability that cannot be explained otherwise.

In addition, baseline intraoperative TEE should assess for the presence of a large, native Eustachian valve; retrospective assessment of our baseline exam demonstrated a valve of 2.8 centimeters in its largest dimension. Direct assessment of the Eustachian valve should also be performed by the surgical team during dissection and mobilization of the native heart. If present, a prominet Eustachian valve should be partially or completely removed before the IVC-RA anastomosis is fashioned. We propose that preemptive resection be considered if the Eustachian valve is greater than 1.5 cm in its largest dimension, or if it represents more than 50 percent of the proximal donor IVC diameter. If the valve is left in situ, a careful TEE evaluation should be performed after CPB to exclude any obstruction of flow from the IVC.

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