End-tidal carbon dioxide (CO₂) values decreased for two reasons. First, the patient’s cardiac output dropped from baseline down to that supported by the ECMO pump, resulting in decreased pulmonary perfusion and a decrease in end-tidal CO₂. Second, with less passive cardiac filling of venous blood, the cardiac output to the pulmonary vascular bed was entirely postoxygenator blood with a lower partial pressure of CO₂ than the admixture of venous and postoxygenator blood flow, resulting in a decrease in the partial pressure of CO₂ diffusion gradient and a drop in end-tidal CO₂.

A life-threatening emergency, such as tamponade in this patient, was masked by a new venovenous ECMO technology because the presentation did not have ECMO flow changes. Urgent bedside echocardiography resulted in a proper diagnosis and resolution of this life-threatening condition. Our anecdotal experience further highlights that clinicians need to always maintain vigilance for classic presentations of old problems within the ambient noise of new technology.

References

We acknowledge Stacy Turpin for her artistic contribution to the manuscript.

Extensive Tricuspid Valve Repair After Endocarditis Using CorMatrix Extracellular Matrix
Jack Wallen, MD, PhD, and Vivek Rao, MD, PhD
Division of Cardiovascular Surgery, Peter Munk Cardiac Centre, Toronto General Hospital-University Health Network, Toronto, Ontario, Canada

Surgical repair of tricuspid regurgitation after medical management of infective endocarditis can present a challenging scenario. We present the case of a 53-year-old patient treated with novel tricuspid valve repair using CorMatrix Extracellular Matrix.

A video can be viewed in the online version of this article [http://dx.doi.org/10.1016/j.athoracsur.2013.05.117] on http://www.annalsthoracicsurgery.org.

Dr Rao discloses a financial relationship with CorMatrix Cardiovascular.
man in whom a conventional tricuspid valve operation was deemed suboptimal. Instead, we used a commercially available extracellular matrix (ECM) to perform an extensive reconstruction of his tricuspid valve. Follow-up shows dramatic symptomatic resolution and reverse remodeling of his dilated right ventricle.


Currently, cardiac valve repair with patching can be accomplished using either bovine or autologous pericardium. Although these materials have good durability when treated with glutaraldehyde to promote cross linking, they do suffer from problems with calcification and eventual degeneration [1]. Extracellular matrix (ECM) has recently become commercially available and approved for repair of cardiac and vascular tissue. CorMatrix ECM (CorMatrix Cardiovascular, Atlanta, GA) is an acellular biomaterial derived from porcine small intestine submucosa that is intended to be surgically implanted to allow tissue repair and remodeling. Currently, it is approved by the US Food and Drug Administration for pericardial closure and the repair of cardiac tissue and was recently approved for carotid artery repair. We present a first-in-man report of extensive tricuspid valve repair in an adult using CorMatrix ECM.

A 53-year-old man presented to the hospital with severe heart failure in November 2011. His medical history is significant for remote endocarditis treated with intravenous antibiotics. Although this successfully treated his sepsis, he was left with residual tricuspid regurgitation (TR) but no evidence of tricuspid valve vegetations. Unfortunately he was lost to medical follow-up until his presentation with anasarca and renal insufficiency. An echocardiogram on presentation showed laminar TR with severe right ventricular dilation; therefore, he was referred for surgical management.

The patient presented as a difficult surgical candidate. He was morbidly obese (body mass index, 47) and wheelchair bound. He was admitted to the cardiology service for medical optimization, including intravenous diuretics, resulting in a 40-kg weight loss over the next 4 weeks. Repeated echocardiography confirmed laminar TR with right ventricular dysfunction. After the medical improvement, several surgical options were considered. Tricuspid valve repair using an undersized annuloplasty band was not feasible because of the risk of dehiscence from his extremely dilated annulus as well as the poor residual leaflet tissue. A conventional bioprosthesis would likely have limited durability in a man of his age. Mechanical tricuspid valve replacement was not considered a good option because of the requirement for lifelong anticoagulation in a patient previously lost to follow-up. Therefore, the novel approach of using a biological material capable of cellular remodeling to repair the native valve was deemed valid.

After standard cannulation and institution of cardiopulmonary bypass and cardioplegic arrest, the native tricuspid valve was excised. A 7 × 10 cm piece of CorMatrix ECM was rehydrated in a sterile crystalloid solution. A 2.5-cm strip was folded over to create a double-thickness reinforced edge. The ends of this reinforced edge were then sutured together using 4-0 Prolene (Ethicon, Inc, Cincinnati, OH) tacking sutures to form a circular annulus. The distal end was then wrapped around the sizer for a stentless porcine valve, and the seam was sewn using continuous 3-0 Vicryl (Ethicon, Inc, Cincinnati, OH). The 10-cm width of the matrix thus produced a tube approximately 30 mm in diameter and 5 cm in length.

The double-thickness end was sutured into the tricuspid valve annulus using 2 interrupted 2-0 TiCron sutures (Covidien, Mansfield, MA) 180 degrees apart. The distal end of this tube was then tacked into the right ventricle using 4-0 polypropylene. The tacking points corresponded to the septal, anterior, and posterior papillary muscles. Finally, the annular suture line was completed by running the 2 previously placed TiCron sutures circumferentially around the annulus (Fig 1). Effectively, this created a valve that functioned as a wind sock. The right atrium was then closed and the patient was weaned from cardiopulmonary bypass. Transesophageal echocardiography (TEE) demonstrated a competent tricuspid valve with trace residual TR. Just before decannulation and protamine administration, TEE revealed dehiscence of the distal end of the tube. Cardiopulmonary bypass was resumed and the valve was examined, revealing that the Prolene sutures at the distal end of the tube had torn out of the ventricular muscle. The distal end was

Fig 1. Intraoperative photograph showing repaired tricuspid valve with CorMatrix ECM (CorMatrix Cardiovascular) sutured into annulus.
resecured using pledgeted 2-0 TiCron sutures deployed in the same 120-degree orientation. After weaning from bypass a second time, TEE revealed mild residual TR and a redundant CorMatrix tube, which we felt would decrease the tension on the distal tube (Fig 2; Video 1). The patient was then transferred to the intensive care unit. His postoperative course was uneventful and he was discharged home.

Three-month follow-up showed that the patient was no longer dependent on diuretics and his anasarca had resolved. With resolution of pedal edema, he was no longer wheelchair bound and had enrolled in an aquafit class in the community. Echocardiography showed only mild residual TR with persistence of the redundant tissue. Although his right ventricle was still dysfunctional, there had been significant reverse remodeling by this time.

Comment

Traditional repair material for cardiac tissue (eg, bovine pericardium) has the disadvantage of having no growth potential and may suffer calcification, thickening, and eventual degeneration despite glutaraldehyde fixation [1]. Synthetic material such as polytetrafluoroethylene is not recommended in cases of endocarditis. In contrast, ECM has the advantage of serving as a biological scaffold into which the patient’s own cells will migrate and grow, ultimately repairing and remodeling the tissue. Two groups have successfully used biological scaffold to create pulmonary valves in sheep [2, 3]. Echocardiography and catheter studies showed good valve function and low gradients.

A number of centers have begun using CorMatrix for valve repair. Quarti and associates [4] reported using CorMatrix ECM for cardiac tissue repair, including 9 valve repairs in which ECM was used for leaflet extension. No reoperation or progression of valve regurgitation or stenosis at a mean follow-up of 12.5 months was reported. Of these 9 patients, however, the eldest was 14 years, and none of the valve repairs were performed as a result of infective endocarditis. Others have also described using ECM to repair valves in children with congenital valve abnormalities [5]. Electron microscopy of an explanted tricuspid valve patch 4 months after operation showed significant resorption of the ECM, replacement of the patch material with organized collagen, and the presence of endothelial cells on the surface of the leaflet. The suitability of using CorMatrix ECM in the systemic circulation is shown by its successful use to repair a traumatic innominate artery injury in a 12-year-old boy [6] and in the patch aortoplasty repair of a penetrating aortic ulcer [7].

A recent report describes the successful use of ECM to repair a 2 × 1 cm defect in the posterior mitral valve leaflet of a 75-year-old man with active streptococcal endocarditis [8]. In our case, we have successfully repaired a tricuspid valve using ECM in an adult with a history of medically managed infective endocarditis. To our knowledge, our case describes the most extensive use of CorMatrix ECM to repair a cardiac valve. Despite intraoperative difficulties in creating the repair, resulting in tissue redundancy, the function of the valve at 3 months was excellent. Based on histologic examination previously reported [5], we would expect tissue infiltration to be well under way. Further study is required to ascertain the durability of this material. The successful outcome of this operation suggests that CorMatrix ECM is a suitable material for extensive valve repair.

References


Fig 2. Intraoperative transesophageal echocardiographic view of repaired tricuspid valve showing CorMatrix ECM (CorMatrix Cardiovascular) in annulus.