and subsequently expectorated. The authors pointed out that "another day or two of growth, and this mass would have severely compromised tracheal airflow and might have been too large to be expelled through the vocal cords."

As in the case reported by Fletcher et al, our patient did not complain of increased cough or sputum production; however, he had expectorated occasional typical "mucous balls." His marked dyspnea developed approximately 14 days before his death. At no time was there difficulty in care of the catheter (SCOOP-I), and adherence to cleaning of the catheter and humidification of the oxygen had been meticulous. In retrospect, cessation of mucous ball production could be a sign of an enlarging mucous plug.

The histologic picture seen in our case suggests that irritation and necrosis of the tracheal wall may complicate the not infrequent development of mucous hypersecretion seen in patients with TTO3T. It remains to be seen whether this complication is more common with the larger catheter (SCOOP), and if the smaller size of the micro-trach is indeed protective, as suggested by Hemlich and Carr. 10

The onset of worsening dyspnea in patients with all TTO3T devices must be carefully evaluated, especially in the absence of radiographic abnormalities. Serial flow-volume loop analysis may suggest the development of tracheal obstruction with a pattern of fixed or variable extrathoracic airway obstruction, as, for example, has been observed in other tracheopathies. 11 In all such cases, early bronchoscopy appears indicated.

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**Native Right Atrial Tamponade with the Jarvik Total Artificial Heart**

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Following a massive myocardial infarction culminating in cardiogenic shock, a 61-year-old man underwent implantation of the Jarvik-70 ml total artificial heart. On the fifth postoperative day, hemodynamic instability coupled with subtle radiographic changes and impaired mechanical right ventricular diastolic inflow were instrumental in establishing the diagnosis of localized native right atrial tamponade. To our knowledge, this report is the first detailed discussion of this phenomenon.

(Chest 1991; 99:1523-25)

**L**ocalized cardiac tamponade following cardiac surgery is a clinical entity with characteristic hemodynamic perturbations. We describe a patient who presented with a similar course attributable to tamponade of the native right atrium following implantation of the Jarvik-7 total artificial heart.

**Case Report**

A 61-year-old man was admitted to the hospital with retrosternal chest pain and shortness of breath of 24 hours' duration. Initial electrocardiographic changes and serial cardiac isoenzymes were diagnostic for an acute anteroseptal myocardial infarction. The patient continued to experience chest pain despite infusion of high doses of intravenous nitroglycerin. Emergent cardiac catheterization demonstrated 100 percent occlusion of both the LAD and RCA coronary vessels, with an 80 percent lesion of the circumflex artery.

Emergent angiotomy of the circumflex artery was unsuccessful. Subsequently, the patient's hemodynamic status deteriorated, culminating in cardiogenic shock (MAP = 60 mm Hg, CVP and PCWP > 20 mm Hg, CI = 1.5 L/min/m2) refractory to high-dose dopamine and norepinephrine infusions. As a temporizing measure, femoral-vein-to-femoral-artery extracorporeal membrane oxygenation (4-L/min flow with 100 percent membrane oxygenation) was initiated, followed by transfer to the University Health Center of Pittsburgh.

Portable echocardiography revealed marked biventricular hypokinesia. The patient immediately underwent implantation of a Jarvik-7 (70-ml capacity; Symbion Inc.) total artificial heart. The surgical technique included bilateral ventriculocentesis with complete preservation of both native atria. A conventional anastomosis between the native atria and each mechanical ventricle was performed with snap-on connectors. No apparent technical complications were noted at the time of surgery. Both Jarvik ventricles were pneumatically driven by the Utahdrive external console with drive

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pressures set to achieve complete ejection of the end-diastolic volume. Right and left ventricular pressure profiles and diastolic filling rates of each cardiac cycle were graphically displayed on the screen of a computerized monitor. Initially, both ventricles displayed normal systolic pressure and diastolic filling rate profiles, with cardiac outputs ranging from 5.5 to 6.5 L/min (Fig 1). A routine postoperative chest x-ray film demonstrated normal placement of the artificial heart (not shown).

Systemic heparinization to prevent embolisms was initiated on the third postoperative day to maintain the PTT at 45 to 50 seconds. The patient’s condition remained hemodynamically stable until the fifth postoperative day, when the arterial pressure fell to 60/40 mm Hg despite repeated infusions of colloid to maintain the CVP greater than 20 mm Hg. The diastolic waveform now demonstrated a marked decrement in early right ventricular filling rate, with significant impairment of stroke volume and outputs of both ventricles (Fig 2). A chest x-ray film was notable for a new convex shadow along the border of the mechanical right ventricle (Fig 3). The PTT, which had never exceeded the desired therapeutic range, was 38 seconds at the onset of hemodynamic instability. Heparin was immediately discontinued. Emergent median sternotomy revealed an accumulation of 800 ml of blood and clots apparently originating from the right atria-mechanical ventricle anastomosis with external compression of the native right atrium. Evacuation of the collection dramatically restored mean arterial pressure, right ventricular filling rates, and outputs of both mechanical ventricles. Despite successful resolution of the episode of tamponade, the patient died on the 15th postoperative day due to multisystem organ failure.

**Discussion**

Localized cardiac tamponade is an infrequent but well-recognized entity that may affect any of the four native cardiac chambers. Prior reports describe this complication as most often occurring during the early or late postcardiomyotomy period. Although localized right atrial tamponade has been reported following implantation of the Jarvik total artificial heart, there are no prior detailed discussions pertaining to the unique aspects of its clinical presentation. The woven Dacron mesh and polyurethane construction of the Jarvik ventricle confers rigidity and thus resistance to external compression, permitting selective compression of only the native remaining structures. This contrast in physical properties makes localized tamponade, as opposed to generalized tamponade, a predictable occurrence following the accumulation of extramural blood.

The Jarvik heart relies on a “Starling-like” principle characterized by complete ejection over a range of filling volumes without afterload limitation. Interruption of right atrial inflow impairs both right and then left ventricular output in serial fashion; however, in contrast to the native heart, compensation for diminished diastolic filling normally provided by primary cardiac, humoral, and neural mechanisms is absent. Instead, attempts at compensation are by necessity derived from changes in the program made via a clinician’s interaction with the external control console.

**Figure 1.** Computerized tracing demonstrating normal right and left mechanical ventricular diastolic filling and cardiac output (CO).

**Figure 2.** Computerized tracing revealing marked impairment and temporary cessation of early right ventricular diastolic inflow (arrow) and decreased cardiac output (CO) of both ventricles.
Localized tamponade is a diastolic phenomenon, efforts to augment systolic mechanical function, such as increasing drive pressure or percentage of systolic time, are misdirected. Furthermore, diastolic maneuvers, such as applying a diastolic vacuum in an attempt to enhance emptying of the native right atrium, were unsuccessful even on a temporary basis and potentially deleterious.

Finally, computerized diagnostic monitoring uniquely demonstrated the secondary impairment of the mechanical right ventricle due to diminished early diastolic filling. The availability of flow data in addition to the corresponding radiographic changes proved invaluable towards establishing the working diagnosis of localized tamponade. Furthermore, the graphic alterations in diastolic flow allow the pathophysiology of localized tamponade to be viewed as an aberrancy of volume transfer between cardiac chambers, rather than the conventional concept of diastolic pressure gradients across the affected chambers.

As both spontaneous or thrombus-induced atrioventricular valve dysfunction might also present with early right ventricular diastolic impairment, median sternotomy is the most effective diagnostic and therapeutic intervention.

Recently, the Food and Drug Administration withdrew approval for the further utilization of the Jarvik-7 total artificial heart due to the unacceptable high rate of complications and an expanding number of superior alternative artificial heart devices. Nevertheless, a similar potential for hemodynamic compromise, mediated by the tamponade of remaining native cardiac structures, still exists with the new generation of implantable devices, since all are invariably dependent on an intact native circulation for adequate filling volume.

In summary, native right atrial tamponade occurring in association with the Jarvik-7 total artificial heart represents a variant of localized tamponade. The unique anatomic, physiologic, and diagnostic monitoring aspects make its occurrence a noteworthy and interesting phenomenon.

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**Long-term Clinical Follow-up of Adult Idiopathic Pulmonary Hemosiderosis and Celiac Disease**

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A 22-year-old man with a history of repeated whole blood transfusions since the age of 7, was admitted to the hospital for dyspnea and blood-stained sputum. A complete blood cell count, a test for reticulain antibodies, an x-ray film of the chest, a transbronchial biopsy and a biopsy of the small bowel were performed and the results confirmed the diagnosis of IPH, associated with CD. The patient has been asymptomatic for four years on a gluten-free diet. In cases of IPH, it may be important to investigate the coexistence of CD because treatment of the latter could lead to a better prognosis.

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IPH = idiopathic pulmonary hemosiderosis; CD = celiac disease

An association between IPH and CD previously has been reported.1-7 We report an additional case of concomitant IPH and CD. Our patient has been asymptomatic with respect to IPH for four years while on a gluten-free diet, suggesting a pathogenetic link between these two diseases.

**CASE REPORT**

A 22-year-old man was admitted to the hospital for study of iron-deficiency anemia and a bilateral interstitial pattern seen on an x-ray film of the chest. From the age of 7 years, he had required repeated blood transfusions for anemia and had experienced dyspnea after moderate exercise. He also had coughed up blood-stained sputum and had occasional episodes of arthralgia.

The physical examination only revealed pale skin and a generalized systolic murmur. The hemoglobin level was 12 g/dl and the hematocrit value was 42 percent. The platelet count, prothrombin time and partial thromboplastin time were normal. The serum iron value was 78 μg/dl (normal: 80 to 160 μg/dl) and the total iron-binding capacity was 500 μg/dl (normal: 50 to 265 μg/dl). Ferrocinetic studies using erythrocytes labelled with chromium showed sequestration of erythrocytes in both lungs.

An x-ray film of the chest showed unchanged widespread micro-

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