with interarterial course and no intramural component, we favor pulmonary artery translocation to create space between the aortic and pulmonic roots, thereby decreasing the risk of pulmonary compression of the coronary artery.⁷ Intraoperative inspection determines which procedure will be performed. If the orientation of the aortic and pulmonic roots is such that anterior movement of the MPA will create space, a LeCompte maneuver is done. Alternatively, if moving the MPA laterally will create space, the MPA is translocated distally toward the left pulmonary artery.

At the current time there is not sufficient data to form firm management guidelines for asymptomatic children with ACAs from the contralateral sinus. Because of the documented risk of sudden death without antecedent symptoms, our policy is to surgically correct all lesions at risk, regardless of symptoms. Although we believe pulmonary artery translocation is protective of subsequent ischemic episodes, long-term follow-up has not been achieved. Whether it will

reduce subsequent risk of myocardial ischemia or sudden cardiac death remains to be determined.

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Quadruple valve replacement in patients with carcinoid heart disease

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Carcinoid is a rare tumor of neuroendocrine cell lineage that occurs in 1.2 to 2.1 persons per 100,000 per year.¹ At diagnosis, 20% to 30% of patients have disseminated disease and consequent carcinoid syndrome.² Carcinoid heart disease affects 40% of patients and remains a source of major morbidity and mortality in carcinoid syndrome. Heart involvement is thought to occur when serotonin and other active substances are released from hepatic metastases or primary ovarian carcinoid tumors, thus bypassing metabolism in the liver.

Carcinoid heart disease typically involves tricuspid and pulmonary valves, and patients often present with signs and symptoms of right heart failure. Left-sided valve involvement is reported infrequently (<10% of patients with carcinoid heart disease)¹ and is possibly due to metabolism of active substances by the lung. Thus, carcinoid

disease of the mitral and aortic valves may occur more frequently in patients with an atrial septal defect or patent foramen ovale (PFO) with right-to-left shunting of blood. Left heart involvement may also occur in the absence of an intracardiac shunt, perhaps with bronchopulmonary carcinoid or high levels of circulating serotonin.³ We describe our experience with 7 patients who, because of carcinoid heart disease, underwent quadruple valve replacement.

CLINICAL SUMMARY

Between July 1989 and April 2010, 7 patients underwent quadruple valve replacement for carcinoid heart disease at Mayo Clinic, Rochester, Minnesota. This group comprised 4% of 168 patients who had valve surgery for carcinoid heart disease and 23% of the 30 patients with concomitant involvement of the mitral or aortic valves.

RESULTS

All patients had clinical signs and symptoms of right and left heart failure and echocardiographic evidence of carcinoid heart disease, including thickened valves with regurgitation. Right-sided valves had more severe involvement than left except for 1 patient who had moderate tricuspid regurgitation and severe regurgitation affecting the 3 other valves. Intraoperative echocardiography identified a PFO

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TABLE 1. Outcomes of 7 patients with carcinoid heart disease who underwent quadruple valve replacement

Patient	Age, y	Gender	Maximum 5-HIAA, mg/24 h	NYHA		Year of surgery	PFO	CBP time, min	Crossclamp, min	Prosthesis type	Survival
				Preoperative	Postoperative						
1	59	M	517	3	2	1989	No	173	104	St Jude C (St Jude Medical, Inc, St Paul, MN) plus PH	39 mo
2	61	M	468	4	Died	1999	No	157	67	St Jude	6 d
3	79	M	170	3	2	2002	Yes	122	59	Carpentier-Edwards (Edwards Lifesciences, LLC, Irvine, CA)	5 mo
4	51	M	475	3	1	2006	Yes	61	7	CarboMedics, Inc, Austin, TX	30 mo
5	69	F	21.8	2	1	2009	No	200	75	St Jude	Alive at FU (6 mo)
6	61	M	192	3	2	2009	Yes	107	59	St Jude	Alive at FU (4 mo)
7	52	F	118	3	2	2009	No	133	67	CarboMedics, Inc	Alive at FU (3 mo)

CBP, Cardiopulmonary bypass; FU, follow-up; 5-HIAA, 5-hydroxyindoleacetic acid; NYHA, New York Heart Association; PFO, patent foramen ovale; PH, pulmonary homograft.

with right-to-left shunting in 3 patients (43%) that was surgically confirmed and repaired. Notably, no defects were detected on preoperative transthoracic echocardiograms.

All patients had increased concentrations of urinary 5-hydroxyindoleacetic acid; levels were similar in patients with or without a PFO (Table 1). Urinary 5-hydroxyindoleacetic acid was only 21.8 mg/24 hours in the sole patient (patient 5, Table 1) with primary ovarian carcinoid tumor.

Surgical Management

Six patients underwent replacement of all 4 valves during 1 operation; 1 patient (patient 4) had aortic and mitral valves replaced with mechanical prostheses at another institution for what was initially thought to be rheumatic heart disease. Subsequently, he was found to have metastatic carcinoid with right heart involvement and underwent tricuspid and pulmonary valve replacement at the Mayo Clinic. Right ventricular outflow tract reconstruction (pulmonary augmentation) with pericardial patch was performed in 5 (71%) of 7 patients. During surgery, 6 patients received

octreotide (median dose, 1.5 mg [range, 0.8-4 mg]). Supplemental octreotide was used in 3 patients during their stay in intensive care (median dose, 2.3 mg [range, 0.5-5.2 mg]). All excised valves had clinical and pathologic findings consistent with carcinoid heart disease.

Surgical Outcomes

Four (57%) of the 7 patients had postoperative cardiac arrhythmias (2 with atrial fibrillation; 2 with heart block), and 1 patient required permanent pacing. One patient with a preoperative creatinine concentration of 3.3 mg/dL had transient worsening of renal insufficiency postoperatively but did not require dialysis.

Follow-up Data

One patient died of heart failure 6 days postoperatively. Functional improvement (eg, increased exercise tolerance, reduced lower extremity edema, reduced ascites, resolution of orthopnea, and paroxysmal nocturnal dyspnea) was noted in all survivors. At last follow-up, left ventricular

FIGURE 1. Posteroanterior and lateral chest radiographs of a patient with carcinoid heart disease after quadruple valve replacement.

end-diastolic diameter was improved in 5 patients; right ventricular size and function improved in 3 patients. Three late deaths due to carcinoid progression occurred postoperatively at 39, 5, and 30 months.

DISCUSSION

Previous studies have shown that tricuspid and pulmonary valve replacement can improve symptoms and survival in patients with right heart failure due to carcinoid heart disease.¹ Improved functional status and cardiac chamber size were also noted in our carcinoid patients with 4 valve replacements. Notably, a PFO was present in only 3 patients, and each was detected only by intraoperative transeptal echocardiography with saline injection. Thus, our experience documents that an intracardiac shunt is not necessary for development of left-sided carcinoid valve disease, despite other reports.^{4,5}

CONCLUSIONS

Although carcinoid heart disease with involvement of all 4 valves is rare, we conclude that quadruple valve replacement in symptomatic patients is a reasonable option that can result in functional improvement with acceptable risks.

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Successful resection of localized pulmonary mucormycosis after bone marrow transplantation using a virtual 3-dimensional pulmonary model on a personal computer

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Mucormycosis is a rare and fatal infectious disease. Pulmonary mucormycosis most often occurs in patients with neutropenia, immune deficiencies, malignant disease, malnutrition, diabetes, and trauma, as well as in patients undergoing organ transplantation or chelation therapy involving deferoxamine.^{1,2} For control of the underlying disease, a polyene administration and surgical resection of infected lung segments may prove helpful. We report a case of localized pulmonary mucormycosis after bone marrow transplantation that was successfully resected using a virtual 3-dimensional pulmonary model on a personal computer.

CLINICAL SUMMARY

A 28-year-old man, treated with allogeneic bone marrow transplantation for acute lymphatic leukemia in March 2009, had progressive dyspnea and productive cough in May 2009. Chest radiography and computed tomography (CT) revealed a fungus ball in the left upper lobe of the lung (Figure 1, A). *Mucor* was detected by bronchoscopic biopsy. When liposomal amphotericin B (L-AMB) was administered, the size of the fungus ball reduced immediately (Figure 1, B). However, because the patient became resistant to L-AMB, he was referred to our division for surgery for pulmonary mucormycosis. Preoperative blood chemistry analysis showed pancytopenia and renal insufficiency (the serum creatinine level 1.94 mg/dL) caused by ongoing L-AMB administration. Chest CT demonstrated an 18-mm cavitary mass in S1+2c of the left lung. For preoperative simulation of surgical resection, we used free software application such as CTTRY, where we could mark on pulmonary arteries, veins, bronchi, and fungus ball of the images on high-resolution CT images. With 60 2-mm high-resolution CT images of the fungus ball and hilum, in DICOM (Digital Imaging and Communications in Medicine) format, we obtained 3-dimensional images for a patient

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