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Severe Symptomatic Tricuspid Valve Regurgitation Due to Permanent Pacemaker or Implantable Cardioverter-Defibrillator Leads

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OBJECTIVES We report a series of patients with severe tricuspid valve regurgitation due to a permanent pacemaker (PPM) or implantable cardioverter-defibrillator (ICD) lead.

BACKGROUND Severe tricuspid regurgitation caused by a PPM or ICD lead is an under-recognized but treatable etiology of severe right heart failure.

METHODS We reviewed the records of 41 patients who underwent tricuspid valve operation for severe tricuspid regurgitation caused by previously placed PPM or ICD leads.

RESULTS During surgery, severe tricuspid regurgitation was found to be caused by the PPM or ICD leads in all 41 patients. There was a perforation of the tricuspid valve leaflet by the PPM or ICD lead in 7 patients, lead entanglement in the tricuspid valve occurred in 4 patients, lead impingement of the tricuspid valve leaflets occurred in 16 patients, and lead adherence to the tricuspid valve occurred in 14 patients. The septal leaflet was most often perforated (6 of 7). In the preoperative evaluation, valve malfunction due to the PPM or ICD lead was diagnosed preoperatively in only 5 of 41 (12%) patients by transthoracic echocardiography. All patients underwent successful tricuspid valve operation (22 tricuspid valve replacement), with one perioperative death occurring. During follow-up (range, 1 to 99 months), there was one patient who died from left-sided heart failure and three patients died of other causes. The remaining patients showed improvement in signs and symptoms of heart failure.

CONCLUSIONS Damage to the tricuspid valve by PPM or ICD leads may result in severe symptomatic tricuspid regurgitation and may not be overtly visualized by echocardiography. This etiology should be considered when evaluating patients with severe right heart failure after PPM or ICD implantation. (J Am Coll Cardiol 2005;45:1672–5) © 2005 by the American College of Cardiology Foundation

Patients who present with severe right heart failure out of proportion to left-sided heart disease present a diagnostic challenge because the etiology may be due to constrictive pericarditis, restrictive cardiomyopathy, or pulmonary vascular disease (1–5). We recently have observed the occurrence of right heart failure due to tricuspid regurgitation resulting from a permanent pacemaker (PPM) and implantable cardioverter-defibrillator (ICD) leads, entities that have not been well recognized. We report on a series of patients who underwent surgical intervention for severe tricuspid regurgitation proven to be due to PPM or ICD leads, as this is a correctable cause of right heart failure.

METHODS

We identified 41 patients who had severe tricuspid regurgitation caused by a PPM or ICD lead and underwent operation to repair or replace the malfunctioning tricuspid valve. Using a Mayo Institutional Review Board-approved protocol, we reviewed the records of 1,465 consecutive patients with severe tricuspid regurgitation who had tricuspid valve operation between January 1, 1993, and December 31, 2003. One hundred fifty-six of these patients had previously placed endocardial PPM or ICD leads. On the basis of operative findings, we identified 64 patients in whom the tricuspid regurgitation was due to the previously implanted PPM or ICD lead. To rule out other confounding causes for the tricuspid regurgitation, we excluded patients who had a morphologic abnormality of the tricuspid valve (previous history of cardiac trauma, [n = 2], bacterial endocarditis [n = 5], previous tricuspid valve surgery [n = 2], or congenital heart disease [n = 14]).

Thus, 41 patients comprised the study population. These patients all had severe tricuspid regurgitation and a morphologically normal tricuspid valve apparatus with evidence of tricuspid valve leaflet damage by the PPM or ICD leads at the time of operation. Forty patients underwent surgery at the Mayo Clinic; one patient had an evaluation and diagnosis made at the Mayo Clinic but tricuspid valve surgery was performed at another institution. Survival and follow-up information was obtained from the clinical record at the Mayo Clinic or from a questionnaire mailed to all patients.

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Abbreviations and Acronyms
ICD = implantable cardioverter-defibrillator
PPM = permanent pacemaker

All 41 patients had preoperative transthoracic echocardiography performed at the Mayo Clinic, 13 patients had preoperative transesophageal echocardiography, and 38 had intraoperative transesophageal echocardiography. The reports from the preoperative and intraoperative echocardiograms were reviewed in all cases; all available echocardiographic images were independently reviewed by two of the authors (G.L. and H.M.C.). All available preoperative chest X-rays (n = 38) were reviewed by two of the authors (G.L. and D.L.H.) to determine PPM or ICD lead position before surgery. Eight patients had their PPM or ICD placed at the Mayo Clinic, and all other patients had their devices placed at other institutions.

RESULTS

Clinical presentation. Baseline clinical characteristics of the 41 patients are shown in Table 1. The mean age of the patients was 70 ± 10 years, and there were 20 men and 21 women. There were 21 patients who presented primarily with severe right heart failure, including a referral diagnosis of constrictive pericarditis or restrictive cardiomyopathy in three patients. The other 20 patients subsequently were found to have severe tricuspid regurgitation in addition to other abnormalities, such as prosthetic valve malfunction, mitral or aortic valve disease, or hypertrophic obstructive cardiomyopathy. All patients had severe New York Heart Association functional class III or IV symptoms upon presentation.

Previously placed pacemaker or ICD. There were 35 patients who had PPM leads and 6 patients who had ICD leads that caused the severe tricuspid regurgitation. The average time from PPM or ICD placement to surgery was 72 months (i.e., 6 years) with a range of 2 months to 19 years. Six patients had had subsequent revisions of their PPM systems, including placement of additional ventricular leads or upgrades to an ICD or biventricular pacemaker.

Table 1. Baseline Characteristics

	Mean	Total (Patient Number)
Age (yrs)	70 ± 10	41
Men		20
Ejection fraction (%)	54 ± 14	41
Rheumatic heart disease		14
Coronary artery disease*		16
Previous valve surgery		16
Aortic		7
Mitral		9
Both		3
Tricuspid annular dilation		15
PPM placement, time from placement to operation (months)	72 (2–228)	

*Previous coronary artery bypass grafting or percutaneous intervention.
PPM = permanent pacemaker.

Table 2. Device Lead Characteristics

Lead type	
PPM	40
ICD	6
Lead insulation*	
Silicone	34
Polyurethane	12
French size*	
11	3
9	30
8	2
7	5
6	5
Active fixation	23
Ventricular lead (multiple)	6

*Data from 46 leads in 36 patients.
ICD = implantable cardiovertor-defibrillator; PPM = permanent pacemaker.

Characteristics of the PPM and ICD lead systems were known in 30 patients (37 leads) and are listed in Table 2. Four patients had multiple leads. Of the seven patients who had tricuspid valve leaflet perforation, two had multiple (i.e., two or three) leads.

Echocardiographic findings. Transthoracic echocardiography was performed preoperatively in all 41 patients. The mean ejection fraction of the left ventricle was 54%. The mean pulmonary artery systolic pressure derived from Doppler echocardiography was 48 mm Hg (range, 28 to 84 mm Hg). There were only 5 of 41 (12%) of patients in whom tricuspid valve leaflet perforation or impingement by the PPM or ICD lead was detected on the initial transthoracic echocardiography interpretation. Although all patients eventually were found to have severe tricuspid regurgitation, only 26 of 41 (63%) of these patients were diagnosed as having severe tricuspid regurgitation on the initial interpretation of the transthoracic echocardiography. Transesophageal echocardiography was performed either preoperatively or postoperatively in 38 patients. Valve malfunction due to the PPM lead was observed in 17 of 38 (45%) patients by transesophageal echocardiography. Transesophageal echocardiography was able to diagnose severe tricuspid regurgitation in all 38 patients studied.

Operative methods and results. All patients were found to have morphologically normal tricuspid valve with malfunction of the valve caused by the PPM or ICD lead at the time of operation (Table 3). Tricuspid valve perforation by the

Table 3. Operative Findings

Operative findings: mechanism of tricuspid regurgitation	
Lead adherence	14
Lead entanglement	4
Lead perforation	7
Lead impingement	16
Operative procedure	
Tricuspid valve replacement	
Mechanical	5
Bioprosthesis	17
Annuloplasty	
Pursestring	7
Ringed	12

PPM or ICD lead occurred in seven patients, lead entanglement of the tricuspid valve apparatus occurred in four patients, lead impingement of the tricuspid valve leaflets occurred in 16 patients, and lead adherence to the tricuspid valve occurred in 14 patients. Fourteen patients had involvement of the posterior leaflet. When the leaflet was perforated, the septal leaflet was most often involved (6 of 7 patients). Secondary annular dilatation was noted in 15 patients.

Nineteen patients had an isolated tricuspid valve operation. Twenty-two patients required surgical intervention on other valves at the time of surgery, and 15 patients had other surgical interventions, including pericardiectomy and myectomy. The surgical approach to the tricuspid valve at operation varied according to individual surgeon preferences. In the absence of extensive tricuspid valve leaflet damage, valve repair was preferred. When valve repair was feasible, it consisted of: 1) removing or displacing the lead away from the affected leaflet; 2) suture repair of a defect in the leaflet; or 3) positioning the PPM lead by suture fixation in recess of either the posteroseptal or anteroposterior commissure. Intraoperative echocardiography was used to assure that the tricuspid regurgitation was reduced after tricuspid valve repair. Tricuspid annular dilatation was treated by either a DeVega purse string or ringed annuloplasty. When tricuspid repair was not possible because of damage to the leaflet by the PM or ICD lead, valve replacement was performed (22 patients). Tricuspid valve replacement was performed by maintaining the native tricuspid valve intact and positioning the pacing lead external to the sewing ring of the prosthesis. There was one perioperative death (operative mortality 2.4%).

Follow-up. Patient follow-up ranged from 1 to 99 months (mean, 8.2 years). Seven patients were lost to follow-up, and two declined to answer the questionnaire. There were four deaths, one due to left heart failure and three of unknown causes. No patient required additional surgery or lead revisions. The remaining patients all noted improvement in symptoms of their right heart failure.

DISCUSSION

This series is the first reporting on patients with severe symptomatic tricuspid regurgitation due to PPM or ICD leads requiring tricuspid valve surgery. Isolated case reports have been noted of entrapment of a PPM lead in the tricuspid apparatus during implantation, resulting in avulsion or laceration of the tricuspid valve leaflets upon removal of the PPM lead (6–11) and case reports of perforation of a tricuspid valve leaflet by a PPM (Table 4) (12–18). Echocardiographic detection of tricuspid regurgitation in patients with a PPM has been reported (19). However, the occurrence of severe symptomatic tricuspid regurgitation due to damage from PPM or ICD leads is not a well-recognized entity.

The mechanism by which a PPM or ICD lead causes tricuspid regurgitation has not been previously evaluated. Autopsy reports have indicated that PPM leads can cause fibrosis and subsequent adherence to the tricuspid valve leaflets as early as 17 days after implantation (16,20–22).

As shown in this study, the mechanism of tricuspid regurgitation due to PPM or ICD leads is variable. The largest subset of patients in our study (n = 16) had only lead impingement on the tricuspid valve leaflets at surgery. Other mechanisms include leaflet perforation, entanglement of the tricuspid valve apparatus, and adhesion of the PPM or ICD to the tricuspid valve leaflet.

It is necessary to have a high clinical index of suspicion for this particular disease entity. Elevated venous pressure with large "V" waves upon physical examination is an important clue to the diagnosis, and one cannot rely on a routine echocardiogram to provide the diagnosis. Even in experienced echocardiographic laboratories, the detection of severe tricuspid regurgitation may be missed because of acoustic shadowing from the pacemaker wires and suboptimal visualization of the regurgitant jet. In addition, direct visualization of the mechanism of the PPM or ICD lead causing severe regurgitation was identified in only 12% of patients with routine transthoracic echocardiography. With a high index of suspicion, further diagnostic information could be obtained from goal-directed imaging by transthoracic or transesophageal echocardiography. On a retrospective independent review of the images of the transthoracic echocardiogram, there were 22% of patients in whom the PPM or ICD lead was identified as a cause of the tricuspid regurgitation. Transesophageal echocardiography was able to visualize the PPM or ICD lead as a cause of tricuspid

Table 4. Reported Cases of Tricuspid Valve Leaflet Perforation by a PPM Lead (12–18)

	No. of Cases	Found at Autopsy or Surgery	Tricuspid Valve Leaflet	Clinical Presentation	Time from PPM Implantation to Presentation	Insulation
Gould et al. (12)	1	Autopsy	Anterior	CHF	4 months	Unknown
Becker et al. (16)	1	Autopsy	Posterior	PPM failure	6 months	Unknown
Vecht et al. (15)	1	Autopsy	Posterior	PPM failure	9 months	Unknown
Petterson et al. (14)	1	Autopsy	Anterior	Bradycardia	1 year	Silicone
Christie and Keelan (13)	1	Autopsy	Septal	CHF	2 years	Polyurethane tined
Champagne et al. (17)	1	Surgery	Posterior	CHF	9 years	Polyurethane tined
Rubio and Al-Basram (18)	1	Surgery	Posterior	CHF	10 years	Unknown

CHF = congestive heart failure; PPM = permanent pacemaker.

regurgitation in 45% of patients. In the future, three-dimensional echocardiographic imaging may be helpful to more clearly delineate the location of the PPM or ICD leads and the impact on the tricuspid valve. Also, patients may not develop symptoms of right heart failure for years after PPM implantation, as shown in this study herein.

We were unable to determine a relationship between lead characteristics and the likelihood of PPM or ICD lead damage to the tricuspid valve as a result of the small number of patients in this study. The increased number of silicone-insulated leads, larger French sizes, and number of passive fixation leads may simply reflect the characteristics of older leads identified in this retrospective study. There are limited published data regarding the physical characteristics of the PPM leads identified in the cases of perforations we reviewed or in autopsy series describing PPM lead adhesion to the tricuspid valve leaflets (12,14–18,20–23).

Although previous series have suggested that having multiple PPM leads across the tricuspid valve may increase echocardiographic findings of tricuspid regurgitation when compared with patients with single leads (24,25), we could not determine whether this relationship was present because of the small number of patients in this series.

The number of cases of severe tricuspid regurgitation due to PPM or ICD leads is probably larger than identified in our series. There has been an increase in the number of tricuspid valve operations to correct tricuspid regurgitation related to PPM lead-related injury performed at our institution in the last few years. From 1993 to 2001, only one to three cases occurred each year, but in 2002 and 2003 we noted 11 and 16 cases, respectively. Thirteen of 27 of the operations performed in 2002 and 2003 were referred primarily for tricuspid valve surgery. We believe this reflects an increasing awareness of this clinical problem rather than a true higher incidence.

Study limitations. This was a retrospective analysis of patients undergoing operation for severe tricuspid regurgitation due to PPM or ICD leads, and we were unable to address the incidence of this complication. We did not exclude patients with left-sided valvular disease, ischemic heart disease, or known rheumatic heart disease. Thus, secondary pulmonary hypertension may have contributed to further increase the severity of tricuspid regurgitation. We cannot rule out the possibility that dyssynchronous contraction caused by right ventricular apical pacing could have contributed to the severity of tricuspid regurgitation. However, in all patients at the time of operation, the surgeon identified the PPM or ICD lead as the primary cause of tricuspid regurgitation.

Our findings suggest that PPM or ICD lead-related injury to the tricuspid valve can result in clinically important severe tricuspid regurgitation and secondary right heart failure. These patients have symptomatic improvement after tricuspid valve repair or replacement. The diagnosis of tricuspid valve injury can be difficult by echocardiography and, thus, a high index of clinical suspicion must be present when patients present with severe right heart failure after PPM or ICD implantation.

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