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ORIGINAL RESEARCH

Diagnosis of Cardiac Device–Related Infective Endocarditis After Device Removal

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OBJECTIVES We sought to determine the incidence, diagnostic value, and outcome of intracardiac masses observed by echocardiography after device removal. We hypothesized that these "ghosts" of leads could be associated with the diagnosis of cardiac device–related infective endocarditis (CDRIE).

BACKGROUND The echocardiographic appearance of residual floating masses in the right atrium after removal of permanent pacemakers and implantable cardioverter-defibrillators was recently described. However, the significance of these ghosts and their relationship with CDRIE are unknown.

METHODS The pre-operative clinical, microbiological, and echocardiographic conditions; the indication; and the removal technique were analyzed in a retrospective cohort including all consecutive patients who underwent percutaneous lead removal. Three groups were formed according to the final diagnosis: CDRIE, local device infection, and noninfectious indications. The incidence of ghosts was compared among the 3 groups. All clinical, infectious, and extraction-related factors were studied for their association with ghosts. All patients with ghosts were followed after hospitalization.

RESULTS Two hundred twelve patients underwent lead removal. Ghosts were observed in 17 patients (8% incidence), including 14 (16%) of 88 patients with CDRIE and 3 (5%) of 59 patients with local device infection. Ghosts were never observed among the remaining 65 noninfected patients. A significant association was found between CDRIE and the presence of a ghost (odds ratio: 7.63, 95% confidence interval: 2.12 to 27.45, $p = 0.001$). At 3 months, 2 patients with ghosts died suddenly, 2 underwent surgery, and 1 had a pulmonary embolism.

CONCLUSIONS Ghosts are observed in 8% of patients after percutaneous device extraction. Their presence is suggestive of device infection and seems to be associated with the diagnosis of CDRIE. The prognostic significance of such findings needs further investigation. (J Am Coll Cardiol Img 2010;3: 673–81) © 2010 by the American College of Cardiology Foundation

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The number of implanted intracardiac devices has dramatically increased during the past decade with the aging of the general population and the publication of large randomized trials demonstrating the beneficial impact of cardiac resynchronization therapy and the implantable cardioverter-defibrillator (ICD) on survival (1–5). Along with this trend, the number of lead removal procedures has been growing rapidly. The main indications for lead removal are cardiac device–related infective endocarditis (CDRIE), local device infection (LDI), lead dysfunction, and device upgrading (6). CDRIE is rare, with reported rates ranging from 0.13% to 7% for permanent pacemakers (7,8) and from 0.7% to 1.2% for ICDs (1,9). The presence of CDRIE substantially increases mortality, morbidity, and costs (10–13). Removal of infected cardiac leads carries with it its own problems, mainly because of the risk of pulmonary embolism (10,14). However, percutaneous removal is usually feasible, even in cases with a large amount of vegetation (15). Moreover, CDRIE is difficult to diagnose because of the high rates of negative blood cultures and negative echocardiographic findings (10,11,16).

ABBREVIATIONS AND ACRONYMS

CDRIE = cardiac device–related infective endocarditis

ICD = implantable cardioverter-defibrillator

LDI = local device infection

TTE = transthoracic echocardiography

After implantation, a fibrotic encapsulating process forms around the device leads (17,18). That fibrous sheath increases over time and becomes endothelialized (19) as a way to tolerate foreign materials in the bloodstream. However, in the presence of lead infection, this fibrous sheath might be mixed with infective vegetation. Recently, Rizzello et al. (20) described an echocardiographic case of a post–lead removal mass representing the persistence of the fibrous sheath covering the lead. We recently described another case of persistent fibrous sheath as the ghost of the infected lead requiring surgical treatment (21). However, the incidence and clinical significance of these ghosts have never been studied. We sought to determine the incidence, diagnostic value, and outcome of intracardiac masses observed by echocardiography after device extraction. We hypothesized that these ghosts of leads could be associated with the diagnosis of CDRIE.

METHODS

Patient population and data collection. The study cohort consisted of all consecutive patients undergoing percutaneous lead removal at the Department of Cardiology (La Timone Hospital, Marseille, France) from July 2004 to July 2008. The population was identified using several resources including the hospital lead extraction database, endocarditis database, and the computerized central diagnostic index. The unique exclusion criterion was the absence of post–lead removal echocardiography during hospitalization.

All data concerning pre-operative clinical, microbiological, and echocardiographic conditions; the indication; and the removal technique were recorded on the day of the procedure.

All echocardiographic examinations were performed within the week after the removal procedure. Transthoracic echocardiography (TTE) was performed before and after lead removal in all patients. Transesophageal echocardiography was performed before removal only in patients with suspected LDI or CDRIE and after removal when TTE was not feasible because of the lack of echogenicity or when doubt persisted.

All patients with suspected infection had standard blood cultures and special samples for isolation of intracellular pathogens and for various specific antibodies performed. Lead culture and wound swab culture from generator-pocket tissue were performed in all patients and interpreted with the clinical and echocardiographic data. In cases of infection, the antibiotic treatment was discussed by a multidisciplinary team. The population was separated into 3 groups according to the final diagnosis: CDRIE, LDI, and noninfective indications.

Definitions. CDRIE patients were defined according to the previous validated diagnostic criteria (10,22). However, as proposed by Sohail et al. (16), presence of lead vegetation and clinical evidence of LDI were considered major criteria for the diagnosis of definite CDRIE. Moreover, lead culture was used as a major criterion of CDRIE only in the absence of pocket infection or when the leads were removed using a remote incision from the pocket (16). Major bacteriologic criteria were defined by blood cultures positive for typical endocardial pathogens or persistently positive for a microorganism consistent with infective endocarditis. Vegetation was defined as an oscillating intracardiac mass on the electrode leads, cardiac valve leaflets, or endocardial surface in the setting of the valve, which was present in >1 echocardiographic plane, and positive blood and/or lead tip cultures. Echocardiographic data included the presence and the maximal length of vegetations. The measurement of vegetation length was performed on various planes,

and the maximal length was used. In the presence of multiple vegetations, the largest length was used for analysis. Valvular regurgitation was assessed semiquantitatively.

LDI was clinically defined by the presence of local signs of inflammation at the generator pocket, including erythema, warmth, fluctuance, wound dehiscence, erosion, tenderness, and purulent drainage.

Percutaneous lead removal procedures. Percutaneous removal or surgery with extracorporeal circulation was based on the judgment of the multidisciplinary treatment team. Criteria that led to surgery with extracorporeal circulation, if general conditions permitted it, were vegetation length >20 mm, severe tricuspid regurgitation, and associated left-sided endocarditis.

All percutaneous removal procedures were performed in an operating room or electrophysiology laboratory, with the patient under general anesthesia or heavy sedation, with on-site cardiothoracic surgery support. The procedures were performed by experienced operators. The first step in all patient extracting procedures was simple traction on the lead from the cardiac device pocket. For leads implanted for >6 months, simple traction was applied after introduction of a locking stylet. When removal by simple traction was unsuccessful, we used at least one of the following tools: laser sheath or snare. Pacemaker-dependent patients were equipped with an epicardial right ventricular pacemaker in the days preceding the removal procedure for CDRIE. Data concerning lead- and procedure-related factors, such as implant duration time, number of atrial and ventricular leads, the presence of defibrillator or coronary sinus lead, and use of laser sheath/lasso, were collected.

End point. Appearance of a ghost was defined as the primary end point. A ghost was defined as a post-removal, new, tubular, mobile mass detected by echocardiography following the lead's intracardiac route in the right cavities (Figs. 1 to 3; Online Video 1). Post-removal lesions of subvalvular tricuspid apparatus were not considered ghosts.

Follow-up. All patients with ghosts were followed. This follow-up consisted of clinical examination and TTE at 1 and 3 months. Further follow-up was obtained by telephone contact (patients and physicians) and TTE at the end of the study. We particularly focused on survival and embolic or infectious events.

Statistical analysis. All continuous variables were expressed as medians (minimal and maximal values) or mean ± SD and compared using the nonparametric Kruskal-Wallis test. Categorical variables were expressed as percentages and compared using the chi-square or Fisher exact test. Odd ratios were estimated by logistic regression. All tests of significance were 2 sided, and a p value <0.05 was considered significant. Statistical analysis was performed using SPSS 15.0 (SPSS Inc., Chicago, Illinois).

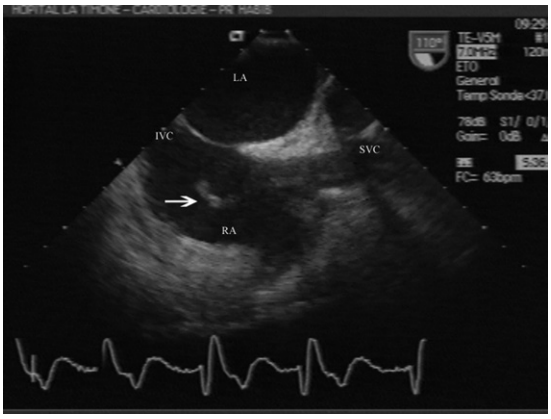

Figure 1. Transesophageal Echocardiography Showing a Ghost in the SVC (Patient #5)

In this patient, a 110° transesophageal echocardiographic view allows a good visualization of both the superior vena cava (SVC), the right atrium (RA), and the left atrium (LA). A ghost presents as a post–lead removal, new, tubular, mobile mass following the lead's intracardiac route in the right cavities **(arrow)**. The long tubular mass is seen in the SVC, going into the RA. See Online Video 1. IVC = inferior vena cava.

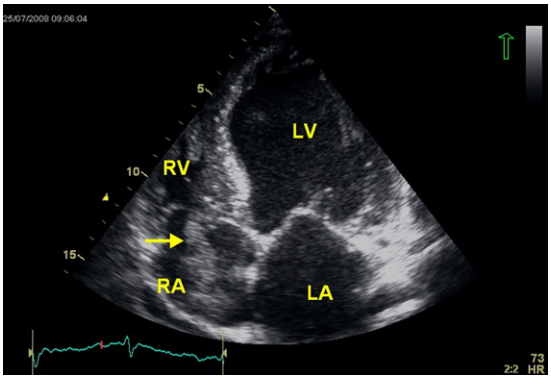

Figure 2. Transthoracic Echocardiographic 5-Chamber View Showing a Ghost in the RA (Patient #16)

This standard apical view allows satisfactory visualization of the right cavities. A large and thick tubular mass **(arrow)** is seen in the RA **(arrow)**, prolapsing into the right ventricle (RV). LV = left ventricle; other abbreviations as in Figure 1.

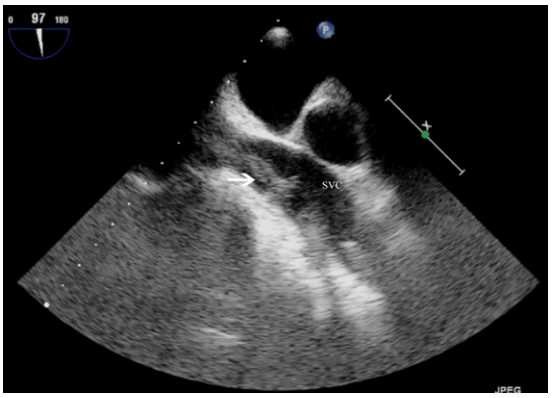

Figure 3. Transesophageal Echocardiography Showing a Ghost in the SVC (Patient #13)

This is an atypical view of the right cavities obtained using a 97° transesophageal echocardiographic view. The probe is placed at the lower portion of the esophagus, allowing visualization of a long segment of the SVC. A long tubular mass is clearly seen in the SVC (**arrow**). Abbreviation as in Figure 1.

RESULTS

Patient characteristics. During the study period, 246 patients underwent percutaneous lead removal. Thirty-four patients were excluded because they could not have an echocardiographic examination at our institution after removal procedure (5 extractions for CDRIE, 15 for local infection, and 14 for other indications). Thus, the study cohort consisted of 212 patients with a total of 456 endovascular leads removed. Indication for lead extraction was CDRIE in 88 patients, LDI in 59 patients, and a noninfective indication in 65 patients. Baseline characteristics of each group of patients are summarized in Table 1. There were 154 male patients (73%) and 58 female patients (27%) with a median age of 72 years (range 13 to 93 years). Detailed indications for lead removal are summarized in Table 2. On average, 2.24 ± 0.76 leads were removed per patient. There were 63 ICD leads and 32 coronary sinus leads removed.

Table 2. Lead Removal Indications

Cardiac device infection–related endocarditis	88 (41%)
Local device infection	59 (28%)
Noninfective indication	65 (31%)
Lead dysfunction	29 (14%)
Upgrading from a PPM to an ICD and/or CRT	26 (12%)
Device replacement	4 (2%)
Symptomatic venous occlusion	2 (1%)
Treatment of breast malignancy	2 (1%)
Heart perforation	1 (0.5%)
Phrenic stimulation	1 (0.5%)

CRT = cardiac resynchronization therapy; ICD = implantable cardioverter-defibrillator; PPM = permanent pacemaker.

Of the 147 patients undergoing removal for infective reasons, microorganisms were found in 113 (77%). In the CDRIE group, blood cultures were positive in 41 patients (46%) and lead cultures were positive in 54 patients (51%). In the LDI group, leads cultures were positive in 44 patients (75%). Coagulase-negative *staphylococci* (33%) and *Staphylococcus aureus* (29%) were the most common causes of cardiac device infection, followed by gram-negative bacilli (9%) and *Propionibacterium acnes* (8%).

Pre-operative echocardiography identified vegetations in 57 infected patients (39%). The median vegetation length was 10 mm (range 5 to 35 mm). On the same pre-operative echocardiography, 8 thickened leads were observed. Post-removal transesophageal echocardiography was performed in 37 patients (29 with CDRIE, 5 with LDI, and 3 for other indications).

Laser or snare assistance was required for 97 of 212 patients (49%). The need for snare or laser sheath increased with the age of the leads, but no

Table 1. Patient Characteristics in the 3 Groups

	CDRIE (n = 88)	LDI (n = 59)	Noninfective Indications (n = 65)	p Value
Age, yrs, median (min-max)	73 (13–93)	76 (36–93)	67 (15–84)	<0.001
Men, n (%)	65 (74)	42 (71)	47 (72)	0.94
LVEF <35%, n (%)	27 (31)	18 (31)	37 (57)	0.001
Number of leads, median (min-max)	2 (1–5)	2 (1–4)	2 (1–3)	0.80
Atrial leads	1 (0–2)	1 (0–3)	1 (0–2)	0.92
Ventricular leads	1 (1–3)	1 (1–2)	1 (1–2)	0.19
Time from implant, months, median (min-max)	46 (0.7–261)	69 (0.9–217)	29 (0.1–211)	0.16
Patients with leads older than 1 yr, n (%)	70 (80)	46 (78)	53 (82)	0.88
Use of laser and/or snare, n (%)	42 (48)	31 (53)	24 (37)	0.19

CDRIE = cardiac device–related infective endocarditis; LDI = local device infection; LVEF = left ventricular ejection fraction.

association was found between the indication of lead removal and the need for a lasso and/or laser sheath.

Ghost identification. Ghosts were observed in 17 patients (8% incidence), including 14 (16%) of 88 patients with CDRIE and 3 (5%) of 59 patients with LDI. Ghosts were never observed among the remaining 65 noninfected patients. A significant association was found between CDRIE and the presence of ghosts (odds ratio: 7.63, 95% confidence interval: 2.12 to 27.45, p = 0.001). The only other factor associated with ghosts was a positive lead culture (odds ratio: 2.98, 95% confidence interval: 1.01 to 8.78, p = 0.048). Univariate analysis of ghost predictors in the entire population is shown in Table 3. The locations of the ghosts were the superior vena cava in 10 patients, right ventricle trabeculations in 4 patients, and the tricuspid valve in 3 patients. The main features of these 17 patients are summarized in Table 4.

Outcome. Patients with a ghost were followed for a median period of 15 months (range 4 to 38 months). The follow-up was complete for clinical and echocardiographic data for all the 17 patients at 3 months. During hospitalization, all patients received at least 1 antibiotic treatment with an average duration of 5.4 weeks. Two patients underwent surgery because of their ghosts. One (Patient #3) required surgery because of an uncontrolled infectious process. The pathological examination of the ghost showed inflammatory thrombi corresponding to possible vegetation. In the second case (Patient #12), the ghost extended from the right to the left atrium through a patent foramen ovale and was removed surgically because of the high risk of systemic embolism (21).

A ghost persisted in 8 patients at 1 month and in 6 patients at 3 months. During the follow-up, 3 patients died, 2 (Patients #1 and #17) suddenly at days 19 and 90 and 1 (Patient #2) of severe cardiac heart failure at 12 months. A ghost was still present on the last TTE in the 3 patients who died. The main characteristics of these patients are summarized in Table 5. Another patient (Patient #10) underwent heart transplantation because of terminal heart failure 5 months after extraction. One patient (Pa-

Table 3. Ghost Predictors in Univariate Analysis

	Ghost Patients (n = 17)	Other Patients (n = 195)	p Value	Odds Ratio (95% CI)
Indications				
CDRIE* vs. other indications (%)	14 (82)	74 (38)	<0.001	7.63 (2.12–27.45)
Patient-related factors				
Age, yrs, median (min-max)	71 (39–87)	72 (13–96)	0.78	
Sex (male/female)	14/3	140/55	0.41	
LVEF <35%, n (%)	6 (35)	76 (39)	0.77	
ICD, n (%)	7 (41)	56 (29)	0.28	
Resynchronization therapy, n (%)	2 (12)	30 (15)	1.00	
Previous TR (yes/no)	0/0	3/2	1.00	
Thickened lead, n (%)	2 (12)	6 (3)	0.13	
Infectious factors				
Positive blood culture, n (%)	5 (29)	31 (16)	0.18	
Positive lead culture, n (%)	12 (71)	87 (45)	0.04	2.98 (1.01–8.78)
Coagulase-negative *staphylococci*,* n (%)	6 (35)	36 (28)		
Staphylococcus aureus,* n (%)	7 (41)	30 (23)		
Others,* n (%)	3 (18)	31 (22)	0.16	
No microorganism identified,* n (%)	1 (6)	33 (25)		
CDRIE* with negative blood cultures,* n (%)	1 (6)	15 (12)	0.70	
Extraction-related factors				
Number of leads, median (min-max)	2 (1–4)	2 (1–5)	0.22	
Auricular leads, median (min-max)	1 (1–2)	1 (0–3)	0.48	
Ventricular leads, median (min-max)	1 (1–2)	1 (1–3)	0.17	
Median implantation time (min-max)	46.7 (0.7–176)	45.7 (0.1–240)	0.91	
Leads >1 yr, n (%)	14 (82)	155 (80)	1.00	
Use of laser sheath/lasso, n (%)	5 (29)	92 (47)	0.16	

*Statistical analysis for infected patients (n = 147).
CI = confidence interval; TR = tricuspid regurgitation; other abbreviations as in Tables 1 and 2.

Table 4. Main Characteristics of the 17 Patients With a Ghost

Patient	Age (yrs)	Sex	Removal Indication	Major Echocardiographic Criteria*	Major Microbiological Criteria†	Number of Minor Criteria	Lead Culture	Time From Implantation (Median Months)	Localization	Ghost Length (mm)	Outcome at 3 Months
1	85	Male	CDRIE	+	+	3	−	29	SVC	25	Dead at day 90
2	77	Male	LDI	−	−	1	+	38	SVC	31	Alive
3	40	Male	CDRIE	+	+	3	+	172	SVC	40	Alive (surgery at day 6)
4	74	Male	CDRIE	+	−	3	+	46	SVC	44	Alive
5	46	Male	CDRIE	+	+	2	+	49	SVC	78	Alive
6	56	Male	LDI	−	−	3	+	173	RVT	24	Alive
7	87	Female	CDRIE	+	+	1	−	8	RVT	50	Alive
8	82	Female	CDRIE	+	+	1	+	94	RVT	40	Alive
9	67	Male	CDRIE	+	+	3	+	16	SVC	30	Alive (PE at day 3)
10	39	Male	CDRIE	+	+	2	−	0.7	SVC	50	Alive
11	58	Female	CDRIE	+	+	2	+	2	SVC	41	Alive
12	71	Male	CDRIE	+	+	1	+	54	SVC	80	Alive (surgery at day 4)
13	70	Male	CDRIE	+	+	2	+	69	SVC	41	Alive
14	79	Male	CDRIE	+	+	1	+	99	RVT	41	Alive
15	68	Male	LDI	−	−	1	+	86	SVC	50	Alive
16	73	Male	CDRIE	+	+	1	−	41	TV	55	Alive
17	74	Male	CDRIE	+	+	2	−	22	TV	45	Dead at day 19

*Major echocardiographic criteria defined by lead or endocardial vegetation or endocardial abscess in contact with the lead. †Major bacteriologic criteria as defined in the Methods section. PE = pulmonary embolism; RVT = right ventricle trabeculations; SVC = superior vena cava; TV = tricuspid valve; other abbreviations as in Table 1.

tient #9) presented with a symptomatic pulmonary embolism 9 days after lead removal. Perfusion and ventilation scintigraphy showed a new defect, and TTE revealed the disappearance of the ghost.

None of the patients presented with a new infectious episode. Patient outcomes are summarized in Table 4.

DISCUSSION

We present the incidence, predictors, and outcome of the ghosts of permanent pacemaker and ICD leads observed after device removal in a large retrospective cohort. We showed that these ghosts are significantly associated with the diagnosis of CDRIE and may be complicated by major cardiovascular events.

Incidence of ghosts. Ghost has not been considered a lead removal complication in the recent Heart Rhythm Society Expert consensus endorsed by the American Heart Association (23). In our study, ghosts were present after lead removal in 8% of patients and were observed only in patients with device infection. Two reasons may explain the relatively high incidence of ghosts. First, our work provides one of the largest series of CDRIE with percutaneous lead removal. Furthermore, post–lead removal echocardiography was systematically performed during hospitalization, allowing identification of this entity more frequently.

Pathophysiology. We found that CDRIE was the main factor associated with the appearance of ghosts. Thus, we can address the question of the pathogenesis of the ghosts. There is a lot of evi-

Table 5. Main Characteristics of the Patients Who Died

Patient	Age (yrs)	Sex	Removal Indication	Pacemaker Indication	Need for Permanent Ventricular Stimulation	Epicardial Stimulation	Cardiac Heart Failure	Complication of Extraction	Ghost Length (mm)	Days After Explantation, Cause of Death
1	85	Male	CDRIE	SAB	−	−	−	−	25	90, sudden death
2	77	Male	LDI	AVB	+	+	+	−	31	391, cardiac failure
17	74	Male	CDRIE	AVB	+	+	−	−	45	19, sudden death

AVB = atrioventricular block; SAB = sinoatrial block; other abbreviations as in Table 1.

dence that permanent pacemaker and ICD leads are surrounded by a fibrous sheath that grows with time (17–19). Stokes et al. (17) proposed a theory about the mechanism of encapsulation of transvenous cardiac pacemaker leads as a function of implant time based on the post-mortem examination of 101 dogs. Thrombosis due to endothelial damage and blood flow perturbation occurs first. Then, thrombus undergoes lysis or organization. This results in the formation of collagenous tissue surrounding the lead. Moreover, in other work, a histological analysis showed that this fibrous sheath with sparse inflammatory cells could be endothelialized and might have the rules of preventing migration of cardiac device leads (19).

Incomplete removal of this fibrous sheath detected by echocardiography was described in 2 case reports of patients with device infection (20,21). In our series, we described 17 cases with incomplete removal of the sheath surrounding the leads. These findings suggest a possible role of infection in the persisting fibrous sheath after lead extraction. Some studies showed that infected leads are more easily extracted than noninfected leads (24–26). The infectious process, possibly breaking the seal between developed adhesions and the endocardial surface, was suspected. However, in our study, we did not find any association between an infectious indication and less use of sophisticated techniques of removal such as laser sheath or snare. Otherwise, some studies found that at least 6 months are needed for fibrous tissue to encapsulate the leads (17). In our series, however, no association was found between the age of the leads and the appearance of ghosts. Two patients who presented with ghosts had had lead removal <6 months after implantation. Moreover, our pathological findings were in agreement with the fact that ghosts are not only fibrous sheaths but possible vegetations. In summary, our proposed explanation is that ghosts might be infected fibrous sheaths mixed with vegetations that come off cardiac device leads because of an infectious process.

Ghost: a criterion for CDRIE? In 1994, Durack et al. (22) defined criteria for infective endocarditis using specific echocardiographic findings. Microorganism isolation and echocardiographic status were proposed as major criteria in this classification. However, some authors showed that these criteria have a poor sensitivity for diagnosing CDRIE (10,16). This fact could be explained by the relatively low sensitivity of echocardiography in detecting vegetation on pacemaker leads (10,11,16,27,28) and by frequently negative blood cultures in this setting (10,16).

Additional criteria have been proposed to increase the sensitivity of Duke criteria, such as local symptoms, pulmonary embolism, and lead tip culture (10,16,29). Recently, Sohail et al. (16) proposed that the presence of lead vegetation associated with clinical evidence of generator pocket infection should classify the patients as having definite CDRIE.

Our study showed that ghosts are strongly associated with a CDRIE diagnosis. However, if we applied Duke criteria in our series, 3 patients (Patients #6, #2, and #15) with ghosts met only the LDI definition. These 3 patients had positive lead cultures and local signs of infection at the removal site. As a result, these 3 patients were considered as possibly having endocarditis. Considering ghosts as a major criterion of CDRIE, the appearance of a ghost combined with LDI signs would classify these 3 patients with LDI as having definite CDRIE. Thus, we propose that the presence of ghosts may be included as a new criterion in the diagnosis of CDRIE.

Outcome. The prognostic value and therapeutic implications of the finding of a ghost are unknown. In our series, all 17 patients were treated as having CDRIE, with a protocol including 6 weeks of intravenous antibiotic therapy associated with lead extraction. No cases of recurring infection were identified at the last follow-up visit. Two patients died during the 3-month follow-up. These 2 patients had no severe comorbidities. They had not experienced any complications from their lead removal, and their infectious process was under control. This unexpected outcome might raise the question of the involvement of a ghost in the pathophysiology of these deaths. Another patient died in the 12th month after lead removal. Although his ghost remained on the last TTE performed, he died of cardiac heart failure. Moreover, 2 other patients required surgery as described previously, and 1 patient had a symptomatic pulmonary embolism. Thus, the presence of a ghost indicates the need for close clinical and echocardiographic follow-up to detect complications. Surgery must be discussed in cases of embolisms and very large and mobile ghosts (21).

Study limitations. This study has several limitations due to its retrospective nature. First, all patients did not undergo transesophageal echocardiography. TTE is known to have a relatively poor sensitivity in detecting cardiac right-sided vegetation (30). In our series however, because of their large size, ghosts could be detected in 15 of the 17 patients by

TTE. Another limitation was the time delay between the lead removal procedure and echocardiography. Echocardiography was performed during the same hospitalization but after variable periods after lead removal. Consequently, some ghosts might have already embolized before echocardiography was performed and may not be detected at the time of echocardiographic examination. Finally, repeat echocardiographic studies were not performed in patients without ghosts.

CONCLUSIONS

A ghost is a floating mass in the right cardiac cavities observed in 8% of cases after percutaneous lead removal. The presence of a ghost seems to be associated with the diagnosis of CDRIE and might explain sudden death in some patients after lead extraction. However, large prospective series of infected patients undergoing percutaneous lead removal are needed to confirm these findings and to define the optimal management of this newly described entity.

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