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Evaluation with Cardiac Catheterization and Echocardiography in Patients Undergoing Implantable Cardioverter-defibrillator Implantation

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Summary. **As coronary artery disease (CAD) is common in adult patients with lethal ventricular arrhythmias, it has become accepted practice to perform coronary angiography prior to implantable cardioverter-defibrillator (ICD) implantation. Echocardiography is also commonly performed in this setting. However, we are unaware of any study that has evaluated the role of routine coronary angiography and echocardiography prior to ICD placement. We theorize that CAD and valvular heart disease are common in patients undergoing ICD Implantation and that angiography and echocardiography in this population frequently result in invasive therapy. We reviewed all cases of ICD implantation at Strong Memorial Hospital over a 14-month period and determined whether coronary angiography and echocardiography performed prior to ICD placement resulted in revasculalization and valve surgery, respectively. Of 120 patients who received an ICD, 64 (53%) had undergone coronary angiography within the prior year. Of those, 53 (83%) had CAD and 25 (39%) subsequently underwent percutaneous transluminal coronary angioplasty (PTCA) (20) or coronary artery bypass grafting (CABG) (5). Sixty two (52%) of the patients studied had had valvular heart disease diagnosed by left heart catheterization or echocardiography within the prior year. Four (6%) pateints had resultant valve surgery. We conclude that coronary angiography performed prior to ICD implantation results in the diagnosis of CAD and the subsequent revascularization in a large number of patients. Those receiving and ICD also have a high incidence of valvular heart disease, the diagnosis of which leads to valve replacement surgery in a small number of patients. There may be a role for routine coronary angiography and echocardiogram prior to ICD placement.**

Key words – ICD, catheterization, angiography, echocardiography, arrhythmia.

INTRODUCTION

The utilization of the implantable cardioverter-defibrillator (ICD) has increased greatly in the last several years as the indications for its use have multiplied. Several large randomized trials have demonstrated the superiority of the ICD compared with antiarrhythmic drugs in the primary and secondary prevention of sudden cardiac death (SCD) due to ventricular arrhythmias.[1,2,3].

In the United States, about eighty percent of patients with the ventricular arrhythmias leading to SCD have coronary artery disese (CAD) or its consequences: that is, acute or chronic ischemia and myocardial scarring. It has therefore become accepted practice to evaluate these patients with coronary angiography prior to ICD placement in order to identify potentially correctable lesions that may have led to a ventricular arrhythmia, and which may significantly affect their long term prognosis. [4] However, we are unaware of any study that has evaluated the role of routine coronary angiography

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Abbreviations – AR, aortic regurgitation; CABG, coronary artery bypass grafting; CAD, coronary artery disease; EF, ejection fraction; EP, electrophysiology; ICD, implantable cardioverter-defibrillator; LV, left ventricule; LVEF, left ventricular ejection fraction; MI, myocardial infarction; MR, mitral regurgitation; SCD, sudden cardiac death; TR, tricuspid regurgitation; VF, ventricular fibrillation; VT, ventricular tachycardia.

prior to ICD placement.

This retrospective study was conducted to examine how frequently patients were evaluated with coronary angiography prior to ICD placement, and how frequently such evaluations revealed significant coronary stenoses necessitating revascularization. We also examined the incidence of valvular heart disease (a less common but correctable cause of ventricular arrhythmia) at the time of ICD placement, to determine how frequently the discovery of such disease resulted in surgical therapy.

METHODS

We reviewed all consecutive cases of ICD placement at Strong Memorial Hospital (SMH) over the 14-month period from April 2000 through May 2001, using a computer database of all evaluations and procedures performed in the Cardiology Unit at SMH (Pronto) as well as a computer database of the discharge summaries of all admissions to SMH.

The study population was defined by searching the Pronto computer database of this hospital and specifying a date and type of procedure (ICD placement). We included patients regardless of age or indication for ICD.

Cases were evaluated to determine whether CAD had ever been documented by coronary angiography in the patient's lifetime. we further determined whether coronary angiograpy had been performed within a one-year period prior to placement of the ICD. The reasons for arbitrarily choosing this one-year period are as follows: In order to use this retrospective data to determine whether there is a role for routine coronary angiography prior to ICD placement, we needed to exclude coronary angiograms performed remote to the time of ICD placement. Such coronary angiograms may not have been performed as part of an evaluation for ICD placement and may have been so remote as to not accurately represent the presence or extent of structural heart disease at the time of ICD placement.

If coronary angiography had been performed within the previous year, we assessed whether CAD (one, two or three vessel disease) was present and whether coronary angioplasty or coronary artery bypass grafting (CABG) was performed as a result. If an angiogram showed evidence of previous CABG, the status of the native vessels was assessed to define whether the patient had 1,2, or 3 vessel disease. Coronary angioplasty was defined as any percutaneous intervention to revascularize a native artery or a graft.

We then looked to see whether there was valvular heart disease diagnosed by left heart catheterization or echocardiography that was performed within a one-year period prior to ICD placement. Valvular heart disease was defined as regurgitation or senosis of a valve (mitral, aortic, tricuspid, or pulmonic) that was graded mild, moderate, or severe as well as mitral valve prolapse or the presence of a prosthetic valve. Valvular sclerosis was not included.

If valvular heart disease was diagnosed within this one-year period, we determined whether valve surgery was performed as a result.

Left ventricular ejection fraction (LVEF) at the time of ICD placement was assessed by using the most recent measurement made either by echocardiography, angiography, or nuclear cardiology study. Estimation of LVEF was not necessarily within the year prior to ICD placement. The ejection fraction (EF) was

Table 1. Types of valvular heart disease documented within one year prior to implantable cardioverter-defibrillator (ICD) placement

Type of valvular heart disease	Number of patients (percentage of total with documented valvular heart disease)
MR	55 (89%)
TR	15 (24%)
AR	12 (19%)
AS	3 (5%)
MVP	1 (2%)
Prosthetic AV	4 (6%)
Prosthetic MV	1 (2%)
MS	0 (0%)

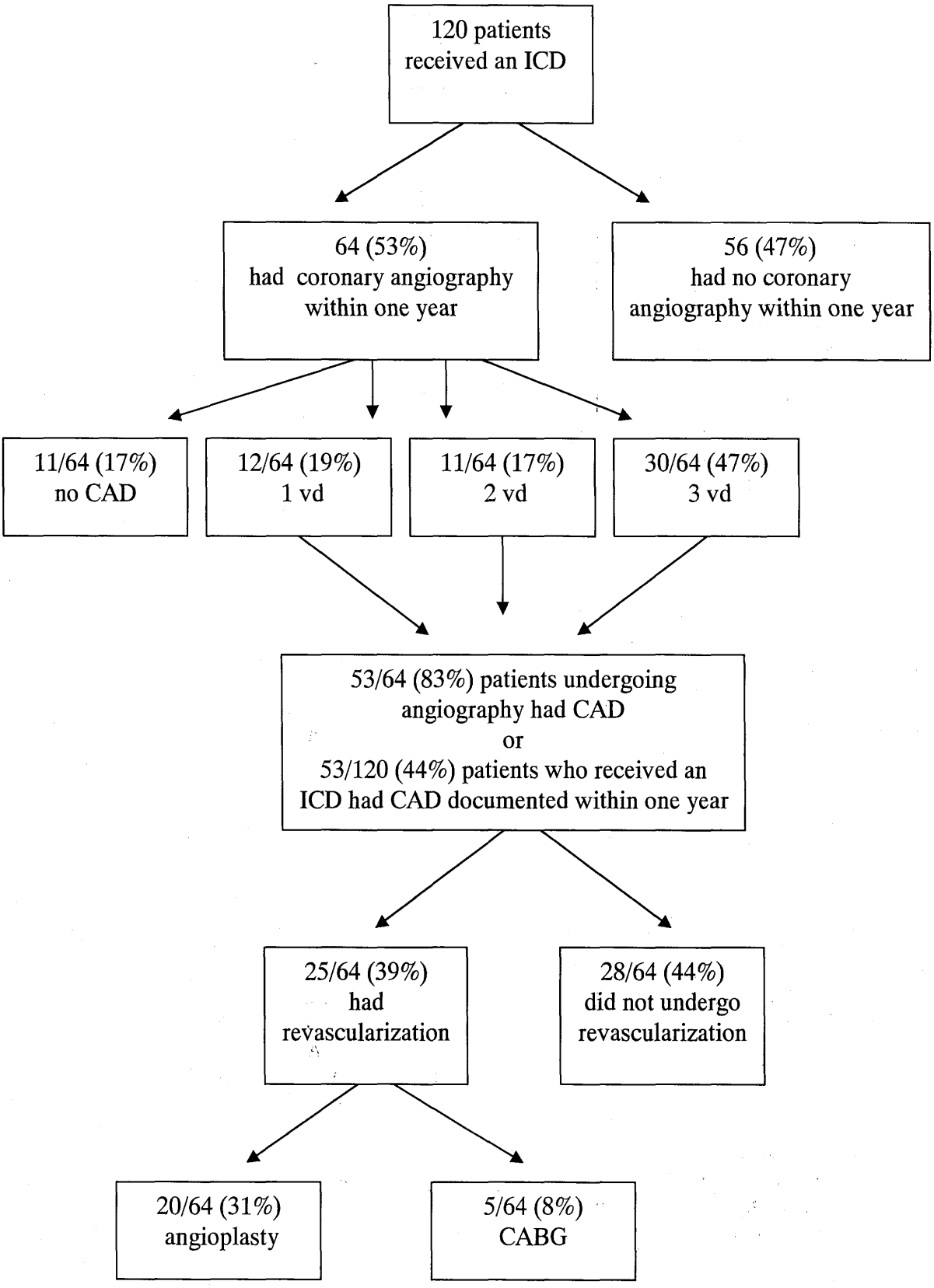

Fig. 1. Freqeuncy of coronary angiography and revascularization within one year of receiving an ICD. Flow diagram shows the results of coronary angiography performed on patients within one year of receiving an ICD. ICD, implantable cardioverter defibrillator; CAD, coronary artery disease; CABG, coronary artery bypass grafting.

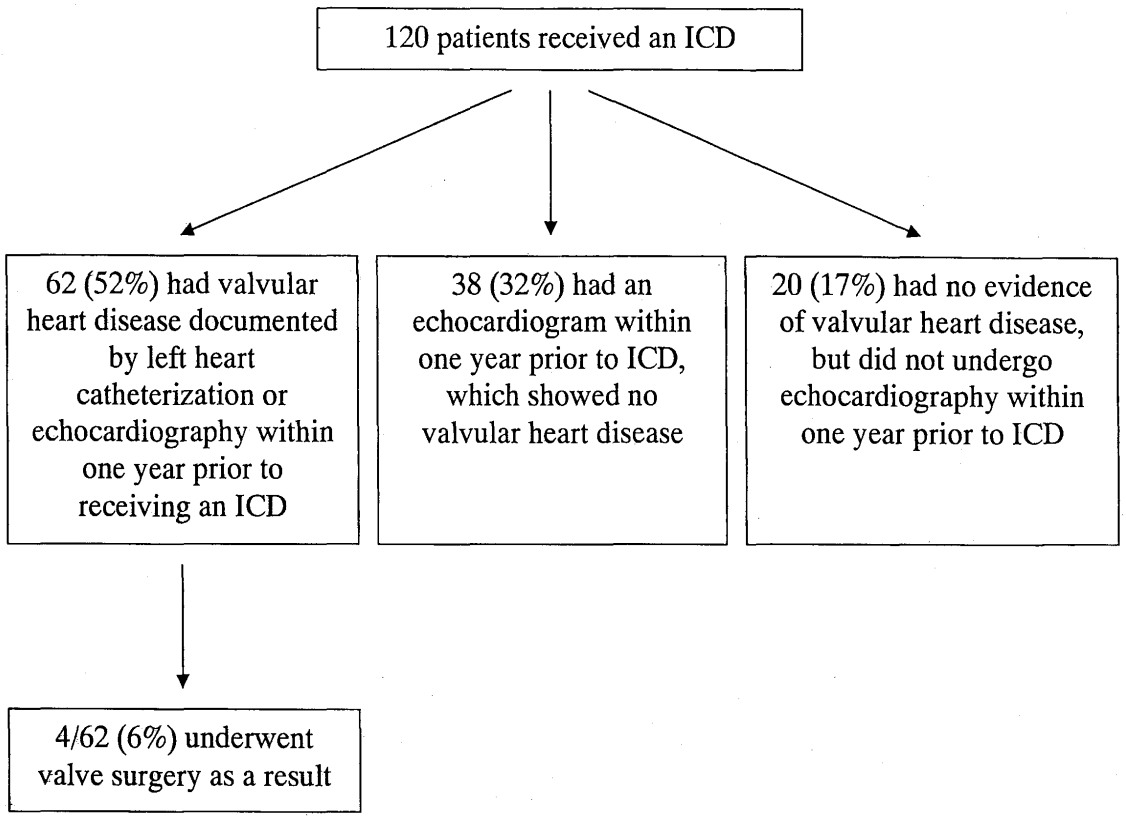

Fig. 2. Incidence of valvular heart disease among patients receiving an ICD. Flow diagram shows the number of pateints who were diagnosed with valvular heart disease and underwent valve surgery within the year prior to receiving an ICD. ICD, implantable cardioverter defibrillator.

categorized as greater than or equal to 40% or less than 40%. If a study qualified LVEF as mild or moderate left ventricular dysfunction without a quantitative estimate, the LVEF for that patient was considered to be unknown. If EF was qualified as severe left ventricular dysfunction without a quantitative estimate, LVEF was assumed to be less than 40%.

RESULTS

One hundred and twenty patients received an ICD during the 14-month period reviewed. There were 99 men and 21 women. Ages ranged from eight to 93 years, with an average of 64.2. Indications for ICD included: cardiac arrest due to ventricular fibrillation (VF) or ventricular tachycardia (VT) (13); spontaneous sustained VT (23); non-sustained VT with previous myocardial infraction (MI), LV dysfunction and induced VT or VF at electrophysiology (EP) testing (49); unexplained syncope with inducible ventricular arrhythmias at EP testing (20); enrollment in clinical trials (3); Long QT syndrome (4); Brugada syndrome (2); hypertrophic cardiomyopathy (2); and symptomatic non-sustained VT (1). For three patients, the indication for ICD placement could not be accurately determined from the available data.

Of the 120 patients, 70 (58%) had one, two or three vessel CAD diagnosed by a previous coronary angiogram at some time in their lives, 39 (33%) had never undergone coronary angiography, and 11 (9%) had a previous coronary angiogram which showed no evidence of CAD.

Sixty-four of the 120 patients (53%) underwent coronary angiography within one year prior to receiving an ICD. Of those who underwent coronary angiography within one year prior to ICD placement, 53 (83%) had evidence of CAD and 11 (17%) had no evidence of CAD. Among the 64 patients who underwent coronary angiography, 12 (19%) had one vessel disease, 11 (17%) had two vessel disease, and 30 (47%) had three vessel disease (Fig. 1)

Table 2. Incidence of combined CAD and valvular heart disease diagnosed within one year prior to ICD

	Results of coronary angiography within one year prior to ICD					
	0 vd	1vd	2vd	3vd	No angiography within one year prior to ICD	Total with CAD
Patients with valvular heart disease diagnosed within one year prior to ICD	5 (8%)	5 (8%)	4 (6%)	13 (21%)	35 (56%)	22/62 (35%)

Table 3. Characteristics of study population by age and EF

	Age > 40	Age < 40	EF > 40%	EF < 40%
Total of patients	109 (91%)	11 (9%)	42 (35%)	72 (60%)
Of patients with catheterization within one year prior to ICD	61 (56%)	3 (27%)	19 (45%)	45 (63%)
Of patients with CAD	53/61 (87%)	0 (0%)	14/19 (74%)	39/45 (87%)
0vd	8/61 (13%)	3/3 (100%)	5 (26%)	6 (13%)
1vd	12/61 (20%)	0 (0%)	2 (11%)	10 (22%)
2vd	11/61 (18%)	0 (0%)	3 (16%)	8 (18%)
3vd	30/61 (49%)	0 (0%)	9 (47%)	21 (47%)
Revascularization	25 (41%)	0 (0%)	9 (47%)	15 (33%)
PTCA	20/61 (33%)	0 (0%)	6 (32%)	13 (29%)
CABG	5/61 (8%)	0 (0%)	3 (16%)	2 (4%)
Valvular HD	56/109 (51%)	6/11 (55%)	24/42 (57%)	43/72 (60%)
Valve Surgery	4/56 (7%)	0 (0%)	0 (0%)	4/43 (9%)

PTCA, percutaneous transluminal coronary angioplasty.

As shown in Fig. 1, twenty-five (39%) of the coronary angiograms performed within the year prior to ICD resulted in a revascularization procedure: coronary angioplasty in 20 (31%) and CABG in five.(8%)

Sixty-two (52%) of the 120 patients had valvular heart disease diagnosed by left heart catheterization and or echocradiography within the year prior to receiving an ICD, and four of those (6%) underwent valve surgery. (Fig. 2)

Mitral regurgitation (MR) was the most common type of valvular disease, followed by tricuspid regurgitation (TR) and aortic regurgitation (AR). (Table 1) Sixty-six percent of the cases of MR were graded as mild, and only two cases (4%) were graded as severe. The etiology of the valvular disease could not be determined in all cases, but the majority of MR was attributed to ischemic disease. One case was secondary to mitral valve prolapse, and no cases were secondary to rheumatic heart disease.

Sixty percent of the cases of TR were graded as mild

and only three cases (20%) were graded as severe. The majority of cases was attributed to right ventricular enlargement while one case was a consequence of congenital heart disease; no cases were attributed to rheumatic heart disease.

Seventy-five percent of the cases of AR were graded as mild and none were graded as severe. The etiology of the AR in the majority of cases was valvular calcification or disease of the aortic root. No cases of AR were attributed to rheumatic heart disease.

Twenty-two (18%) of the 120 patients in the study had both CAD and valvular heart disease diagnosed by evaluations within the year prior to ICD placement. (Table 2)

Of the 120 patients studied, 42 (35%) had an EF greater than 40%, 72 (60%) had an EF less than 40%, and in six (5%) patients, the EF was unknown. One hundred and nine (91%) of the patients studied were forty years of age or older, and 11 (9%) were less than forty. The characteristics of patients according to their EF are shown in Table 3.

DISCUSSION

In the population studied here the majority of patients had CAD diagnosed at some point in their lifetime. This is not surprising, given that myocardial ischemia and/or infarction with resultant scar formation can provide a substrate for the cardiac arrhymias that would qualify one for an ICD. The prevalence of CAD in this population of patients explains why a coronary angiogram is commonly performed prior to placement of an ICD. In our study, over half of the patients who received an ICD had undergone coronary angiography within the prior year. Because we studied all recipients of an ICD in a 14-month period, we included a number of the younger patients in whom the likehood of CAD was very low. Thus, the percentage of our study population that underwent coronary angiography prior to ICD placement probably under-represents the percentage of older individuals in whom CAD could reasonably be suspected, and who should undergo coronary angiography as part of a routine evaluation prior to ICD placement.

Of those undergoing coronary angiography in the year prior to ICD placement, over half were found to have CAD, and nearly half of those underwent revascularization as a result. From this data, we conclude that coronary angiography prior to ICD placement in this population translated into a large number of coronary interventions, and therefore there may be a role for routine coronary angiography prior to ICD placement. While it is not clear from our study whether these interventions translated into improved morbidity or mortality, many randomized prospective trials have consistently demonstrated that coronary revascularization in patients with life-threatening ventricular arrhythmias reduces the incidence of recurrent ventricular arrhythmia, either induced or spontaneous [5,6,7], and also improves survival rate [8].

Valvular heart disease is a less common, but known cause of the ventricular arrhythmias that warrant an ICD. We showed that over half of those who received an ICD had valvular heart disease diagnosed by echocardiography or left heart catheterization within the year prior to ICD placement. That valvular heart disease was so common in this study is likely explained by the fact that we considered valvular disease to be present even if it was graded as mild. Indeed, mild MR, TR, and AR accounted for most of the valvular disease reported. In addition, the majority of valvular heart disease in this study was felt to be a result of ventricular cavity dilatation which is consistent with the burden of ischemic heart disease and LV dysfunction in this population.

A small percentage of those with valvular heart disease had resultant valve surgery. That a much smaller percentage of those documented to have valvular heart disease prior to ICD had a resultant clinical intervention than did those with CAD is not surprising. Valve surgery may not be embarked upon until the disease is severe or symptomatic, as there is significant morbidity and mortality associated with the procedure. In contrast, angioplasty, which accounted for the majority of cardiac invasive therapy in the group discovered to have CAD prior to ICD placement, carries significantly less risk and thereby is performed more frequently.

We conclude that a small but significant percentage of pateints documented to have valvular heart disease prior to ICD placement went on to have valve surgery (6%), and that based upon this there may be a role for a routine evaluation for valvular disease(e.g. with echocardiography) prior to ICD placement. It is not clear whether the valve surgery translated into a mortality benefit, nor can valvular heart disease documented in the presence of a ventricular arrhythmia be assumed to be the etiology for the arrhythmia. A larger prospective study would be better equipped to determine whether there is a mortality benefit.

It is important to note that there is already good evidence for performing echocardiography in certain candidates for an ICD, as determining eligibility for the ICD often is contingent upon assessment of EF [1,2].

The EF is widely used as a marker of the extent of structural heart disease and has a high reliability to predict death from cardiac causes [9]. In our study

population, the majority of patients receiving an ICD had an LVEF < 40%. Compared with patients with an LVEF > 40%, a greater percentage of those with an LVEF < 40% underwent coronary angiography within the year prior to ICD placement, and a greater percentage had CAD documented at the time of that angiogram. Indeed, this confirms what we already know: there is a greater incidence of the ventricular arrhythmias that qualify one for an ICD in patients with a low EF [5], and in the United States, those with structural heart disease are more likely to have CAD.

This study is limited by the fact that it is a retrospective analysis of a relatively small number of patients. Inherent in this design is that there were no predetermined, uniform criteria for the severity or significance of coronary artery stenoses or valvular heart disease, or for the indication for coronary revascularization or valve surgery.

CONCLUSIONS

Coronary angiography prior to ICD placement results in a significant number of revascularizaition procedures, and evaluation for valvular heart disease prior to ICD placement results in a smaller but significant number of valve surgeries. This study was not designed to determine whether there was a mortality benefit associated with evaluating for CAD and valvular heart disease prior to ICD placement. However, larger, randomized, prospective trials may help to answer this question and to determine whether such evaluation should be routine.

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