Prevalence and consequences of noncardiac incidental findings on preprocedural imaging in the workup for transcatheter aortic valve implantation, renal sympathetic denervation, or MitraClip implantation

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Background Dedicated data on the prevalence of incidental findings (IF) stratified according to overall clinical relevance and their subsequent correlation to outcome are lacking. The aim of the present study was to describe the prevalence and consequences of noncardiac IF on computed tomography or magnetic resonance imaging in the workup for interventional cardiovascular procedures.

Methods A total of 916 patients underwent preprocedural computed tomography or magnetic resonance imaging in the workup for transcatheter aortic valve implantation (TAVI), renal sympathetic denervation (RDN), or MitraClip implantation.

Results IF were found in 395 of 916 patients (43.1%), with an average of 1.8 IF per patient. Classifying the IF resulted in 155 patients with minor, 171 patients with moderate, and 69 patients with major IF. The intended procedure was delayed or canceled in only 15 of 916 (1.6%) of the patients because of the presence of potential malignant IF. In patients that did undergo the intended procedure (n = 774), the presence of a moderate or major IF (23.8%) did not impact 1-year mortality compared to no or minor IF (adjusted HR 0.90, 95% CI 0.56-1.44, *P* value = .65). These findings were consistent among patients referred for TAVI, RDN, or MitraClip.

Conclusions IF are frequent in patients referred for cardiovascular procedures. IF did not result in a delay or cancellation of the intended procedure in the vast majority of cases, irrespective of their clinical relevance. The presence of a major or moderate IF did not significantly impact 1-year mortality. (Am Heart J 2018;204:83-91.)

The number of incidental findings (IF) detected by diagnostic imaging modalities used for screening patients with a variety of cardiovascular diseases rapidly increased during the past 2 decades. This has been explained by an expanding number of percutaneous treatment options in which detailed preprocedural radiological assessment using high-resolution computed tomography (CT) or magnetic resonance imaging (MRI) is of paramount importance to guarantee optimal treatment results.[1,2] Although IF have been reported in 25% to 85% of patients referred for cardiovascular interventions, their clinical implications most often remain elusive.[3-6] Thereby, the definition of (clinically relevant) IF remains a topic of debate, explaining the large heterogeneity in reported prevalences.[7,8]

At present, dedicated data on the prevalence of IF stratified according to overall clinical relevance and their subsequent correlation to outcome are lacking. The aim of the present study is to describe the prevalence and consequences of noncardiac IF on CT or MRI in the workup for transcatheter aortic valve implantation (TAVI), renal sympathetic denervation (RDN), or MitraClip implantation.

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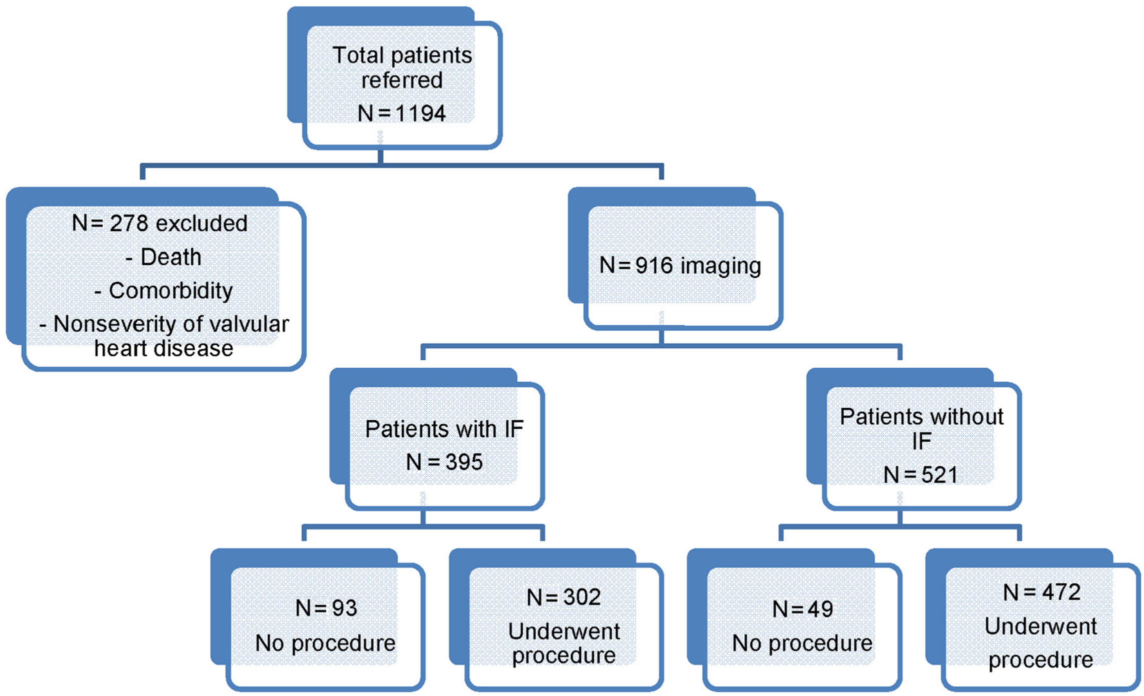
Figure 1



Total patients referred for TAVI, RDN, and MitraClip implantation.

Methods

Study population

Between May 2009 and December 2016, a total of 1,194 patients were referred for TAVI (n = 1,060), RDN (n = 110), or MitraClip (n = 24) implantation. A total of 278 patients were excluded because of either mortality in the screening process before radiological evaluation or a clinical decision not to proceed with screening for the respective procedure. Eventually, 916 patients with preprocedural workup including CT (n = 869) or MRI (n = 47) were included in the final analyses, of which 85.4% were screened for TAVI, 12.0% were screened for RDN, and 2.6% were screened for MitraClip implantation. Following the completion of the diagnostic workup and in accordance with European Society of Cardiology guidelines,[9] all patients referred for TAVI and MitraClip implantation were discussed in a multidisciplinary team including interventional cardiologists, cardiothoracic surgeons, anesthesiologists, and geriatricians. Patients undergoing RDN in the context of treatment-resistant hypertension, atrial fibrillation, and heart failure with reduced ejection fraction were screened according to recent recommendations.[10] A total of 142 patients did not undergo the procedure for which they were initially referred (Figure 1).

For the purpose of this study, patients were not subject to study interventions; neither was any mode of behavior imposed, other than as part of their regular treatment. Therefore, according to Dutch law, written informed consent for a patient to be enrolled in this study was not required. This study was conducted according to the privacy policy of the Erasmus MC and to the Erasmus MC regulations for the appropriate use of data in patient-orientated research, which are based on international regulations, including the Declaration of Helsinki. All patients consented to the use of their data for scientific research.

The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper, and its final contents.

Definition and methodology

IF were defined as any radiological abnormality not related to the illness or causes that prompted the diagnostic imaging test. IF were stratified according to clinical importance as being either minor (eg, cysts or osteoarthritis), moderate (eg, pulmonary nodules or adrenal adenomas), or major (eg, aneurysms, lymphadenopathy according to a recently proposed classification described by Lumbreras et al[8]). In case multiple IF were found, the patient was categorized in highest-ranked cohort (major > moderate > minor) for further analysis. The impact of the presence of moderate or major IF on outcome 1-year mortality was based on the cohort of 789 of 916 patients that either underwent the procedure or were deferred because of the presence of IF, excluding the 127 patients that did not undergo the intended procedure because of non–IF-related issues (frailty, vascular access site issues, etc).

Data extraction and follow-up

Data on IF were acquired by evaluating radiologic findings from preprocedural CT or MRI by specialized (cardiovascular) radiologists.

Patients were evaluated with CT prior to TAVI to achieve appropriate valve sizing and to evaluate the best access pathway before the procedure. The scan protocol was made up of 3 scans on a second- or third-generation dual-source CT scanner (Siemens Healthineers, Forchheim, Germany) for the analysis of the peripheral access (from the extracranial carotids up to the femoral bifurcation) and aortic valve assessment. The valve sizing scan was reconstructed at 0.75-mm slice thickness and 0.4-mm increment at every 5% of the RR interval of the available data. Peripheral artery access was analyzed on 1-mm slices with 0.5-mm increment data.

Patients were evaluated with CT prior to MitraClip when echocardiographic findings were in question; a diagnostic CT angiography scan was performed of the aorta, heart, and proximal peripheral access vessels on a dual-source CT scanner (Siemens Healthineers, Forchheim, Germany). The scan was performed in dual-source flash mode to obtain maximum temporal resolution and thereby minimize motion artifacts of the heart. Scan timing was set to 8 seconds after contrast arrival in the ascending aorta and the systolic phase of the RR interval. Evaluation was performed on data which were reconstructed at ≤0.75-mm slices with 30%-50% slice overlap.

Preprocedural imaging for RDN includes an abdominal (including arterial phase) CT or MR to confirm anatomical suitability and as a part of an evaluation for secondary causes of hypertension. The MR scan protocol prior RDN was performed on a 1.5-T scanner (Discovery MR450; GE Medical systems, Milwaukee, WI). A 3D vascular fast time of flight (TOF) spoiled gradient echo sequence was used to acquire images of the renal vasculature. To determine the arterial scan delay for the contrast-enhanced MR angiography (CEMRA) scan, a test bolus sequence was acquired. Images were acquired during a 20-second breath hold, depending on the number of slices per slab. An MR compatible contrast injector (Medrad Spectris, Warrendale, PA) was used to inject gadobutrol (Gadovist 1.0 mmol/mL; Bayer, Mijdrecht, the Netherlands).

In case of an abdominal CT for RDN, a standard diagnostic abdominal CT angiography was performed on a multislice CT scanner of minimal 128 slices (Somatom AS+, Edge, Drive or Force; Siemens Healthineers, Forchheim, Germany). The scan covered the diaphragm trough lesser trochanters. Evaluation was performed on data which were reconstructed at ≤0.6-mm slices with 30%-50% slice overlap.

Baseline characteristics of all patients were obtained from local procedural databases and additional medical record review in case of missing data. Survival information was obtained through medical record review and contact with the municipal civil registries. Median follow-up period postprocedure was 424 days (131-830).

Funding

No extramural funding was used to support this work.

Statistical analysis

Continuous variables are presented as mean ± standard deviation. Categorical variables are expressed as percentages. Continuous variables were compared using Student *t* test or 1-way analysis of variance in patients with versus without IF. Comparisons among the 3 groups (major, moderate, minor) were performed by the F test from an analysis of variance for continuous variables and Pearson χ^2 test for categorical variables. All statistical tests are 2-tailed. The incidence of mortality over time was studied with the use of the Kaplan-Meier method, whereas log-rank tests were applied to evaluate differences between the groups. Patients lost to follow-up were considered at risk until the date of last contact, at which point they were censored. Cox proportional-hazards regression analyses were applied to adjust for potential confounders. Baseline variables with $P < .10$ in univariate analyses were entered in a multivariable Cox proportional-hazards models. Final results are presented as adjusted hazard ratios with 95% CI. Variables with $P < .05$ were considered as statistically significant. Statistical analyses were performed using SPSS (version 21.0).

Results

Prevalence and types of IF

Mean age of the total population was 78 ± 10 years, 53.8% of the patients were male, and 18.4% had a history of neoplasms. IF were found in 395 of the 916 patients (43.1%). No relevant differences were observed in the baseline characteristics of patients with versus without IF on preprocedural imaging (Table I).

The total number of IF was 698, resulting in an average of 1.8 IF per patient with IF in the overall cohort. The number of IF per patient varied from 1.8 (range 1-5) in the TAVI cohort to 1.4 IF per patient in the RDN (range 1-3) and to 1.3 IF per patient in the MitraClip (range 1-2) cohort, respectively.

The 3 most frequent IF were renal cysts, pulmonary nodules, and pulmonary consolidations in 16.3%, 13.3%, and 6.6% of the patients with IF, respectively (Table II). Classifying the IF resulted in 155 patients (16.9%) with minor findings, 171 (18.7%) with moderate findings, and 69 patients (7.5%) with major IF. No significant differences in baseline characteristics were found between patients identified with either class of IF (Supplement,

Table I. Baseline characteristics of the total study population

	All patients	Patients with IF	Patients without IF	*P* value
	N = 916	n = 395	n = 521	(with vs without)
Age, y	78 ± 10	78 ± 10	77 ± 11	.13
Male, n (%)	493 (53.8)	216 (54.7)	277 (53.2)	.65
BMI, kg/m^2	27.4 ± 8.1	27.6 ± 10.8	27.2 ± 5.2	.53
CV risk factors, n (%)				
Diabetes	268 (29.3)	118 (29.9)	150 (28.8)	.92
Hypertension	701 (76.5)	290 (73.4)	411 (78.9)	.13
Dyslipidemia	553 (60.4)	232 (58.7)	321 (61.6)	.64
Smoker, current	73 (8.0)	27 (6.8)	46 (8.8)	.04
Prior MI, n (%)	209 (22.8)	82 (20.8)	127 (24.4)	.17
Prior PCI, n (%)	304 (33.2)	115 (29.1)	189 (36.3)	.04
Prior CVA, n (%)	93 (10.2)	42 (10.6)	51 (9.8)	.24
eGFR, mL/min	52 ± 26	52 ± 28	52 ± 25	.99
COPD	192 (21.0)	80 (20.3)	112 (21.5)	.23
Neoplasm in history, n (%)	168 (18.4)	76 (19.3)	92 (17.7)	.61
Breast cancer	29 (3.2)	12 (3.0)	17 (3.3)	
Colorectal cancer	25 (2.7)	12 (3.0)	13 (2.5)	
Prostate cancer	23 (2.5)	11 (2.8)	12 (2.3)	
Skin cancer	20 (2.2)	10 (2.5)	10 (1.9)	
Non-Hodgkin lymphoma	12 (1.3)	6 (1.5)	6 (1.2)	
Hodgkin lymphoma	8 (0.9)	6 (1.5)	11 (2.1)	
Bladder cancer	11 (1.2)	–	6 (1.2)	
Lung cancer	10 (1.1)	4 (1.0)	4 (0.8)	
Gynecological cancer	8 (0.9)	4 (1.0)	2 (0.4)	
Laryngeal cancer	5 (0.5)	2 (0.5)	3 (0.6)	
Leukemia	4 (0.4)	3 (0.8)	1 (0.2)	
Neuroendocrine cancer	4 (0.4)	1 (0.3)	3 (0.6)	
Multiple myeloma	3 (0.3)	2 (0.5)	1 (0.2)	
Esophageal cancer	2 (0.2)	2 (0.5)	–	
RCC	2 (0.2)	2 (0.5)	–	
Vestibular Schwannoma	2 (0.2)	–	2 (0.4)	

Values are mean ± SD or n (%). *BMI*, body mass index; *CV*, cardiovascular; *MI*, myocardial infarction; *PCI*, percutaneous coronary intervention; *CVA*, cerebrovascular accident; *eGFR*, estimated glomerular filtration rate; *RCC*, renal cell carcinoma.

Table SI). The total number of moderate or major IF was 476, resulting in an average of 2.0 IF per patient with moderate or major IF (range 1-5). The number of moderate or major IF per patient varied from 2.0 (range 1-5) in the TAVI cohort to 1.7 IF per patient in the RDN (range 1-3) and to 1.3 IF per patient in the MitraClip (range 1-2) cohort, respectively.

In the 395 patients with IF, active malignancies were found in 15 cases (3.8%). Malignancies included lung carcinoma (n = 8), breast cancer (n = 3), bladder cancer (n = 1), renal carcinoma (n = 1), non-Hodgkin lymphoma (n = 1), and multiple myeloma (n = 1). In patients with a history of neoplasms (n = 168), IF were present in 76 cases (45%) and proved to be malignant in 7 cases (4.2%).

Consequences

A total of 142 patients of the initially screened cohort of 916 patients eventually did not undergo the procedure for which they were initially referred (Figure 1).

Procedures were delayed (n = 7) or canceled (n = 8) in 15 of 916 cases (1.6%) because of the presence of IF (breast cancer, lymphoma, renal cell carcinoma, lung cancer, bladder cancer). Mean delay was 130 ± 120 days. Procedures did not take place in the remaining cases because of either a variety of non–IF-related issues (comorbidity, vascular access issues, renal anatomy not compatible for current intravascular treatment options for RDN, nonsevere valvular heart disease) or death while waiting for the intended procedure.

Impact on mortality

Unadjusted cumulative 1-year mortality was comparable in patients (n = 789) with versus those without IF (14.9% vs 16.1%; log-rank P = .82). Unadjusted cumulative 1-year mortality rates were 14.8% in patients with no or minor IF and 18.5% in patients with moderate or major IF (P = .25).

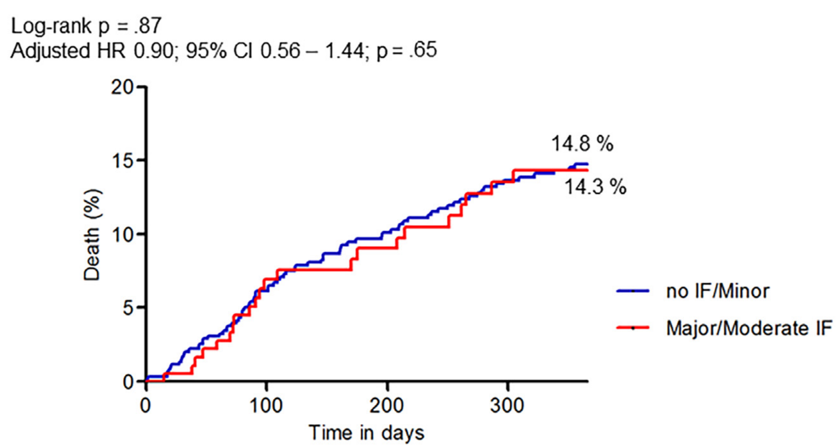
In patients that eventually underwent the procedure (n = 774), 1-year mortality rates were identical in patients with versus without moderate or major IF (14.3% vs. 14.8%, respectively; log-rank P = .87; adjusted HR 0.90; 95% CI 0.56-1.44; P = .65) (Figure 2). Renal insufficiency

Table II. Specification of IF per category (n = 698)

Organ system	Major (90)	Moderate (287)	Minor (321)
Head-chest	Laryngeal mass (2)	Thyroid IF (39)	
Vascular	Aortic aneurysm (22)	Abdominal aortic ectasia (2)	Renal artery stenosis (31)
		Hepatic hemangioma (16)	FMD (3)
			MVD (24)
			Carotid disease (29)
Reticuloendothelial	Lymphadenopathy (43)	Splenomegaly (1)	Splenic cyst (2)
Thoracic cavity	Pulmonary mass (7)	Pulmonary nodules (93)	Pleural plaques (32)
	Pulmonary embolism (2)	Pulmonary consolidation (46)	
Hepatobiliary		Pancreatitis (2)	Cholelithiasis (26)
		Pancreatic calcification (1)	Pancreatic cyst (6)
		Liver cirrhosis (2)	Hepatic steatosis (7)
			Liver cyst (40)
Peritoneal cavity	Renal mass (9)	Adrenal adenoma (15)	Renal cyst (114)
	Pelvic mass (3)	Adrenal mass (benign) (23)	Adrenal cyst (1)
Gastrointestinal tract		Diverticulosis (44)	
Gynecological	Breast mass (2)	Uterine enlargement (3)	Ovarian cyst (4)
			Breast cyst (2)

FMD, fibromuscular disease; *MVD*, mesenteric vascular disease.

Figure 2



Number at risk

No IF/ Minor	589	499	438	398
Major/ Moderate IF	183	147	124	110

Cumulative 1-year mortality in patients that underwent the intended procedure (n = 774) stratified according to the presence of a moderate or major IF.

and chronic obstructive pulmonary disease (COPD) at baseline appeared to be the sole independent predictors of 1-year mortality (Table III). Finally, also the total number of moderate or major IF was not a predictor for 1-year mortality (adjusted HR 0.91; 95% CI 0.73-1.14; *P* = .41).

In the cohort of patients that did not undergo the intended procedure (n = 142), 1-year mortality rates were numerically higher in the cohort with moderate or major IF (57.9%) versus the cohort with no or minor IF (31.1%) (adjusted HR 1.51; 95% CI 0.81-2.82; *P* = .20) (Figure 3). Renal insufficiency appeared to be the sole independent predictor of 1-year mortality (Table IV). Also in this cohort, the total number of moderate or major IF was not a predictor for 1-year mortality (adjusted HR 1.14; 95% CI 0.89-1.46; *P* = .29).

In patients in whom the intended procedure was delayed or canceled because of the presence of IF

Table III. Multivariate predictors of 1-year mortality in patients who underwent the intended procedure (n = 774)

	Unadjusted HR	Adjusted HR
Variable	HR (95% CI; *P* value)	HR (95% CI; *P* value)
Age	1.00 (0.98-1.02; .93)	
Female sex	0.89 (0.60-1.33; .57)	
Hypertension	0.72 (0.46-1.13; .15)	
Diabetes mellitus	1.28 (0.85-1.93; .24)	
Dyslipidemia	0.68 (0.46-1.00; .05)	0.69 (0.46-1.02; .06)
Smoking	1.00 (1.00-1.01; .30)	
Prior PCI	0.85 (0.56-1.30; .45)	
Prior MI	1.36 (0.89-2.06; .16)	
Prior CVA	1.46 (0.85-2.49; .17)	
COPD	1.67 (1.12-2.48; .01)	1.58 (1.06-2.35; .023)
Malignancy in history	0.95 (0.67-1.38; .79)	
Renal insufficiency	1.73 (1.06-2.83; .03)	1.65 (1.01-2.70; .046)
Moderate-major IF	0.96 (0.60-1.54; .87)	0.90 (0.56-1.44; .65)

(n = 15), 14 died within 1 year. Ten patients (67%) died because of a malignancy underlying their IF, whereas 4 patients died because of their initial cardiac condition while waiting for additional analyses of the IF.

Sensitivity analyses in the cohort of patients that underwent TAVI revealed similar findings, with an adjusted 1-year mortality rate for the presence of moderate or major IF of 1.37 (95% CI 0.96-1.96; *P* = .09). Renal insufficiency was the only independent predictor of 1-year mortality (adjusted HR 1.76, 95% CI 1.12-2.81; *P* = .02) (Supplement, Table SII). A subanalysis in the cohort of patients that underwent RDN or MitraClip showed also that the presence of a moderate or major IF was not a predictor for 1-year mortality (adjusted HR 0.98; 95% CI 0.11-8.13; *P* = .98).

Additionally, the total number of moderate or major IF did not impact 1-year mortality in patients that underwent TAVI (adjusted HR 1.04; 95% CI 0.81-1.34; *P* = .75).

Discussion

In this large-scale retrospective single-center registry, we demonstrate that IF are frequently detected in patients screened for TAVI, RDN, or MitraClip implantation. In 43.1% of the patients referred, noncardiac IF were found. Although the majority of the total number of IF were minor, the presence of moderate or major IF resulted in a delay or cancellation of the intended procedure in only a fraction of the patients and did not significantly impact 1-year mortality.

Preprocedural screening can identify an asymptomatic disease, a risk factor, or a harmful disease such as a malignancy.[4,11,12] The present study demonstrates that a broad spectrum of IF can be found in patients referred for percutaneous cardiovascular interventions. Of the 698 IF found in a total of 395 patients with IF, 39.2% of the patients were diagnosed only with a finding of minor clinical relevance, mostly determined by the presence of renal cysts (114/698). Although this is in line with previous studies showing that most of the IF are believed to be benign, it could explain the lack of a correlation between the presence of an IF per se and outcome in previous studies.[2,7,11,13,14]

To the best of our knowledge, the present study is the first to assess whether IF stratified according to clinical relevance could predict 1-year mortality. To stratify the IF, we used a classification into 3 categories: minor, moderate, or major, as previously described by Lumbreras et al.[8] In their systematic review comprising 44 studies, the authors reported a mean IF frequency of 23.6%. Follow-up was initiated in only 64.5%, and with a lack of specific outcome data in the vast majority of the cases, the authors concluded that the optimal management strategy for these findings remains elusive.

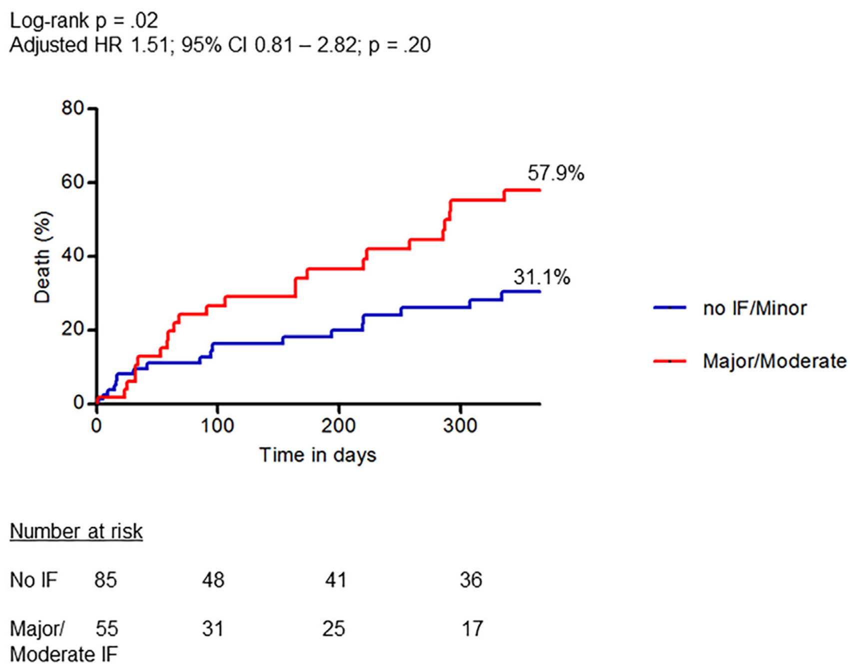
The present study demonstrates that the presence of a moderate or major IF did not significantly impact 1-year mortality rates in patients undergoing TAVI, RDN, or MitraClip implantation. This finding was consistent among the individual subgroups of TAVI, RDN, or MitraClip. Instead, renal insufficiency and COPD at baseline appeared to be the sole independent predictors for 1-year mortality.

Previous work by Orme et al concluded that a higher number of potentially pathological IF per patient might impact 2-year mortality in 424 patients screened for TAVI.[15] In the subgroup of patients from our study that were screened for TAVI (n = 782), we were not able to confirm that the number of moderate or major IF per patient significantly predicts 1-year mortality. This discrepancy might be explained by the exceptionally high number of IF detected in the work by Orme et al. The authors reported an average of at least 5.3 IF per patient as compared to 1.8 in the present study, 0.3 in a large registry by Koonce et al, and 0.4 in previous work specifically focusing on TAVI patients.[2,6]

Untreated symptomatic severe aortic stenosis has been associated with 1-year mortality rates of up to 50%.[16] In patients that actually underwent the intended procedure in the present study, survival curves in patients with moderate or major IF as compared to those with minor or no IF were superimposed.

Additional analyses in patients that did not undergo the intended procedure revealed an increased crude mortality rate when moderate of major IF were present. The mortality difference in this subset appeared to be explained by the fact that 14 of 15 patients with moderate or major IF died, 10 because of the consequences of the IF; however, 4 patients died because of their underlying cardiac condition for which the treatment was delayed for IF screening purposes. Although the latter is in agreement with recent guidelines for valvular heart disease in which TAVI is only indicated in patients with a life expectancy of at least 1 year, it also illustrates that delaying a potentially lifesaving cardiovascular intervention could have important clinical implications.[9]

Figure 3



Cumulative 1-year mortality in patients that did not undergo the intended procedure (n = 142) stratified according to the presence of a moderate or major IF.

Table IV. Multivariate predictors of 1-year mortality in patients who did not undergo the intended procedure (n = 142)

	Unadjusted HR	Adjusted HR
Variable	HR (95% CI; *P* value)	HR (95% CI; *P* value)
Age	1.05 (1.02-1.08; <.01)	1.02 (0.98-1.06; .29)
Female sex	1.35 (0.74-2.46; .33)	
Hypertension	0.86 (0.46-1.61; .64)	
Diabetes mellitus	1.65 (0.91-3.02; .10)	
Dyslipidemia	1.63 (0.88-3.02; .10)	
Smoking	1.01 (1.00-1.01; .08)	1.00 (1.00-1.01; .23)
Prior PCI	0.98 (0.52-1.84; .94)	
Prior MI	0.81 (0.44-1.51; .51)	
Prior CVA	1.40 (0.52-3.76; .51)	
COPD	0.85 (0.38-1.89; .68)	
Malignancy in history	1.00 (0.94-1.07; .98)	
Renal insufficiency	5.40 (1.93-15.1; <.01)	3.62 (1.16-11.3; .03)
Moderate-major IF	2.02 (1.11-3.70; .02)	1.51 (0.81-2.82; .20)

Nevertheless, despite the high number of total IF, the intended procedures were delayed or canceled in only a fraction of the patients (15/916) because of the presence of active malignancies deserving further attention in a study cohort in which the average age was 78 years. Although these numbers might appear trivial, a total of 698 IF were found in the present study comprising 916 patients. Unfortunately, we do not have specific details on the screening process of patients referred for additional diagnosis. Nevertheless, it is likely that the presence of IF might have caused a significant clinical and economic burden to both patient and health care parties.

Currently, there is a broad variety in the quality of international guidelines for follow-up of specific IF. Some are clear from a radiological perspective, whereas others need extensive clinical data which are usual not readily available to radiologist or even local operator. The latter leads to extensive heterogeneity in how these recommendations are being followed up in clinical practice. Lee et al described that only in one-third of the patients in which IF were found did radiologists recommend further follow-up.[17] In the vast majority of radiology reports in patients with IF, explicit follow-up recommendations are lacking. On the other hand, the same study reports that, frequently, in case follow-up recommendations were explicitly reported, clinical and imaging follow-up was not performed. Although precise reporting by radiologists is essential, we should realize that previous imaging data from patients referred for TAVI, RDN, or MitraClip in tertiary referral centers are usually not readily available, complicating validated follow-up recommendations. Finally, radiologists are frequently not part of multidisciplinary teams involved in decision making regarding high-risk cardiovascular procedures.[18]

Finally, the total number of IF will only increase along with the improving image quality of current-generation

CT or MRI scanners. With the exception of clear active malignancies, there seems currently no reason to delay or cancel potential lifesaving procedures as TAVI based on the presence of IF. Furthermore, with a prevalence of 43.1% of non–clinically evident radiological findings, there is need for larger prospective studies focusing on the sense and nonsense of follow-up of a broad spectrum of these findings, allowing the development of practical guidelines helping physicians in deciding whether or not to refer a patient for additional screening. Until then, it remains important that, in case of IF, a follow-up plan should be made along with a decision as to whether or not the intended procedure should be delayed. Based on the data presented above, the presence of a moderate or major IF did not impact 1-year mortality.

Limitations

The present study has several limitations. First, detailed data on the percentage of patients with IF that did undergo additional tests are unknown, precluding any statements on their potential clinical and economic consequences. This limitation was inherent to the nature of our institution, being a tertiary referral site for the previously mentioned procedures. Dedicated follow-up for IF was left to the discretion of the referring physician. Second, we might have underestimated the actual incidence of IF because of a lack of structural reporting and the use of different scan protocols associated with the different imaging modalities used. Third, the classification of IF in 3 categories remains disputable and has not been considered a strict rule to stratify these abnormalities. Moderate IF such as adrenal adenomas or breast nodules might become major clinical problems in cases associated with an active malignancy. In the present study, however, the prevalence of active malignancies was only 1.6%, suggesting that, in the vast majority of cases, IF were benign. Besides these known limitations, we were the first to assess whether classification of IF into these 3 categories resulted in different 1-year mortality rates, potentially justifying a differential screening approach to those with moderate of major IF.

Conclusion

IF are frequent in patients referred for percutaneous cardiovascular procedures. IF did not result in a delay or cancellation of the intended procedure in the vast majority of the cases, irrespective of their severity. The presence of a major or moderate IF did not significantly impact 1-year mortality in patients referred for TAVI, RDN, or MitraClip implantation.

Impact on daily practice

The total number of IF detected on current generation CT or MRI scanners will increase because of improving image quality. The strongest predictor for prognosis in patients as described in this study remains whether or not they undergo the procedure for which they are initially referred. There is need for larger prospective studies focusing on the sense and nonsense of follow-up of a broad spectrum of these findings, allowing the development of practical guidelines helping physicians in deciding whether or not to refer a patient for additional screening.

Declarations of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ahj.2018.06.015.

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