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# Prevalence and Clinical Relevance of Extracardiac Findings on Preprocedural Computed Tomography Angiography for Catheter Ablation of Atrial Fibrillation

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## Abstract

**Objectives:** Atrial fibrillation (AF), a common cardiac arrhythmia with significant stroke risk, is expected to increase in prevalence with an ageing population. Cardiac computed tomography angiography (CCTA) is a non-invasive imaging modality that provides detailed cardiac and extracardiac anatomical information, particularly relevant for preprocedural assessment of AF catheter ablation. This study aimed to determine the prevalence of extracardiac findings (ECFs) during CCTA performed prior to AF catheter ablation.

**Materials and Methods:** This retrospective single-center study reviewed data from 163 patients with AF who underwent catheter ablation between January 2021 and January 2022. Among the 163 patients, 140 (85.88%) underwent preprocedural CCTA. ECFs were defined as newly detected findings necessitating follow-up, diagnostic workup, or therapeutic measures, excluding known abnormalities and clinically nonsignificant findings.

**Results:** Out of the 140 patients who underwent CCTA, 50 patients (35.7%) had 52 incidental ECF. Pulmonary findings were the most common, including pulmonary nodules (>6 mm) in 20 patients (14.2%), pulmonary infiltrates in 8 patients (5.71%), and a pulmonary mass in 1 patient (0.71%). Other significant findings included aortic aneurysms in 3 patients (2.13%), enlarged mediastinal lymph nodes in 8 patients (5.71%), abdominal mass in 1 patient (0.71%), and unclear liver lesions in 5 patients (3.55%). Two incidental findings led to the postponement of the AF catheter ablation procedure.

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**Conclusion:** Pre-procedural CCTA serves as a valuable opportunistic screening tool, identifying significant ECF in over one-third of patients. These findings underscore the importance of multidisciplinary collaboration between cardiology and radiology to optimize comprehensive patient management in these workflows.

**Keywords:** Extracardiac findings, incidental, computed tomography, atrial fibrillation

## Introduction

Atrial fibrillation (AF) is one of the most common cardiac arrhythmias with serious consequences, including stroke[1]. The incidence is expected to increase in parallel with population ageing[2].

Cardiac computed tomography angiography (CCTA) is a rapidly advancing non-invasive imaging modality that facilitates preprocedural imaging for AF ablation[3]. It can visualize any thrombus in the heart chambers and produce a highly detailed 3-dimensional (3D) image of the heart, providing an in-depth view of the cardiac chambers and vessels[4]. Early studies suggested that integrating computed tomography (CT) images into 3D mapping systems could reduce ablation time and radiation exposure[5,6]. Recent studies, following advancements in electro-anatomical mapping (EAM)[7] and the emergence of "zero-fluoroscopy" techniques[8], have led to a re-evaluation of the necessity of routine pre-procedural CT for this purpose. However, recent studies show that cardiac CT remains widely used. In a Europe-wide survey, 44% of electrophysiologists reported routinely performing preprocedural CT, and one-third of these reported integrating it with EAM[9].

Pre-procedural CCTA can also provide diagnostic information about non-cardiac organs and contribute to the procedure, depending on the field of view (FOV) used. CCTA has been reported to reveal incidental ECFs in 23.8-72% of cases[10-17]. Although most extracardiac findings (ECFs) are benign, reports have highlighted pathologically significant findings in 4.2%-38% of cases[13-16,18].

This study aimed to determine, based on one year of experience at our institute, the clinical characteristics and prevalence of ECFs identified on CCTA performed before atrial fibrillation catheter ablation (AFCA).

## Materials and Methods

The study employed a retrospective, single-center design. All data were collected, managed, and analyzed at the Heart Rhythm Center and the Radiology Department of Dokuz Eylul University. This study reviewed 163 patients who underwent AFCA between January 2021 and January 2022 and who were referred for preprocedural CT.

The study protocol was approved by the Institutional Ethics Committee and conformed to the tenets of the Declaration of Helsinki. This study included data from the identified medical records. All patients who underwent AFCA were included in this study. Exclusion criteria included patients with previous AFCA and previously known abnormalities on computed tomography angiography (CTA); CTA data were analyzed for all cardiac CTAs performed, and all incidental findings were identified. The CCTA images were independently reviewed at Dokuz Eylul University by an experienced radiologist (M.M.B., 10 years of experience in cardiac imaging) and an experienced cardiologist (R.Y.Y., 4 years of experience in preprocedural imaging of AF). The interpreters were blinded to the patients' clinical outcomes and procedural details of the AFCA to minimize bias

A total of 163 patients who underwent catheter ablation for AF were retrospectively reviewed. CTA was performed in 140 patients (85.88%). The two main reasons for not performing CTA were glomerular filtration rate <50 and patient refusal; these affected 23 patients.

### Computed Tomography Angiography Protocol

Cardiac CT scans were performed on a 64-slice scanner with prospective electrocardiogram-triggered axial acquisition mode, with current adjusted according to patient characteristics. To control heart rate, metoprolol

was administered orally (100 mg) and, if necessary, intravenously (5-10 mg). Iomeprol contrast was used, with a maximum volume of 100 mL at a flow rate of 4.5-5.5 mL via antecubital venous access using an 18-gauge catheter. Bolus tracking in the left atrial (LA) was used to ensure accurate scan timing.

### Definition of Extracardiac Findings

ECF was defined as any newly detected ECF necessitating follow-up, diagnostic workup and/or therapeutic measures. Known extracardiac abnormalities were not considered ECFs. The official clinical CCTA report was reviewed for any described abnormal extracardiac structures, excluding cardiac-related findings, clinically nonsignificant nodules (<5 mm), atelectasis, and degenerative bone abnormalities. These findings were divided into three anatomical sections based on their localization (thorax, upper abdomen, vascular).

ECFs are defined as pulmonary parenchymal abnormalities, pleural effusion, mediastinal lymph node enlargement, and aortic dilatation. Aortic dilatation is defined as an inner-edge-to-outer-edge diameter of the ascending aorta exceeding 40 mm. Mediastinal lymph node enlargement is defined as a lymph node diameter greater than 10 mm or as lymph nodes requiring follow-up. If an abdominal finding requires follow-up or treatment, it is defined as an ECF (Figure 1). This classification is based on Sohns et al.[14].

### Statistical Analysis

Data are presented as counts and percentages for categorical variables and as medians (interquartile ranges) or means ± standard deviations for continuous variables. Chi-square and Fisher's exact tests were used to compare the categorical variables. As appropriate, continuous variables between groups were analyzed using the student's t-test or the Mann-Whitney U test. Statistical significance was set at $p<0.05$. Statistical analysis was performed using the SPSS 26.0 software package (SPSS Inc., Chicago, IL).

## Results

A total of 140 consecutive patients (mean age 62±10 years; 59% male) were included in the CTA (+) group. The mean CHA2DS2-VASc score was 2.3±1.4. The prevalence of tobacco use was 37%. A total of 52 ECFs were observed. Demographic and clinical characteristics were summarized (Table 1).

A total of 52 ECFs in the chest and upper abdomen were identified in 50 patients. Two patients each had two incidental findings identified simultaneously. Pulmonary findings were the most common, observed in 31 patients (22.1% of the cohort), and included pulmonary nodules (>6 mm) in 20 patients (14.9%), pleural effusion in 2 patients, pulmonary infiltrates in 8 patients (5.7%), and a pulmonary mass in 1 patient (0.7%). Other significant findings included aortic aneurysms in 3 patients (2.1%), enlarged mediastinal lymph nodes in 8 patients (5.7%), abdominal masses in 1 patient (0.7%), and unclear liver lesions in 5 patients (3.6%). Detailed incidental findings are summarized in Table 2.

Two of these incidental findings led to the procedure being postponed. One patient was diagnosed early with asymptomatic lung cancer, and another patient had pneumonia requiring antibiotic therapy. Patients with pulmonary nodules >6 mm and enlarged mediastinal lymph nodes (10 mm) were recommended for follow-up. One patient with a 40-mm ascending aortic aneurysm was recommended for echocardiographic follow-up. Some of these patients are summarized in Figure 2.

## Discussion

In this retrospective study, the prevalence of incidental ECFs during pre-procedural CCTA was 35.7% (50 patients). While the primary clinical objective of CCTA is to delineate LA geometry and pulmonary vein (PV) anatomy, our results show that over one-third of patients have ECFs that may necessitate follow-up or clinical management. Notably, in 1.4% of our cohort, these findings led to the postponement of the AFCA (Figure 3).

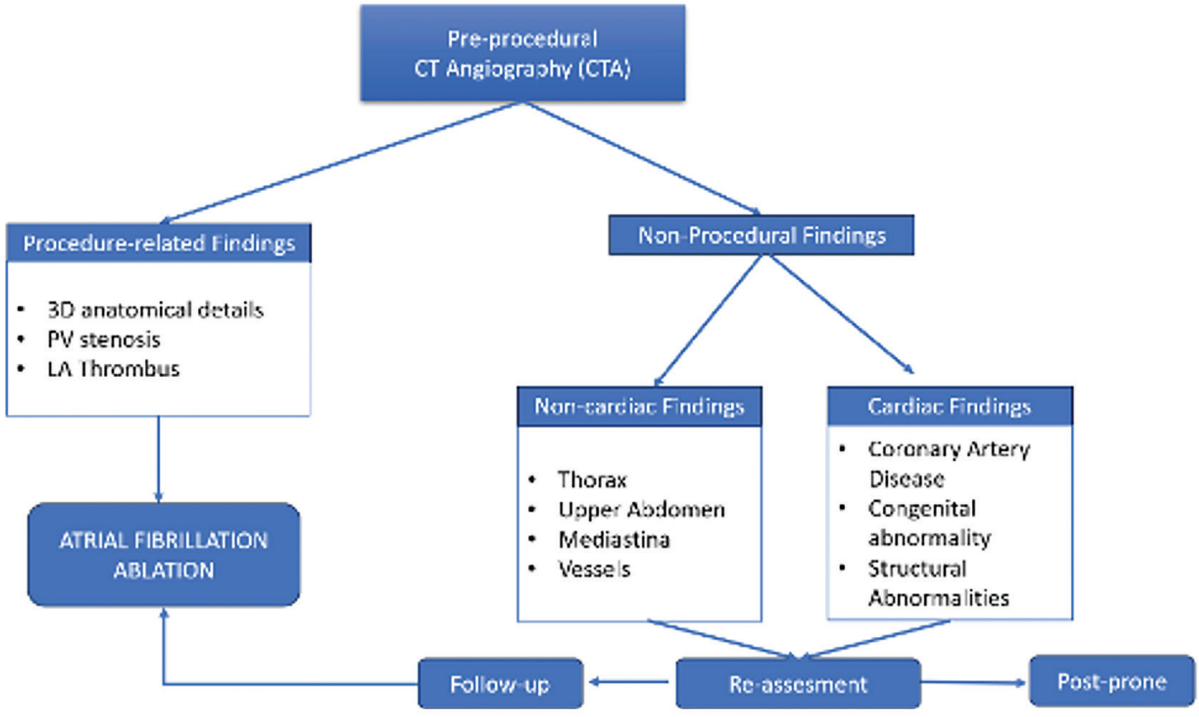



**Figure 1.** Schematic visualization of the management of preprocedural computed tomography angiography findings undergoing atrial fibrillation ablation
*CT: Computed tomography, CTA: Computed tomography angiography, 3D: 3-dimensional, PV: Pulmonary vein, LA: Left atrium*

Several studies have shown that cardiac imaging performed before AFCA frequently identifies incidental cardiac or ECFs. The prevalence of incidental findings on CT scans reported in previous studies varies widely due to differences in FOV and definitions. Schietinger et al.[12] identified ECFs in 69% of the 149 patients undergoing pre-procedural multidetector CT, with pulmonary nodules being the most frequent abnormality detected. Wissner et al.[10] observed unexpected findings in 53% of the 95 patients. Sohns et al.[14] studied 158 patients and screened only for extracardiac incidental findings, finding that 72% had such findings. At least one clinically or potentially significant finding was present in 31% of patients. The most common significant abnormalities included mediastinal lymph node enlargement and degenerative spinal disease; lung cancer was histologically confirmed in two patients. Martins et al.[16] reported an incidental finding prevalence of 23.2% in their cohort of 250 patients, noting that patients with findings were significantly older than those without. Pulmonary abnormalities accounted for 50% of the findings, and the identification of two lung cancers directly altered patient management, leading to cancellation of the ablation procedure[16]. Hamed et al.[13] also reported only incidental findings, including cardiovascular diseases such as coronary artery disease (CAD), incomplete cor triatriatum, and pericardial effusion. They found incidental findings in 23.8% of 218 patients undergoing CTA for AF ablation. Casella et al.[17] reported that among 173 patients undergoing AF ablation, 56% had collateral findings on chest CT scans, of which 28% were clinically significant, Simon et al.[15] conducted the largest study to date, involving 1,952 patients, and identified incidental ECFs in 42.0% of the cohort, of which 21.3% were categorized as clinically significant.

Lung masses and nodules were the most common ECFs in our study and in other studies. Our study included only

**Table 1.** Demographical and clinical characteristics of groups

| | All patient (+) n=140 | ECF (+) n=50 | ECF (-) n=90 | p-value |
|---|---|---|---|---|
| Age | 56.5±10.6 | 56.6±10.3 | 56.5±9.5 | 0.7 |
| Gender (male) | 77 (55%) | 25 (50%) | 52 (57.8%) | 0.2 |
| HT | 56 (40%) | 18 (36%) | 38 (42.2%) | 0.47 |
| DM | 22 (15.7%) | 9 (18%) | 13 (14.4%) | 0.58 |
| CAD | 7 (5%) | 5 (10%) | 2 (2.2%) | **0.04** |
| Stroke | 5 (3.6) | 4 (8%) | 1 (1.1%) | **0.03** |
| Prior pulmonary disease | 16 (11.4%) | 7 (%14) | 9 (10%) | 0.4 |
| Smoking history | 70 (50%) | 31 (62%) | 39 (43%) | **<0.01** |
| LVEF (%) | 56.06±8.5 | 53.7±10.1 | 57.3±8.3 | **<0.01** |
| LA diameter (mm) | 41.86±5.8 | 44±5.0 | 40±5.4 | 0.79 |
| CHADS2VASc | 1.6±1.2 | 1.8±1.2 | 1.5±1.2 | 0.58 |
| RF ablation | 87 (62.1%) | 37 (74%) | 50 (55.6%) | **0.04** |
| Type of AF (paroxysmal AF) | 110 (78.6%) | 39 (78%) | 71 (78.9%) | 0.5 |

*All patients, extracardiac finding (ECF) positive group, ECF negative groups*
*AF: Atrial fibrillation, HT: Hypertension, DM: Diabetes mellitus, CAD: Coronary artery disease, CT: Computed tomography, LVEF: Left ventricular ejection fraction, RF: Radiofrequency, LA: Left atrium*

one patient newly diagnosed with lung cancer, consistent with previous research. The etiologies of lung nodules are wide-ranging and include both benign and malignant causes. In our study, 37% of patients were smokers, and lung parenchymal changes, such as consolidation and interstitial lung diseases, were the second most frequent findings. Notably, the prevalence of ECFs was more pronounced in patients with a high atherosclerotic burden, specifically those with a history of smoking, stroke, CAD, or a reduced left ventricular ejection fraction. This clinical profile is of particular importance as these comorbidities significantly impact both procedural success and long-term clinical outcomes following AF ablation. Specifically, Duğral et al.[19] demonstrated that smoking is a significant and independent predictor of arrhythmia recurrence after ablation therapy.

Incidental ECFs have several clinical implications. In our study, all clinical findings were clinically significant. In addition, 1.4% of the patient cohort requires postponement due to a clinical condition. Casella et al.[17] reported that

**Table 2.** The regional distribution and prevalence of incidental extracardiac (clinically significant or potentially significant) computed tomography findings in computed tomography angiography.

| Thorax | n | Prevalance |
|---|---|---|
| Nodule (>6 mm) | 20 | 14.2% |
| Mass-malignity | 1 | 0.7% |
| Parenchymal disease (bronchiectasis, infiltration) | 8 | 5.7% |
| Pleural effusion | 2 | 1.4% |
| Lymphatic node enlargement (>10 mm) | 8 | 5.7% |
| Mammarial mass | 1 | 0.7% |
| **Upper abdomen** | | |
| Liver nodules or mass | 4 | 3.5% |
| Gallbladder stone | 3 | 2.1% |
| Adrenal mass-incidentaloma | 1 | 0.7% |
| Kidney stone | 1 | 0.7% |
| **Vascular** | | |
| Ascendant aorta aneurism (40 mm<) | 1 | 0.7% |
| Mural thrombus | 1 | 0.7% |
| Median arcuate ligament syndrome | 1 | 0.7% |

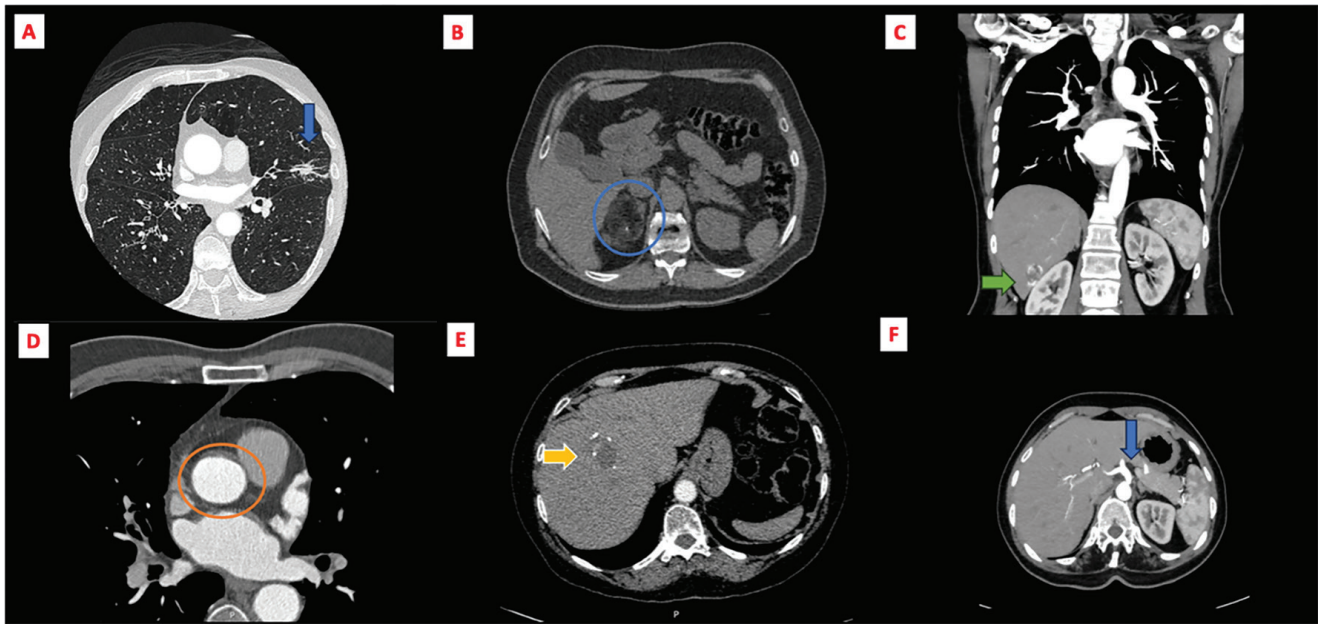



**Figure 2.** Examples of extracardiac findings detected during computed tomography angiography before atrial fibrillation ablation. A) Lung cancer (blue arrow) B) Surrenal adrenal myolipoma (blue circle) C) Hepatic cyst (green arrow) D) Mural thrombus in ascending aorta (orange circle) E) Hepatic cystic hydatid (yellow arrow) F) Coeliac arcuate ligament (blue arrow)

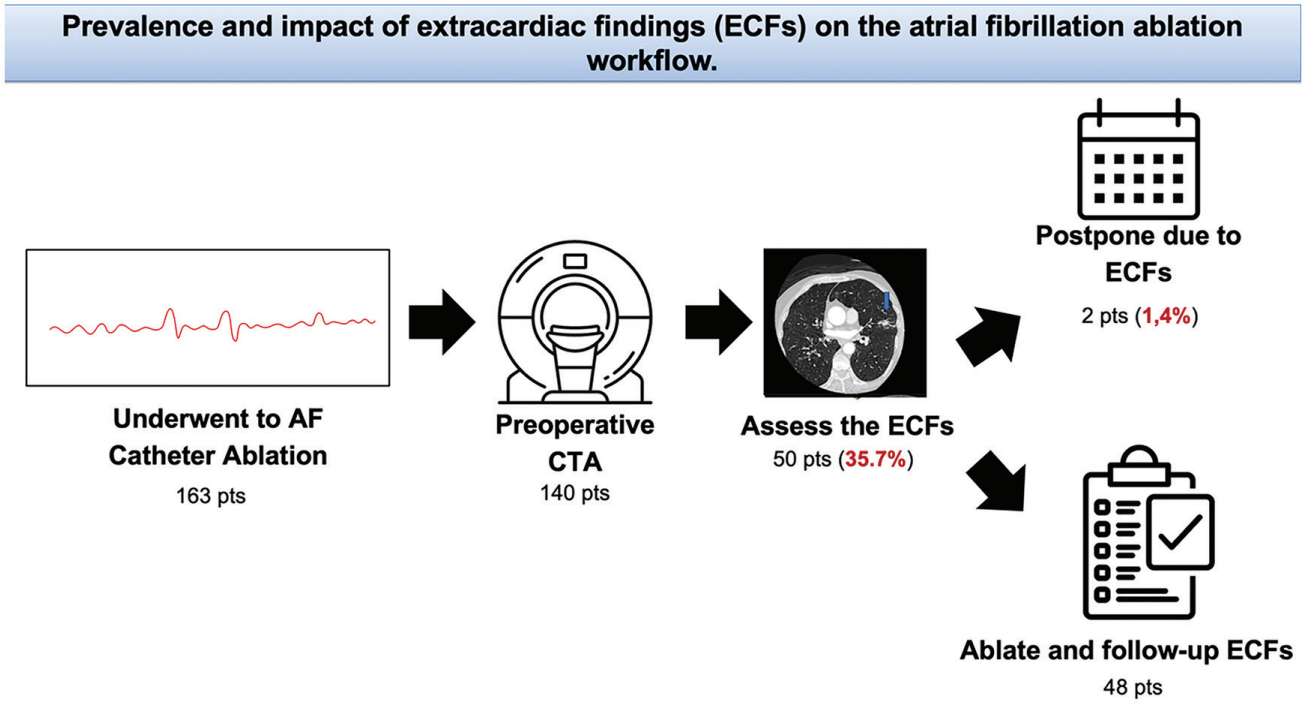



**Figure 3.** Prevalence and impact of extracardiac findings (ECFs) on the Atrial fibrillation ablation workflow. The diagram illustrates the screening of 140 patients via preoperative CTA. Although the majority of patients with ECFs (n=50) underwent the planned ablation and subsequent follow-up, 1.4% of the total cohort required postponement of the procedure because of clinically significant findings
*CTA: Computed tomography angiography*

**Table 3.** Previous studies about incidental findings or extracardiac findings detected cardiac computer tomography

| Study | Year | Sample size | IF/ECF | Malignancy rate | CT | Ref |
|---|---|---|---|---|---|---|
| Schietinger et al.[12] | 2008 | 149 | 69% (ECF) | 0% | 16-slice | 12 |
| Wissner et al.[10] | 2009 | 95 | 53% (IF) | 1.1% | 16-slice | 10 |
| Martins et al.[16] | 2011 | 250 | 23% (IF) | 0.8% | 64-slice | 16 |
| Sohns et al.[14] | 2011 | 158 | 72% (ECF) | 1.3% | 64-slice | 14 |
| Casella et al.[17] | 2012 | 173 | 56% (IF) | 1.7% | 64-slice | 17 |
| Hamed et al.[13] | 2022 | 218 | 28.8% (ECF) | 0.45% | NR | 13 |
| Simon et al.[15] | 2022 | 1.952 | 42.0% (ECF) | NR | 256-slice | 15 |
| Present study | 2026 | 140 | 35.7% (ECF) | 0.7% | 64-slice | * |

**: Refers to the present study*
*Incidental finding, an incidentally discovered mass or lesion, detected by imaging modalities (such as CT or MRI), which is not related to the primary objectives of the examination. These are also referred to as "collateral findings" or "incidentalomas."*
*Any unsuspected abnormality detected outside of the pericardium within the field of view (e.g., lungs, mediastinum, spine, or upper abdomen) during a cardiac imaging study*
*FOV: Field of view, IF: Incidental findings, ECF: Extracardiac finding, NR: Nothing reported, Ref: Reference, MRI: Magnetic resonance imaging, CT: Computed tomography*

10% of patients required treatment. In Simon et al.[15] multivariate logistic regression analysis, after adjusting for potential confounders such as hypertension, gender, and CAD, age (odds ratio: 1.04; 95% confidence interval: 1.02-1.06) emerged as the independent predictor of clinically significant ECFs Wissner et al.[10] report that ECFs led to additional diagnostic testing in 16% of the cohort and to a direct change in clinical management in 7%. Notably, their findings resulted in life-saving diagnoses, such as pulmonary embolism and lung cancer, and led to the postponement of ablation therapy in four patients. CTA may be a useful opportunistic screening technique for detecting previously unknown, clinically relevant diseases, especially lung cancer. AF cancer often coexist due to shared pathophysiological mechanisms, indicating comorbidity[20,21]. Previous literature on the prevalence of malignancies is summarized in Table 3. Beyond the cost-effectiveness of screening, radiation exposure is another primary concern of CCTA. Lee et al.[22] revealed incidental ECFs in 43% of patients, of which 52% were potentially clinically significant. Only 4% receive follow-up, with average additional costs of $17.42 per patient screened and $438.39 per patient with imaging follow-up. However, it remains uncertain whether the increased cost, radiation exposure, and invasive procedures associated with CTA will result in lower mortality rates or improved quality of life for patients[23,24]. Pre-procedural atrial imaging can define a patient's atrial anatomy, and studies suggest that integrating CT images with EAM may be beneficial. The development of the EAM system and the emergence of the zero-fluoro concept in the EP lab led to the avoidance of CT imaging before AFib ablation procedures. Di Cori et al.[7] found that preprocedural CT did not improve procedural duration or fluoroscopy time, but was associated with increased radiation exposure.

While electrophysiologists primarily utilize these images for anatomical road-mapping of the left atrium and PV, or to exclude LAA thrombus, the CT-irradiated FOV contains vital extracardiac information that falls within the expertise of radiologists.

### Study Limitations

This study has several limitations. First, it was a retrospective, single-centre study with a small sample size, which may have affected the generalizability of the results. In addition, the reported results are based on retrospective analyses, which may have affected the accuracy of the data collected. This observational study determined the prevalence of these incidental findings and did not include long-term follow-up. Further studies with larger cohorts are needed to perform robust multivariate analyses to identify independent predictors of significant ECFs in the AF population. Despite these limitations, this study provides valuable real-world data that can inform future research.

## Conclusion

Pre-procedural CCTA imaging in clinical workflows may extend beyond procedural guidance for ablation. Our findings indicate that CCTA is an effective opportunistic screening tool; significant ECFs were observed in more than one-third of patients. This underscores the importance of multidisciplinary collaboration between cardiologists and radiologists to optimize patient management.

### Ethics

**Ethics Committee Approval:** Approval was obtained from the Dokuz Eylül University Non-Interventional Research Ethics Committee (approval no: 2023/37-21 date: 22.11.2023).

**Informed Consent:** The records of the patients were retrospectively examined through the hospital information system and archival records.

**Acknowledgment:** The study was presented as an abstract at the EHRA 2025 Congress.

**Data Availability Statement:** The data supporting the findings of this study are available from the corresponding author upon reasonable request.

### Footnotes

**Conflict of Interest:** The authors declare no conflicts of interest concerning the authorship or publication of this article.

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### Authorship Contributions

Surgical and Medical Practices: Yılancıoğlu RY, Turan OE, Barış MM, Concept: Yılancıoğlu RY, Özcan EE, Design: Yılancıoğlu RY, Barış MM, Data Collection and/or Processing: Turan OE, Analysis and/or Interpretation: Turan OE, Yılancıoğlu RY, Literature Search: Turan OE, Yılancıoğlu RY, Writing: Yılancıoğlu RY.

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