Clinical Manifestations, Outcomes, and Mortality Risk Factors of Atrial-Esophageal Fistula: A Systematic Review

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Keywords

Atrial fibrillation · Esophageal fistula · Diagnosis · Treatment · Mortality

Abstract

Introduction: Atrial-esophageal fistula (AEF) is a rare but life-threatening complication of catheter ablation. The clinical presentation and mortality risk factors of AEF have not been fully elucidated. The aim of this study was to systematically review the clinical characteristics and prognosis of AEF. **Methods:** PubMed was searched from inception to October 2020 following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement protocol. **Results:** A total of 190 AEF patients were included. The mean age was 59.29 ± 11.67 years, 74.21% occurred in males, and 81.58% underwent radiofrequency ablation. AEF occurred within 30 days after ablation in 80.82% of patients and occurred later in patients presenting with neurological symptoms compared with other symptoms (median of onset time: 27.5 days vs. 16 days, $p < 0.001$). Clinical presentation included fever

(81.58%) and neurological symptoms (80.53%). Chest computed tomography (abnormal rate of 91.24%) was the preferred diagnostic test, followed by magnetic resonance imaging of the brain (abnormal rate of 90.91%). Repeated testing improved diagnostic evaluation sensitivity. Distinctive imaging results included free air in the mediastinum (incidence rate of 81.73%) and air embolism of the brain (incidence rate of 57.53%). The overall mortality was 63.16%, with worse nonsurgical treatment outcomes compared with outcomes of surgical treatment (94.19% vs. 33.71%, $p < 0.001$). Conservative or stent intervention was an independent risk factor for mortality. Age (adjusted odds ratio, 1.063, $p = 0.004$), presentation with neurological symptoms (adjusted odds ratio, 5.706, $p = 0.017$), and presentation with gastrointestinal bleeds (adjusted odds ratio, 3.009, $p = 0.045$) were also predictors of mortality. **Conclusions:** AEF is a fatal ablation complication. AEF can be diagnosed using a combination of a clinical history of ablation, infection, or neurological symptoms and an abnormal chest CT. Our analysis supports that surgical treatment reduces the mortality rate.

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Introduction

Catheter ablation is an effective treatment strategy for symptomatic atrial fibrillation (AF) [1]. Atrial-esophageal fistula (AEF) is the most severe complication of catheter ablation, with a prevalence of 0.01%–0.15% and a mortality rate of approximately 55% [2–6]. The occurrence of AEF may be related to ablation pressure, ablation duration, or procedures that are undertaken without using intracardiac echocardiography [7]. AEF awareness and prevention measures are inadequate. Several case reports and small series cases describe the clinical manifestations and prognosis of AEF [8, 9]. However, the reports are heterogeneous. Furthermore, reviews of clinical presentations and outcomes of AEF failed to adopt systematic methods [2, 10] or contained only a few cases [4, 6]. Therefore, a systematic review of AEF cases will enhance our understanding of the manifestations and risk factors of AEF and provide guidelines for clinical practice.

Methods

We reviewed articles, including case reports, on AEF following ablation procedures for AF. PubMed articles were retrieved from inception to October 31, 2020. The search terms included (“atrio-esophageal fistula”) OR (“atrio-esophageal fistula”) OR (“atrio-oesophageal fistula”) OR (“atrial-esophageal fistula”) OR (“atrial-oesophageal fistula”) OR (“esophagoatrial fistula”) OR (“esophageal injury” AND “ablation”) OR (“esophageal perforation” AND “ablation”) OR (“esophageal fistula” AND “ablation”).

We collected cases under the following criteria: (1) undergoing AF ablation procedure, (2) definite AEF, (3) being reported for the first time, and (4) involving information containing at least one aspect of presentation, diagnosis, and treatment. The language of the reviewed materials was restricted to English. Two researchers extracted information and ruled out inconsistent results. Data, including patient characteristics, clinical presentation, diagnostic evaluation, treatment, and outcome, were extracted. The data were consistent with the description of the original article. However, we applied the necessary synonym conversion and classification induction.

Continuous data are presented as mean with SD; categorical data are presented as absolute numbers and percentages. Differences between groups were compared using Student's *t* tests, χ^2 analyses, or Fisher's exact tests. To detect the mortality risk factors, univariate and multivariate logistical regression analyses ($p < 0.05$ for inclusion into the model) were used, and variables, including age, sex, leukocytosis, gastrointestinal bleeding, ≥ 1 neurological symptom, underwent computed tomography (CT) of the chest, underwent CT of the brain, underwent esophagogastroduodenoscopy/transesophageal echocardiogram and treatment (surgery, conservative treatment, stent, and surgery + stent), were involved in the multivariate logistical regression analyses model. All data analyses were performed with SPSS 26.0 (IBM SPSS Statistics for Windows). The significance level was set at $p < 0.05$.

Results

Article and Patient Characteristics

The analysis included 117 articles containing 190 AEF patients (shown in Fig. 1). The reported patients increased over time (shown in online suppl. Fig. 1; see www.karger.com/doi/10.1159/000519224 for all online suppl. material). Clinical characteristics are shown in online supplementary Table 1. The mean patient age was 59.29 ± 11.67 years, and ranged from 24 to 79 years. The majority of cases occurred in males (141/190, 74.21%).

The procedural characteristics are shown in online supplementary Table 2. Most ablations were performed with percutaneous radiofrequency ablation. Detailed ablation parameters were recorded in a few patients.

Clinical Presentations

The median AEF onset time from the ablation procedure was 21 days and ranged from 0 to 60 days; 80.82% of patients occurred within 30 days, and 67.12% of patients occurred between 11 and 30 days after the ablation (shown in Fig. 2). Of note, the onset time was significantly later in patients presenting with neurological symptoms at onset than in those presenting without neurological symptoms at onset (median: 27.5 days vs. 16 days, $p < 0.001$). For the clinical presentation at onset, fever was the most common symptom (72/134, 53.73%), followed by chest pain/discomfort (39/134, 29.10%), focal neurology (36/134, 26.87%), and altered mental status (24/134, 17.91%) (shown in online suppl. Fig. 2a). For general clinical presentation, fever (155/190, 81.58%) was also most common, followed by hemiparesis (66/190, 34.74%), chest pain/discomfort (64/190, 33.68%), gastrointestinal bleeding (61/190, 32.11%), and altered mental status (47/190, 24.74%) (shown in online suppl. Fig. 2b).

Diagnostic Evaluation

Computed Tomography/Magnetic Resonance Imaging

The rates of abnormal manifestations on the initial chest CT or brain magnetic resonance imaging (MRI) were 83.94% and 88.64%, respectively, and increased to 91.24% and 90.91% after repeated examinations (shown in Table 1). The median intervals between initial and repeated tests were 4 (range 1–14) days for chest CTs and 1 (range 0–14) day for brain CTs (shown in online suppl. Fig. 3a, b). In addition, the detection rate using CT/MRI with intravenous contrast or oral contrast was not significantly different from noncontrast imaging modes (81.48% vs. 75.00%, $p = 0.645$).

Fig. 1. Research procedure. The figure describes the process of document retrieval. A total of 117 articles were included in the analysis after 396 articles were excluded. AF, atrial fibrillation; AEF, atrial-esophageal fistula.

Fig. 2. Onset symptom distribution following onset time. Onset time, time from ablation to onset presentation; onset symptom, the symptom occurred within the first day of atrial-esophageal fistula attacking; abscissa axis means the onset time; ordinate axis means the number of patients who has the corresponding onset symptom. If the patient has >1 kind of onset symptom, he will be included in the corresponding groups simultaneously and be counted, respectively.

Additional Tests

Contrast esophagograms exhibited an abnormal rate as high as 80.00% (shown in Table 1). ST-T wave, may be related to coronary air embolism, was the most common electrocardiograph presentation. Intracardiac microbubbles were detected on transthoracic echocardiogram (TTE), but the occurrence rate was relatively low (32.00%), especially in the early stage of AEF (shown in Table 2). White blood cell count was an early and sensitive laboratory marker for AEF [11]. Blood culture samples, ob-

tained after sepsis, commonly reported bacteria in the oral cavity.

Treatment and Outcome

Treatments and mortality are unchanged over the past 20 years (shown in online suppl. Table 3). The overall mortality in patients with AEF was 63.16% (120/190). Mortality was significantly lower in patients treated with surgery than in those treated nonsurgically (33.71% [30/89] vs. 94.19% [81/86], $p < 0.001$). Mortality in pa-

Table 1. Diagnostic evaluation

	Abnormal, <i>n</i> (%)		Abnormal, <i>n</i> (%)
CT/MRI of chest (<i>N</i> = 137)	125 (91.24)	Repeat [‡]	8 (53.33)
CT of chest (<i>N</i> = 137)		Contrast CT/MRI or not	
Initial [†]	115 (83.94)	Contrast (<i>N</i> = 54)	44 (81.48)
Repeat [‡]	125 (91.24)	Noncontrast (<i>N</i> = 8)	6 (75.00)
MRI of chest (<i>N</i> = 2)		Contrast esophagogram (<i>N</i> = 15)	12 (80.00)
Initial [†]	2 (100.00)	TEE/EGD (<i>N</i> = 90)	
CT/MRI of brain (<i>N</i> = 98)	85 (86.73)	Initial [†]	73 (81.11)
CT of brain (<i>N</i> = 73)		Repeat [‡]	76 (84.44)
Initial [†]	44 (60.27)	Chest X-ray (<i>N</i> = 15)	
Repeat [‡]	57 (78.08)	Initial [†]	3 (20.00)
MRI of brain (<i>N</i> = 44)		Repeat [‡]	4 (26.67)
Initial [†]	39 (88.64)	ECG (<i>N</i> = 28)	24 (85.71)
Repeat [‡]	40 (90.91)	TTE (<i>N</i> = 52)	25 (48.08)
CT of abdomen (<i>N</i> = 15)		Lumbar puncture (<i>N</i> = 10)	5 (50.00)
Initial [†]	7 (46.67)	EEG (<i>N</i> = 4)	1 (25.00)

"*N*" indicates the number of cases involved in the corresponding test, while "*n*" indicates the number of cases found with abnormal performances. CT, computed tomography; ECG, electrocardiography; EEG, electroencephalography; EGD, esophagogastroduodenoscopy; MRI, magnetic resonance imaging; TEE, transesophageal echocardiogram; TTE, transthoracic echocardiogram. [†] Only involves cases found with abnormal performances from the first test. [‡] Involves cases found with abnormal performances no matter which test was performed.

tients who underwent esophageal stent and conservative treatment was 85.71% (18/21) and 96.43% (54/56), respectively, which were both inferior to surgical therapy ($p < 0.001$) (shown in Fig. 3).

To measure risk factors of mortality, we utilized univariate and multivariate logistic regression analyses. Conservative intervention (adjusted odds ratio, 41.607; 95% CI, 8.376–206.675; $p < 0.001$) and stent intervention (adjusted odds ratio, 15.118; 95% CI, 3.254–70.246; $p = 0.001$) were independent predictors of mortality (shown in Table 3).

Discussion

In the systematic review article of AEF, we found that: (1) most cases occurred within 30 days after ablation, and clinical onset manifestation was related to onset time; (2) chest CT was the most sensitive evaluation method, and sensitivity improved after repeated testing; (3) conservative and stent intervention, whether active or passive, were independent risk factors of a poor prognosis; (4) age was an inherent independent predictor of mortality (adjusted odds ratio, 1.063, $p = 0.004$); and (5) presentation with neurological symptoms (adjusted odds ratio, 5.706,

$p = 0.017$) and presentation with gastrointestinal bleeds (adjusted odds ratio, 3.009, $p = 0.045$) were multivariable predictors of mortality.

Clinical Presentation

AEF typically manifested within 2 months after the ablation procedure. A previous study suggested that the latency between ablation and the onset of symptoms depends on the initial treatment, the fistula size, and the number of additional complications [12]. The results from our study showed that the onset time was related to the onset manifestation; onset in patients initially exhibiting neurological symptoms was later. No evidence suggested that the initial onset time was related to the prognosis. Our results are in agreement with another study [6], showing that the onset time was not associated with mortality (22 ± 11.6 vs. 24 ± 12.1 days; $p = 0.344$).

Diagnosis

In addition to a history of ablation, abnormal chest or brain CT/MRI is the next red flag suggesting a potential diagnosis of AEF; 83.94% of patients were diagnosed by the initial chest CT, whereas up to 91.24% were diagnosed after repeated tests. Thus, we recommend a repeated chest CT within 4 days or brain CT within 1–3 days. A

Table 2. Abnormal diagnostic performances

Abnormal diagnostic performances	Rate, n (%)		Rate, n (%)
CT of chest (N = 104)		Esophageal perforation	10 (15.63)
Free air	85 (81.73)	Fistula	8 (12.50)
Anomalous communication	24 (23.08)	LA damage	6 (9.38)
Fistula tract	12 (11.54)	Thrombus	5 (7.81)
Contrast extravasation	9 (8.65)	Free air	1 (1.56)
Esophageal perforation	4 (3.85)	ECG (N = 24)	
LA changes [†]	15 (14.42)	ST-T wave abnormalities	11 (45.83)
Mediastinal abnormality [‡]	13 (12.50)	Atrial fibrillation	5 (20.83)
Esophageal changes [§]	8 (7.69)	Sinus tachycardia	5 (20.83)
Thrombus	6 (5.77)	Right bundle branch block	3 (12.50)
MRI of chest (N = 2)		Supraventricular tachycardia	2 (8.33)
Free air	1 (50.00)	TTE (N = 25)	
Thrombus	1 (50.00)	Microbubbles	8 (32.00)
CT of brain (N = 58)		Dilated LVEF	8 (32.00)
Ischemia/infarction	35 (60.34)	Pericardial effusion	5 (20.00)
Air embolism	33 (56.90)	Thrombus	5 (20.00)
MRI of brain (N = 40)		Lumbar puncture (N = 5)	
Ischemia/infarction	35 (87.50)	Inflammatory changes	5 (100.00)
Air embolism	11 (27.50)	EEG (N = 1)	
CT of abdomen (N = 8)		Severe depression globally	1 (100.00)
Embolic lesions [¶]	7 (87.50)	General blood test items (N = 99)	
Chest X-ray (N = 4)		Leukocytosis	75 (75.76)
Pleural effusion	2 (50.00)	Elevated inflammatory markers	23 (23.23)
Infiltrates	1 (25.00)	Elevated cardiac troponin/BNP	15 (15.15)
Pneumonia	1 (25.00)	Anemia	13 (13.13)
Contrast esophagogram (N = 12)		Lactic acid metabolic acidosis	5 (5.05)
Extravasation	12 (100.00)	Reduced renal and hepatic function	5 (5.05)
TEE/EGD (N = 64)		Blood cultures (N = 58)	
Esophagus damage	16 (25.00)	Streptococcus	50 (86.21)
Bleeding	13 (20.31)		

"N" indicates the number of cases found with abnormal performances, while "n" indicates the number of cases with the special abnormal performances. CT, computed tomography; ECG, electrocardiography; EEG, electroencephalography; EGD, esophagogastroduodenoscopy; MRI, magnetic resonance imaging; TEE, transesophageal echocardiogram; TTE, transthoracic echocardiogram. [†] Indicates diverticulum, thrombus, thickening, irregularity, vegetation, pseudoaneurysm, etc. [‡] Indicates inflammation, soiling, thickening/induration/absence of fat, pericardial effusion, etc. [§] Indicates diverticulum, thrombus, thickening, irregularity, narrowing, ulceration, abscess, etc. [¶] Indicates embolic lesions occurred in the liver, spleen, or kidney.

previous study proposed contrast CT for the diagnosis of AEF [3]; however, our survey found no differences in diagnostic sensitivities between contrast and noncontrast imaging. Despite these results, contrast imaging may be reasonable, considering the dismal outcomes of AEF.

Esophagogastroduodenoscopy and transesophageal echocardiogram are contraindicated if AEF is suspected [13]. Instrumentation of the esophagus, even placing a nasogastric feeding tube, could potentially open the tissue flap [14] and promote esophageal peristalsis, resulting in the enlargement of the AEF [15]. Enlargement of AEF may cause massive iatrogenic air embolism and life-

threatening bleeding. Esophagogastroduodenoscopy is particularly harmful because it requires air insufflation, which creates a pressure gradient that favors the passage of air via the fistula. Recently, we reported a case of AEF diagnosed early with carbon dioxide-insufflation esophageal endoscopy under TTE monitoring; however further evaluation of this method is required [16].

Although TTE is usually used to eliminate endocarditis, detection of air bubbles in the cardiac chambers is a sensitive diagnostic tool for AEF when transpulmonary shunting through an arteriovenous fistula is excluded. In our study, spontaneous microbubbles were detected in

Fig. 3. Mortality of AEF with different interventions. The figure details mortality expressed in absolute and percentage terms after different treatments. Differences between groups were compared with the χ^2 analyses or Fisher exact test. p value was set near the line linking 2 groups. AEF, atrial-esophageal fistula.

the left atria and ventricles in 8 patients [17–20]; of note, in one of those 8 patients, bubbles only appeared when the patient had a cough [17].

ST-segment elevation among AEF patients is thought to originate from a massive coronary air embolism. In our study, ST-segment elevation was detected in 9 patients, and coronary air embolism was proved in 2 of those patients [21, 22]. Due to the anterior position of the right sinus of Valsalva, the right coronary artery is frequently affected by air embolism [23]. It is noteworthy that 5 of 6 patients' ST-segments elevation in the inferior leads were concordant with this anatomical susceptibility.

Treatment

Once the diagnosis of AEF is made, urgent surgical repair is essential because the prognosis is better for surgical repair. No uniform surgical procedures have been established. However, primary left atrial repair combined with esophageal repair is advised [2]. A muscle flap provides a physical separation between the left atrial and the esophagus and an increased blood supply to the contaminated area [24]. Other managements include broad-spectrum antibiotics and total parenteral nutrition.

Stenting should be used secondary to surgical repair due to the danger of the intervention measures through the esophagus. Our previous report and another study suggest that the risk of an air embolism can be avoided by using CO₂ cautiously at very low flow rates to replace air [16, 25].

Hyperbaric oxygen therapy may be beneficial by promoting absorption of free air within the vasculature. The complete recovery from major neurologic symptoms by emergency surgical repair in combination with postoperative hyperbaric oxygen therapy has been reported in 1 case [19].

Prevention

Several measures for the prevention of AEF have been reported, including reducing the energy output or ablation time on the posterior left atrial wall and using an esophageal temperature monitor, contact force catheters, and prophylactic proton pump inhibitors. However, the evidence for the preventive effects of these measures against the occurrence of AEF is not convincing.

Employing mechanical techniques to dislocate the esophagus during ablation of the posterior LA may reduce the temperature of the esophagus, and the benefits

Table 3. Univariate and multivariate regression of mortality

Variables	Univariate regression adjusted odds ratio (95% CI)	p value	Multivariate regression adjusted odds ratio (95% CI)	p value
Age	1.045 (1.014–1.076)	0.004	1.063 (1.019–1.108)	0.004
Sex	2.716 (1.097–6.726)	0.031		
Ablation energy				
Radiofrequency	Ref	0.926		
Cryoballoon	1.316 (0.324–5.349)	0.701		
Ultrasound	1.128 (0.099–12.799)	0.922		
Onset time	1.017 (0.988–1.048)	0.255		
Fever	0.406(0.154–1.072)	0.069		
Leukocytosis	0.471 (0.235–0.943)	0.034		
Chest pain	0.514 (0.263–1.007)	0.052		
≥1 gastrointestinal symptom	1.120 (0.579–2.167)	0.736		
Gastrointestinal bleed	2.537 (1.169–5.502)	0.018	3.009 (1.026–8.822)	0.045
≥1 neurological symptom	3.143 (1.303–7.581)	0.011	5.706 (1.367–23.819)	0.017
Focal neurology	1.012 (0.526–1.950)	0.971		
Chest CT	0.149 (0.050–0.446)	0.001	0.215 (0.054–0.849)	0.028
Brain CT	2.201 (1.042–3.920)	0.037		
EGD/TEE	1.952 (1.004–3.798)	0.049		
Treatment				
Surgery	Ref	<0.001	Ref	<0.001
Surgery + stent	2.000 (0.460–8.698)	0.355	3.283 (0.543–19.837)	0.195
Stent	12.000 (3.216–44.778)	<0.001	15.118 (3.254–70.246)	0.001
Conservative	48.000 (10.743–214.465)	<0.001	41.607 (8.376–206.675)	<0.001

CT, computed tomography; EGD, esophagogastroduodenoscopy; MRI, magnetic resonance imaging; TEE, transesophageal echocardiogram.

of this technique have been demonstrated in several studies [26, 27]. However, due to the risk of esophageal trauma, further assessment is required.

Currently, new ablation strategies with target values have proven to be both efficacious and safe. The ablation index (AI), a comprehensive ablation metric of time, power, and contact force, is now routinely used to guide AF ablation. The occurrence of esophageal or periesophageal injury was markedly low (1.2%) using an AI of 403 ± 38 au at the posterior wall [28]. In the VISTAX study, a favorable safety profile was also observed with 3.6% primary adverse events and no AEF occurred, which was partly attributable to the standardization and simplicity of the technique and the VISITAG SURPOINT/intertag distance-guided workflow [29]. We hope further evaluation of esophageal injury by endoscopy or ultrasound will prove the benefits of this technique. In addition, the AI target value at the posterior wall may be related to esophageal injury. Zhang et al. [30] showed that the AI-350 group has a lower incidence of esophageal injury than the AI-400 group (3.3% vs. 26.7%, $p = 0.03$).

Considering that few prevention strategies have garnered widespread acceptance, early identification of AEF patients is essential. After AF ablation procedures, the discharge report should mention the rare complication and treatment of AEF.

Strengths and Limitations

The present study has the following strengths: (1) a strict systematic evaluation method, (2) a large number of cases, and (3) evaluation of the risk factors for mortality. However, the current study has several limitations: (1) existence of the inevitable publication bias because of the limitations of the included study type, (2) incomplete information of the included cases, which decreases the reliability of the results, and (3) exclusion of some cases without essential information.

Clinical Implications

The present study provides clues for clinical practice and future research. We found that AEF often presents with fever and neurological symptoms. As a result, the initial consultation tends to take place in the noncardiol-

ogy department. For the timely diagnosis of AEF, enhancement in physicians' awareness of AEF sequenced after ablation is needed, thorough patient education regarding signs of AEF upon discharge is warranted, and regular follow-up of patients is deserved. We found that chest CT is the most important diagnosis tool of AEF and becomes more sensitive after repeated examinations. Therefore, repeated examinations should be performed instead of eliminating the diagnosis of AEF when patients with a history of ablation have a sign of AEF. We analyzed the changes of treatment through 20 years and did not find a significant increase in the surgical rate (shown in online suppl. Table 3). Our analyses indicated that surgery is the best way to improve the prognosis. We suggest taking the prompt surgical correction as the standard of AEF treatment. In addition, the reason why the total surgical rate did not improve after many case reports proved the feasibility of surgery also deserves to be explored in the future.

Conclusion

AEF is a life-threatening complication with a total mortality rate of 63.16%. This complication is the outcome sequence of catheter ablation. Patients having suspicious symptoms usually visit within 30 days. It is critical to know that chest CT is the preferred diagnostic test, and survival depends on prompt surgery intervention.

References

- Andrade JG, Wells GA, Deyell MW, Bennett M, Essebag V, Champagne J, et al. Cryoablation or drug therapy for initial treatment of atrial fibrillation. *N Engl J Med*. 2021;384(4):305–15.
- Singh SM, d'Avila A, Singh SK, Stelzer P, Saad EB, Skanes A, et al. Clinical outcomes after repair of left atrial esophageal fistulas occurring after atrial fibrillation ablation procedures. *Heart Rhythm*. 2013;10(11):1591–7.
- Han HC, Ha FJ, Sanders P, Spencer R, Teh AW, O'Donnell D, et al. Atrioesophageal fistula: clinical presentation, procedural characteristics, diagnostic investigations, and treatment outcomes. *Circ Arrhythm Electrophysiol*. 2017;10(11):e005579.
- Jehaludi A, Heist EK, Giveans MR, Anand R. Retrospective review of 65 atrioesophageal fistulas post atrial fibrillation ablation. *Indian Pacing Electrophysiol J*. 2018;18(3):100–7.
- Hindricks G, Potpara T, Dagres N, Arbelo E, Bax JJ, Blomström-Lundqvist C, et al. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J*. 2021;42(5):373–498.
- Chavez P, Messerli FH, Casso Dominguez A, Aziz EF, Sichrovsky T, Garcia D, et al. Atrioesophageal fistula following ablation procedures for atrial fibrillation: systematic review of case reports. *Open Heart*. 2015;2(1):e000257.
- Friedman DJ, Pokorney SD, Ghanem A, Marcello S, Kalsekar I, Yadalam S, et al. Predictors of cardiac perforation with catheter ablation of atrial fibrillation. *JACC Clin Electrophysiol*. 2020;6(6):636–45.
- Zima LA, Fornoff LE, Surdell DL. Atrioesophageal fistula: considerations for the neurological clinician. *Clin Neurol Neurosurg*. 2018;170:58–60.
- Schuring CA, Mountjoy LJ, Priaux AB, Schneider RJ, Smith HL, Wall GC, et al. Atrioesophageal fistula: a case series and literature review. *Am J Case Rep*. 2017;18:847–54.
- Li CY, Li SN, Jiang CY, Fu H, Liang M, Wang ZL, et al. Atrioesophageal fistula post atrial fibrillation ablation: a multicenter study from China. *Pacing Clin Electrophysiol*. 2020;43(7):627–32.
- Kapur S, Barbhuiya C, Deneke T, Michaud GF. Esophageal injury and atrioesophageal fistula caused by ablation for atrial fibrillation. *Circulation*. 2017;136(13):1247–55.
- Finsterer J, Stöllberger C, Pulgram T. Neurological manifestations of atrio-esophageal fistulas from left atrial ablation. *Eur J Neurol*. 2011;18(10):1212–9.

Statement of Ethics

Our research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. No one was exposed to individual messages.

Conflict of Interest Statement

No author has potential conflicts of interest to any industry.

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Author Contributions

Aihua Liu contributed to conceptualization, data analysis/interpretation, drafting the article, critical revision of the article, and approval of the article; Mingjie Lin contributed to data collection, critical revision of the article, and approval of the article; Kellina Maduray contributed to data collection, critical revision of the article, and approval of the article; Wenqiang Han contributed to data collection, critical revision of the article, and approval of the article; Jing-quan Zhong contributed to conceptualization, methodology, and approval of the article.

Data Availability Statement

The research data are confidential. If needed, data can be accessed via correspondence with the authors.

- 13 Calkins H, Hindricks G, Cappato R, Kim YH, Saad EB, Aguinaga L, et al. 2017 HRS/EHRA/ECAS/APHRS/SOLAECE expert consensus statement on catheter and surgical ablation of atrial fibrillation: executive summary. *Europace*. 2018;20(1):157–208.
- 14 Wuestenberghs F, Pirson N, Bulpa P, Fervaille C, Dive A. Iatrogenic cerebral air embolism revealing an atrial-esophageal fistula. *Intern Emerg Med*. 2017;12(5):715–6.
- 15 Saporta I, Chennamadhavuni A, Dolan MJ. Atrioesophageal fistula: a rare complication of radiofrequency ablation. *WMJ*. 2017;116(2):84–6.
- 16 Rong B, Zhang X, Tian H, Zhang H, Zhong N, Zhong J. Transthoracic echocardiography-monitored CO(2)-insufflation esophageal endoscopy for diagnosis of Atrioesophageal fistula and prevention of iatrogenic air embolism: a case report. *BMC Cardiovasc Disord*. 2020;20(1):219.
- 17 Angulo CI, El Tallawi KC, Avenatti E, Sukumaran A, Quinones M, Nagueh SF. Detection of an atrioesophageal fistula on a transthoracic echocardiogram. *CASE*. 2017;1(4):128–30.
- 18 Kawasaki R, Gauri A, Elmouchi D, Duggal M, Bhan A. Atrioesophageal fistula complicating cryoballoon pulmonary vein isolation for paroxysmal atrial fibrillation. *J Cardiovasc Electrophysiol*. 2014;25(7):787–92.
- 19 Hirji SA, Haney JC, Welsby I, Lombard FW, Berry MF. Hyperbaric oxygen therapy for treatment of neurologic sequela after atrioesophageal fistula. *Ann Thorac Surg*. 2015;99(2):681–2.
- 20 Mackle T, Pistawka K. Atrioesophageal fistula after ablation for atrial fibrillation. *J Emerg Med*. 2017;53(1):e1–4.
- 21 Shim CY, Lee SY, Pak HN. Coronary air embolism associated with atrioesophageal fistula after ablation of atrial fibrillation. *Can J Cardiol*. 2013;29(10):1329.e17–e19.
- 22 Aryana A, Arthur A, O'Neill PG, D'Avila A. Catastrophic manifestations of air embolism in a patient with atrioesophageal fistula following minimally invasive surgical ablation of atrial fibrillation. *J Cardiovasc Electrophysiol*. 2013;24(8):933–4.
- 23 Lamm G, Auer J, Punzengruber C, Ng CK, Eber B. Intracoronary air embolism in open heart surgery: an uncommon source of myocardial ischaemia. *Int J Cardiol*. 2006;112(3):e85–6.
- 24 Khakpour H, Shemin RJ, Lee JM, Buch E, Boyle NG, Shivkumar K, et al. Atrioesophageal fistula after atrial fibrillation ablation: a single center series. *J Atr Fibrillation*. 2017;10(3):1654.
- 25 Takahashi T, Mohara J, Ogawa H, Igarashi T, Motegi Y. Successful surgical treatment of left atrioesophageal fistula following atrial ablation. *Gen Thorac Cardiovasc Surg*. 2018;66(11):664–6.
- 26 Mateos JC, Mateos EI, Peña TG, Lobo TJ, Mateos JC, Vargas RN, et al. Simplified method for esophagus protection during radiofrequency catheter ablation of atrial fibrillation: prospective study of 704 cases. *Rev Bras Cir Cardiovasc*. 2015;30(2):139–47.
- 27 Parikh V, Swarup V, Hantla J, Vuddanda V, Dar T, Yarlagaadda B, et al. Feasibility, safety, and efficacy of a novel preshaped nitinol esophageal deviator to successfully deflect the esophagus and ablate left atrium without esophageal temperature rise during atrial fibrillation ablation: the DEFLECT GUT study. *Heart Rhythm*. 2018;15(9):1321–7.
- 28 Wolf M, El Haddad M, De Wilde V, Philips T, De Pooter J, Almorad A, et al. Endoscopic evaluation of the esophagus after catheter ablation of atrial fibrillation using contiguous and optimized radiofrequency applications. *Heart Rhythm*. 2019;16(7):1013–20.
- 29 Duytschaever M, Vijgen J, De Potter T, Scherr D, Van Herendaal H, Knecht S, et al. Standardized pulmonary vein isolation workflow to enclose veins with contiguous lesions: the multicentre VISTAX trial. *Europace*. 2020;22(11):1645–52.
- 30 Zhang ZW, Zhang P, Jiang RH, Liu Q, Sun YX, Yu L, et al. Risk of esophageal thermal injury during catheter ablation for atrial fibrillation guided by different ablation index. *Pacing Clin Electrophysiol*. 2020;43(7):633–9.