REVIEW



Long-term outcomes of catheter ablation for atrial fibrillation in octogenarians

Nikola Kozhuharov^{1,2} · Nabeela Karim^{3,4} · Antonio Creta⁵ · Lisa W. M. Leung⁶ · Rick Veasey⁷ · Armin Osmanagic⁸ · Anna Kefala⁹ · Mike Pope^{10,11} · Apostolos Vouliotis¹¹ · Sven Knecht¹² · Philipp Krisai^{12,13} · Pierre Jaïs¹³ · Claire Martin¹⁴ · Christian Sticherling¹¹ · Matthew Ginks¹⁰ · Waqas Ullah¹¹ · Richard Balasubramaniam⁹ · Manish Kalla⁸ · Mark M. Gallagher⁶ · Ross J. Hunter⁵ · Tom Wong^{3,4} · Dhiraj Gupta¹

Received: 15 April 2024 / Accepted: 14 July 2024 © The Author(s) 2024

Abstract

Background and aims Catheter ablation is superior to pharmacological therapy in controlling atrial fibrillation (AF). There are few data on the long-term outcome of AF ablation in octogenarian patients. This analysis aims to evaluate the outcome of AF ablation in octogenarians vs. younger patients.

Methods In this retrospective study in 13 centres in the UK, France, and Switzerland, the long-term outcomes of 473 consecutive octogenarian patients undergoing ablation for AF were compared to 473 matched younger controls (median age 81.3 [80.0, 83.0] vs. 64.4 [56.5, 70.7] years, 54.3% vs. 35.1% females; *p*-value for both < 0.001). The primary endpoint was the recurrence of atrial arrhythmia after a blanking period of 90 days within 365 days of follow-up.

Results Acute ablation success as defined as isolation of all pulmonary veins was achieved in 97% of octogenarians. Octogenarians experienced more procedural complications (11.4% vs 7.0%, p = 0.018). The median follow-up time was 281 [106, 365] days vs. 354 [220, 365] days for octogenarians vs. non-octogenarians (p < 0.001). Among octogenarians, 27.7% (131 patients) experienced a recurrence of atrial arrhythmia, in contrast to 23.5% (111 patients) in the younger group (odds ratio 1.49; 95% confidence interval 1.16–1.92; p = 0.002). In a multivariable regression model including gender, previous AF ablation, vascular disease, chronic kidney disease, CHA2DS2-VASc score, left atrial dilatation, and indwelling cardiac implantable electronic device, age above 80 remained an independent predictor of recurrence of arrhythmia.

Conclusion Ablation for AF is effective in octogenarians, but is associated with slightly higher procedural complication rate and recurrence of atrial arrhythmia than in younger patients.

Keywords Atrial fibrillation ablation · Prognosis · Octogenarians

What's new? Catheter ablation for atrial fibrillation is effective in octogenarians, with an acute success rate of 97%, comparable to younger cohorts.

Arrhythmia recurrence: Arrhythmia recurrence in octogenarians over the 365-day follow-up period is significantly higher as compared to younger patients.

Clinical impact: Despite the higher recurrence rate, AF ablation remains an effective treatment for octogenarians, offering an alternative to pharmacological therapy to improve quality of life.

Nikola Kozhuharov and Nabeela Karim have contributed equally and should be considered first authors

Tom Wong and Dhiraj Gupta have contributed equally and should be considered senior authors

Abbreviations

- AF Atrial fibrillation
- CIED Cardiovascular implantable electronic device
- PVI Pulmonary vein isolation

1 Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia, and is associated with increased morbidity and mortality [1, 2]. Catheter ablation, with pulmonary vein isolation (PVI) as its cornerstone, has proven to be an efficacious therapeutic strategy for AF, augmenting the quality of life and functional capacity of patients. [3–5]

The ageing population serves as a major risk factor for the incidence and prevalence of AF [6]. Projections

Extended author information available on the last page of the article

suggest a more than twofold increase in the prevalence of AF by 2060, a surge attributable, at least in part, to the increase in life expectancy. Increasingly, octogenarians represent a significant proportion of patients referred for AF management. [2, 7, 8]

In octogenarian patients, the impact of AF on morbidity and mortality is even more accentuated. Medical management is particularly challenging due to the increased restrictions of the use of antiarrhythmic drugs in this patient group [2, 3]. Despite these realities, there is a paucity of data regarding catheter ablation's acute and longterm outcomes in patients aged 80 and above. This data deficit is primarily due to the limited number of procedures in this age group and their systematic exclusion from most clinical trials [1, 3, 9-11]. Although a few relatively small studies have suggested that AF ablation in octogenarians may be safe and yield favourable success rates, [9, 11–14] concerns regarding potential procedural complications and limited efficacy continue to restrict the application of catheter ablation therapy in this demographic [15]. We hypothesised that contemporary atrial fibrillation ablation is as effective in octogenarians as in younger patients and sought to assess this hypothesis in a large, multicentre, international study.

2 Methods

2.1 Study population and design

In this retrospective, multicentre study, data from consecutive octogenarian and non-octogenarian patients undergoing AF ablation were collected from 11 tertiary hospitals in the UK (Supplemental Table 1), and 1 each in Switzerland (as part of the Swiss Atrial Fibrillation Pulmonary Vein Isolation Registry, ClinicalTrials.gov registry, Number NCT03718364) and France. The outcomes of octogenarian patients were compared to a matched cohort of non-octogenarian patients who underwent AF ablation within the same timeframe. The patients were matched on the following parameters: paroxysmal vs. non-paroxysmal AF, de novo vs. previous AF ablation, and the hospital of treatment. We excluded patients who had chosen to opt out of the use of their routinely collected clinical data for research purposes.

The study was carried out according to the principles of the Declaration of Helsinki and received approval from the relevant ethics committees. All patients granted their written informed consent for using their routinely collected clinical data in clinical research. The authors designed the study, gathered and analysed the data according to the STROBE guidelines for cohort studies (Supplemental Table 2) [16], and vouch for the data integrity and analysis.

2.2 Ablation procedures

Catheter ablation included PVI and was performed either using point-by-point radiofrequency or with a cryoballoon ablation. All radiofrequency PVI procedures were performed with wide-area circumferential ablation using electroanatomical mapping and an irrigated tip contact force-sensing ablation catheter (CARTO 3, Biosense Webster Inc. Diamond Bar, CA, USA or Rhythmia, Boston Scientific, Marlborough, MA, USA, or EnSite NavX/ Velocity, St. Jude Medical, Minneapolis, MN, USA). Following wide-area circumferential ablation, PVI was confirmed by documenting at least entrance block [3]. Additional lesions at the operators' discretion were performed. These included but were not limited to left atrial posterior wall isolation. Cryoballoon ablation was performed using the 28-mm Arctic Front Advance cryoballoon (Medtronic Inc, Minneapolis, USA) and Achieve Advance Mapping catheter (Medtronic Inc, Minneapolis, USA). Cryoballoon ablation duration per vein was at least 180-s cryo-lesion aiming to achieve PVI and/or - 40 °C at 60 s, as previously described [17]. Additional cryo-applications were used according to the physician's discretion.

2.3 Patient follow-up and arrhythmia recurrence

Follow-up was performed according to clinical routine procedures at each participating centre, with the follow-up period for the primary outcome set at 365 days. According to the practice of the participating centres, patients were followed up in clinic visits every 3-4 months with an assessment of symptoms. The 12-lead ECG was performed at these visits; where appropriate, patients also received supplementary ambulatory ECG monitoring. Recurrence of atrial arrhythmia after an initial blanking period of 90 days was defined as at least one of the following: (1) need for further ablation for AF/atrial tachycardia (including cavotricuspid isthmus ablation); (2) need for DC cardioversion; (3) AF/atrial flutter or atrial tachycardia > 30 s recorded on ECG/Holter, or (4) in the opinion of the treating physician, experienced symptoms consistent with paroxysmal AF, even in the absence of documented AF/AT [2, 3]. Sensitivity analyses were conducted to verify the consistency of results, specifically excluding patients who had no ECG monitoring during follow-up, as well as those considered to have experienced a recurrence of atrial arrhythmia based solely on the physician's assessment without any ECG confirmation.

2.4 Outcome measures

The primary outcome measure was the recurrence of atrial arrhythmia after an initial blanking period of 90 days in octogenarian vs. non-octogenarian patients following atrial fibrillation ablation. Predefined subgroup analyses were performed to verify the consistency of the treatment effect. Secondary outcome measures encompassed comparisons of baseline and procedural characteristics between the octogenarian and non-octogenarian cohorts and predictors of the long-term success of AF ablation in octogenarians.

2.5 Statistical analysis

The Kolmogorov-Smirnov test and visual inspection of the shape of the distribution of the variables were used to assess their normality. Continuous variables are presented as medians (with interquartile range), and categorical variables are as numbers and percentages. Comparisons between groups were made using Fisher's exact test, Mann-Whitney U test, or Kruskal-Wallis test, as appropriate. The recurrence of atrial arrhythmia during follow-up was analysed using survival analysis for cumulative event rates, including Kaplan-Meier estimates and Cox regression for calculating hazard ratios. Interaction tests were conducted between the age groups and the prespecified subgroup variables using bivariate Cox regression models with tests for interaction to evaluate the consistency of treatment effects. The predefined subgroup variables included female gender, previous PVI, chronic kidney disease, ischemic heart disease, valvular heart disease, congestive heart failure, history of cerebrovascular accident/ transient ischemic attack, left atrial dilatation, and left ventricular systolic dysfunction. Cox regression analyses were applied to identify predictors of atrial arrhythmia recurrence in univariable and multivariable analyses. The available baseline characteristics variables were treated as potentially confounding variables and were entered into the univariable model. Variables that were significant in that model were added to a multivariable model. No imputation was performed for missing values. No adjustments for multiple comparisons were made. All hypothesis testing was 2-sided, and a *p*-value < 0.05 was considered significant. This was an exploratory analysis within a retrospective study, and the sample size of the overall cohort was not explicitly determined for this analysis. Statistical analyses were carried out using SPSS/PC Software Package (version 25.0) and R Statistical Software (version 3.5.1).

3 Results

3.1 Patient demographics and characteristics

A total of 473 octogenarian patients with a median age of 81.3 [80.0, 83.0] were enrolled between January 2013 and June 2021. Of these, 222 (46.9%) had paroxysmal atrial fibrillation, and 251 (53.1%) had persistent AF. One hundred twenty-one (25.7%) had previous AF ablation (Table 1 and Supplemental Fig. 1). Following matching for the type of AF, previous AF ablation, and treating hospital, 473 non-octogenarian patients who underwent ablation in the same hospitals in the same timeframe with a median age of 64.4 [56.5, 70.7] were included in the analysis. In the octogenarian group, 257 (54.3%) patients were women vs. 166 (35.1%) in the non-octogenarian group (p < 0.001). Octogenarian patients had more comorbidities as compared to non-octogenarian patients, including hypertension (263 (55.6%) vs. 208 (44.0%), p < 0.001), diabetes (44 (9.3%) vs. 64 (13.5%), p < 0.041), previous history of CVA/TIA (42 (8.9%) vs. 19 (4.0%), p < 0.002), and presence of valvular heart disease (86 (18.2%) vs. 56 (11.8%), p < 0.006). Radiofrequency ablation was more utilised than cryoballoon PVI in octogenarians (327 (77.1%) vs. 289 (61.9%), p < 0.001). An indwelling permanent pacemaker or an ICD was more common among octogenarians (50 (10.7%) vs. 9 (1.9%) patients, p < 0.001). This provided continuous rhythm monitoring with a pacemaker, ICD, or implantable loop recorder in a greater proportion of octogenarian patients as compared to non-octogenarians (75 (18.8) vs. 28 (6.2%), p < 0.001).

3.2 Atrial fibrillation ablation complications

Acute complications were more common in the octogenarians' group (54 (11.4%) vs. 33 (7.0%), p=0.018). The most common adverse events following atrial fibrillation ablation were vascular access complications, in 18 (3.8%) octogenarians vs. non-octogenarians 13 (2.7%) and cardiac perforation and/or tamponade (8 (1.7%) vs 11 (2.3%), p=0.013, Table 1).

3.3 Recurrence of atrial arrhythmia

Among 946 patients in the overall cohort, the median follow-up time until reaching an event, completion of 365 days of follow-up, or patient lost to follow-up was 322 [153, 365] days for the overall cohort. The median

Table 1	Baseline clinical	characteristics, procedura	characteristics, an	d follow-up	characteristics in	octogenarians v	s. non-octogenarians

Patient characteristics(n=473)(n=473)Age, years. median [IQR]813 [800, 830]644 [565, 70.7]Benda gender, n (%)257 (54.3)16 (63.1)BML, kgm², median [IQR]253 (24.1, 29.1]28.9 [25.3, 32.4]Arrial fibrillation type, n (%)222 (46.9)222 (46.9)Pervissent212 (45.9)222 (46.9)Congestanding persistent217 (45.9)22 (47.6)Congestanding persistent34 (7.2)26 (5.5)Pervious AF ablation, n (%)21 (25.7)21 (25.7)CHA.DS2 VAS escer. median [IQR]30 (30.4) cJ20 (10.3, 0]Prior history, n (%)21 (25.7)24 (41.0)CHA.TSA (%)23 (55.6)28 (44.0)Diabetes median [IQR]30 (35.6)28 (41.0)Diabetes median [IQR]40 (35.5)26 (41.3)CVA/TIA42 (8.9)16 (40.5)Valvalar hacase46 (18.2)50 (10.6)Clastest and disease61 (13.2)50 (11.6)CVA/TIA42 (8.9)13 (2.7)Peripheral embolism61 (13.1)13 (2.7)Real inpairment79 (16.7)27 (5.8)Indwelling CIED, n (%)21 (4.5)22 (4.5)Verver (%)21 (4.5)23 (4.9)LD CO CKF1.7 (3.6)13 (2.7)Indwelling Miniparied35 (80.5)32 (8.2)Middly inpaired21 (4.5)23 (4.9)Secrely impaired21 (4.5)23 (4.9)Verter (%)21 (4.1)23 (4.9)Verter (%)21 (4.1)23 (4.9)	р
Female gender, n (%)257 (54.3)166 (35.1)BML kgrr², median [LQR]26.1 (24.1, 29.1]25.3 (24.1)BML kgrr², median [LQR]222 (46.9)222 (46.9)Persistent217 (45.9)25 (47.6)Long-standing persistent34 (7.2)26 (5.5)Previous AF ablation, n (%)20 (10.3 0)20 (10.3 0)CHAZDSZ VASe score, median [LQR]30 (30.4 0,4)20 (10.3 0,1)Prior history, n (%)21 (25.7)21 (25.7)CHAT63 (5.6)28 (44.0)Diabetes meditus44 (9.3)28 (41.0)Diabetes meditus44 (9.3)29 (40.0)CVATIA42 (8.9)91 (4.0)Subates meditus46 (13.5)20 (10.6)CVATIA20 (8.1)30 (10.6)Diabetes meditus66 (18.2)50 (10.6)Other vascular disease80 (18.2)50 (10.6)Other vascular diseases70 (16.7)27 (5.8)Indueling CIED, n (%)71 (3.6)71 (3.6)UED or CRT17 (3.6)12 (3.7)Indueling CIED, n (%)20 (2.1)30 (8.4)UTEr, n (%)21 (4.5)22 (4.5)Normal35 (7.9)39 (8.4)Middy impaired35 (7.9)39 (8.4)Severely impaired20 (2.1)11 (3.2)Severely impaired21 (2.1)21 (4.3)Severely impaired22 (7.1)29 (6.1)Middy inding impaired21 (2.1)21 (4.3)Severely impaired22 (7.1)29 (6.1)Severely impaired22 (7.1)29 (
BMI, kg/m², median [IQR]263 [24.1, 29.1]28.9 [25.3, 32.4]Atrial fibrillation type, n (%)222 (46.9)222 (46.9)Proxysnand222 (46.9)225 (47.6)Lang-standing persistent217 (45.9)212 (25.7)Lang-standing persistent20 [1.0, 3.0]20 [1.0, 3.0]Provious AF ablation, n (%)21 (25.7)121 (25.7)CHA2DS2 VASc score, median [IQR]30 [3.0, 4.0]20 [1.0, 3.0]Prior history, n (%)54 (11.4)21 (25.7)CHF67 (14.2)54 (11.4)Hyperension263 (55.6)208 (44.0)Diabetes mellitus44 (9.3)64 (13.5)CVATTA2 (8.9)19 (4.0)Valvular heart disease86 (18.2)56 (11.8)Stehenic heart disease17 (3.6)7 (1.5)Peripheral embolism61 (13.1)13 (2.7)Renal impairment17 (3.6)7 (1.5)Peripheral embolism50 (10.7)9 (1.9)ICD or CRT17 (3.6)7 (1.5)LFF n (%)12 (25.2)11 (4.5)VEFF n (%)12 (25.2)11 (4.5)Middy impaired25 (50.5)38 (8.2)Middy impaired23 (52.2)11 (4.5)Severely impaired26 (3.2)14 (3.2)Middry enlarged15 (3.2)11 (4.5)Middry enlarged15 (3.2)11 (3.2)Middry impaired26 (3.0)12 (3.2)Middry enlarged16 (1.7)28 (6.1)Cryphallocn, n(%)28 (26.3)14 (3.2)Middry enlarged26 (7.7	< 0.001
Atrial fibrillation type, n (%)221 (d-s)222 (d-s)Paroxysnal227 (d-s)225 (d-s)Paroxysnal217 (d-s)225 (d-s)Long-standing persistent34 (7.2)26 (5.5)Previous AF ablation, n (%)21 (2.5.7)12 (2.5.7)Protoin Story, n (%)30 (3.0, 40)20 [1.0, 3.0]Prior history, n (%)26 (5.5)308 (4.0)Prior history, n (%)26 (5.5)308 (4.0)Diablets mellitus44 (9.3)64 (13.5)Oblabets mellitus42 (8.9)94 (4.0)Valuar heart disease86 (18.2)50 (10.6)Schemic heart disease66 (18.2)50 (10.6)Schemic heart disease61 (8.2)50 (10.6)CVATTA70 (6.7)27 (5.8)Paripheral embolism70 (16.7)27 (5.8)Indwelling CED, n (%)17 (3.6)17 (3.6)Prifteral embolism35 (80.5)382 (82.2)Indwelling TED, n (%)21 (4.5)20 (4.5)LDE or CR17 (3.6)17 (3.6)LDE for fight35 (80.5)382 (82.2)Middy impaired35 (80.5)382 (82.2)Middy impaired35 (80.5)382 (82.2)Middy impaired35 (80.5)39 (8.4)Left attrial size, n(%)24 (6.3)21 (4.5)Severely impaired25 (7.5)39 (8.4)Middy impaired45 (3.9)32 (4.5)Severely impaired61 (17.4)52 (4.3)Severely impaired61 (7.4)21 (4.5)Severely impaired62 (7.4) <td>< 0.001</td>	< 0.001
Paroxysmal 222 (46.9) 222 (46.9) Persistent 217 (45.9) 25 (47.6) Long-standing persistent 34 (72.9) 26 (5.5) Previous AF ablation, n (%) 121 (25.7) 121 (25.7) CHA2DS2 VA5s score, median [IQR] 30 (30, 4.0) 20 (10, 3.0) Prior history, n (%) CH 67 (14.2) 54 (11.4) UP of thistory, n (%) 263 (55.6) 208 (44.0) Diabetes mellitus 40 (3.3) 64 (13.5) Valvalar heart disease 86 (18.2) 56 (11.8) Stehemic heart disease 86 (18.2) 50 (10.6) Other vaccutar disease 17 (3.6) 7 (1.5) Peripheral embolism 6 (1.3) 13 (2.7) Renal inpairment 79 (16.7) 9 (1.9) ICD or CKT 17 (3.6) 7 (1.5) Peripheral embolism 355 (80.5) 382 (82.2) Middy inpaired 35 (7.9) 9 (8.4) Moderately impaired 28 (6.3) 23 (4.9) Left atrial size, n (%) 24 (4.3) 56 (4.3.0) Middy enlarged	0.546
Persistent217 (45.9)225 (47.6)Long-standing persistent34 (7.2)26 (5.5)Pervious AF ablation, n (%)30 (3.0, 4.0]20 [1.0, 3.0]CHA2DS2 VASc score, median [IQR]30 (3.0, 4.0]20 [1.0, 3.0]Prior history, n (%)7 (1.4.2)54 (1.1.4)CHF026 (55.6)208 (44.0)Diabets mellitus44 (9.3)64 (1.5.5)CVATIA28 (8.9)19 (4.0.)Valvalar heart disease86 (18.2)56 (11.8)Schemicheart disease86 (18.2)56 (11.8)Schemicheart disease7 (3.6)13 (2.7)Peripheral embodism61.3)13 (2.7)Renal impairment70 (16.7)9 (1.9)ICD or CRT17 (3.6)13 (2.7)INPM55 (80.5)82 (82.2)Mildy impaired35 (7.9)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired24 (3.3)23 (4.9)Ididy enlarged15 (32.9)118 (32.5)Mildy enlarged15 (32.9)118 (32.5)Mildy enlarged61 (7.1)24 (8.1)Severely impaired24 (7.4)24 (8.1)Severely impaired24 (7.4)24 (8.1)Mildy enlarged16 (2.9)118 (32.5)Mildy enlarged21 (7.1)28 (6.1)Severely impaired22 (4.5)24 (4.5)Severely impaired24 (4.5)24 (4.5)Severely ingreged24 (4.5)24 (4.5)Severel	< 0.001
Long-standing persistent 34 (7.2) 26 (5.5) Previous AF ablation, n (%) 121 (25.7) 121 (25.7) CHA2DS2 VASc score, median [IQR] 30 (3.0, 4.0] 2.0 (1.0, 3.0) Provious AF ablation, n (%) 67 (14.2) 54 (11.4) Hypertension 263 (55.6) 208 (44.0) Diabetes mellitus 44 (9.3) 64 (13.5) CVATTA 42 (8.9) 19 (4.0) Valvular heart disease 86 (18.2) 50 (10.6) Other vascular diseases 86 (18.2) 50 (10.6) Other vascular diseases 17 (3.6) 7 (1.5) Peripheral embolism 6 (1.3) 13 (2.7) Renal impairment 70 (16.7) 9 (1.9) ICD or CRT 17 (3.6) 7 (1.5) PPM 50 (10.7) 9 (1.4) Midly impaired 35 (7.9) 39 (8.4) Moderately impaired 25 (5.2) 21 (4.5) Severely impaired 26 (3.3) 23 (4.9) Left atrial size, n (%) 148 (42.3) 156 (43.0) Midly impaired 15 (32.9) 1	
Previous AF ablation, n (%)121 (25.7)121 (25.7)CHA2DS2 VAS score, median [IQR]30 (30. 4.0)201 (0. 5.0]Prior history, n (%)67 (14.2)54 (11.4)Hypertension263 (55.6)208 (44.0)Diabetes mellitus44 (9.3)64 (13.5)CVATIA42 (8.9)19 (4.0)Valvalar heart disease86 (18.2)56 (11.8)Ischemic heart disease86 (18.2)50 (10.6)Other vascular diseases17 (3.6)13 (2.7)Renal impairment79 (16.7)27 (5.8)Indwelling CIED, n (%)71 (3.6)17 (3.6)VPM55 (80.5)382 (82.2)Middy impaired357 (89.0)382 (82.2)Middy impaired23 (5.2)21 (4.5)Severely impaired28 (5.3)23 (4.9)Left atrial size, n (%)115 (32.9)118 (32.5)Middy enlarged115 (32.9)118 (32.5)Middy enlarged27 (77.1)289 (61.9)Middy enlarged27 (77.1)289 (61.9)Crybalton, n (%)214 (60.1)28 (50.3)Crybalton, n (%)214 (60.1)23 (3.3)Crybalton, n (%)214	
CHA2DS2 VASc score, median [IQR]3.0 [3.0, 4.0]2.0 [1.0, 3.0]Prior history, n (%)CHF67 (14.2)54 (11.4)Diabetes mellitus67 (14.2)208 (44.0)Diabetes mellitus44 (9.3)64 (13.5)CVATIA42 (8.9)19 (4.0)Valvular heart disease65 (18.2)50 (11.8)Ischemic heart disease86 (18.2)50 (10.6)Other vascular diseases17 (3.6)7 (1.5)Peripheral embolism61 (1.3)31 (2.7)Renal impairment70 (16.7)27 (5.8)Indvelling CIED, n (%)713 (2.7)PPM50 (10.7)9 (19.1)CD or CRT17 (3.6)17 (3.6)LVEF, n (%)55 (80.5)382 (82.2)Middy impaired35 (7.9)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired15 (32.9)118 (32.5)Middy enlarged115 (32.9)118 (32.5)Middy enlarged115 (32.9)118 (32.5)Moderately enlarged22 (7.1)28 (6.19)Cryoballoon, n(%)22 (14.3)26 (17.4)Procedural characteristics146 (22.9)148 (38.1)Pulmonary venisolation acute success, n (%)21 (46.7)28 (50.0)Uninterrupted DOAC248 (06.7)152 (33.3)Additional LA lines145 (30.8)153 (30.9)Pulmonary venisolation acute success, n (%)214 (6.1)23 (3.2)Additional LA lines1	
Prior history, n (%)CHF67 (14.2)54 (11.4)Hypertension263 (55.6)208 (44.0)Diabetes mellius44 (9.3)64 (13.5)CVATIA42 (8.9)19 (4.0)Valvular heart disease86 (18.2)56 (11.8)Ischemic heart disease71 (3.6)71 (.5)Peripheral embolism6 (1.3)13 (2.7)Renal impairment70 (3.6)71 (.5)Indwelling CIED, n (%)71 (3.6)71 (.5)Pripheral embolism50 (10.7)9 (1.9)ICD or CRT17 (3.6)71 (.5)INOTRAN55 (80.5)382 (82.2)Mildly impaired355 (80.5)382 (82.2)Mildly impaired25 (50.5)382 (82.2)Lift atrial size, n (%)21 (4.5)21 (4.5)Severely impaired25 (50.5)382 (82.2)Mildly impaired35 (7.9)39 (8.4)Lift atrial size, n (%)21 (4.5)21 (4.5)Severely emaged26 (3.2)14 (4.5)Moderately enlarged115 (32.9)118 (32.5)Moderately enlarged20 (7.1)28 (9.6)Cryoballoon, n (%)22 (77.1)289 (61.9)Cryoballoon, n (%)22 (77.1)28 (9.6)Cryoballoon, n (%)214 (60.1)22 (3.3)Additional et atriat ensities118 (33.1)76 (16.7)Ininterrupted DAC24 (6.7)12 (3.3)Additional et atriat ablation, n (%)214 (60.1)22 (3.3)Additional et atriat ablation, n (%)21 (3.7)30 (3.6) <t< td=""><td>1</td></t<>	1
CHF67 (14.2)54 (11.4)Hypertension263 (55.6)208 (44.0)Diabetes mellius44 (9.3)64 (13.5)Diabetes mellius44 (9.3)19 (4.0)Valvular heart disease86 (18.2)56 (11.8)Ischemic heart disease86 (18.2)50 (10.6)Other vascular diseases17 (3.6)7 (1.5)Peripheral embolism6 (1.3)13 (2.7)Renal impairment79 (16.7)27 (5.8)Indwelling CIED, n (%)91 (1.7)9 (1.9)ICD or CRT17 (3.6)17 (3.6)ICD or CRT17 (3.6)17 (3.6)IVEF, n (%)91 (8.4)355 (80.5)382 (82.2)Middly impaired355 (80.5)382 (82.2)Moderately impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired155 (80.5)156 (43.0)Middly enlarged115 (32.9)118 (32.5)Moderately impaired20 (7.1)28 (61.9)Severely impaired26 (7.4)37 (1.0)Severely impaired26 (7.4)37 (1.0)Severely impaired28 (96.8)445 (99.3)Moderately enlarged16 (22.9)18 (38.1)Procedural characteristics14 (60.1)28 (60.0)Cryballoon, n(%)214 (60.1)22 (3.3)OAC, n (%)124 (60.1)22 (3.3)OAC, n (%)124 (60.1)22 (3.3)OAC, n (%)124 (60.1)22 (3.3)Additional L4 lines145 (0.8)123 (2.9)<	< 0.001
Hypertension263 (55.6)208 (44.0)Diabetes mellitus44 (9.3)64 (13.5)CVA/TIA42 (8.9)19 (4.0)Valvular heart disease86 (18.2)56 (11.8)Ischemic heart disease86 (18.2)50 (10.6)Other vascular diseases17 (3.6)7 (1.5)Peripheral embolism6 (1.3)13 (2.7)Renal impairment97 (16.7)97 (15.7)IDCD or CRT0 (10.7)9 (1.9)ICD or CRT7 (3.6)17 (3.6)LVEF, n (%)100.7)98 (8.4)Normal355 (80.5)382 (82.2)Middly impaired25 (7.9)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)23 (4.9)Left atrial size, n (%)115 (32.9)118 (32.5)Middly enlarged16 (17.4)25 (14.3)Severely inpaired26 (7.4)37 (10.2)Procedural characteristics148 (42.3)156 (43.0)Riddion, n (%)428 (96.8)45 (99.3)OAC, n (%)146 (22.9)18 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)45 (99.3)OAC, n (%)118 (33.1)28 (50.0)Uninterrupted DAC24 (6.7)12 (3.7)Interrupted OAC24 (6.7)12 (3.7)Additional LA lines44 (53.8)123 (29.0)PAU23 (30.8)123 (29.0)PAU23 (30.8)123 (29.0)PAU12 (37.7)30 (0.8)	
Dibates mellitus44 (9.3)64 (13.5)CVA/TIA42 (8.9)19 (4.0)Valvalar heart disease86 (18.2)56 (11.8)Schemic heart disease87 (13.6)7 (1.5)Peripheral embolism6 (1.3)13 (2.7)Renal impairment70 (16.7)27 (5.8)Indwelling CIED, n (%)17 (3.6)17 (3.6)ICD or CRT17 (3.6)9 (1.9)ICD or CRT17 (3.6)18 (2.2)Midly impaired25 (5.9)39 (8.4)Midly impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired15 (3.2.9)118 (32.5)Midly enlarged115 (32.9)118 (32.5)Midly enlarged115 (32.9)118 (32.5)Moderately enlarged227 (77.1)289 (6.19)Severely enlarged227 (77.1)289 (6.19)Croyballoon, n (%)227 (77.1)289 (6.19)Cryoballoon, n (%)227 (77.1)289 (6.19)Cryoballoon, n (%)227 (77.1)289 (6.19)Cryoballoon, n (%)24 (60.1)28 (50.0)Uninterrupted DOAC24 (60.1)28 (50.0)Uninterrupted DOAC24 (6.7)22 (3.3)Additional LA lines14 (43.3)76 (16.7)Interrupted OAC24 (6.7)3 (2.3)Additional LA lines123 (29.0)23 (29.0)PW23 (20.0)3 (2.3)Additional LA lines123 (29.0)3 (2.12.8)	0.21
CVA/TIA42 (8.9)19 (4.0)Valvular heart disease86 (18.2)56 (11.8)Ischemic heart disease86 (18.2)71 (1.5)Other vascular diseases71 (3.6)71 (1.5)Peripheral embolism61 (1.3)13 (2.7)Renal impairment79 (16.7)27 (5.8)Indwelling CIED, n (%)71 (3.6)71 (3.6)LVEF, n (%)17 (3.6)17 (3.6)LVEF, n (%)35 (80.5)382 (82.2)Mildly impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)23 (4.9)Left atrial size, n (%)115 (32.9)118 (32.5)Mildly enlarged115 (32.9)118 (32.5)Mormal148 (42.3)156 (43.0)Mildly enlarged115 (32.9)118 (32.5)Mormal (%)227 (77.1)289 (61.9)Severely enlarged61 (17.4)52 (14.3)Severely enlarged61 (17.4)28 (9.6)Procedural characteristics124 (60.1)28 (9.0)RF ablation, n (%)227 (77.1)289 (61.9)Cryoballoon, n(%)428 (96.8)445 (99.3)OAC, n (%)118 (33.1)76 (16.7)Uninterrupted DAC24 (6.7)12 (3.3)Uninterrupted OAC24 (6.7)12 (3.3)Additional LA lines44 (53.0)123 (29.0)Additional LA lines123 (29.0)23 (29.0)PWI23 (30.8)123 (29.0)PMI23 (30.8)23 (29.0)	< 0.001
Valvalar heart disease 86 (18.2) 56 (11.8) Ischemic heart disease 86 (18.2) 50 (10.6) Other vascular diseases 17 (3.6) 7 (1.5) Peripheral embolism 6 (1.3) 13 (2.7) Renal impairment 79 (16.7) 27 (5.8) Indwelling CIED, n (%) 9 (1.9) 17 (3.6) 7 (1.5) PPM 50 (10.7) 9 (1.9) 17 (3.6) 17 (3.6) ICD or CRT 17 (3.6) 17 (3.6) 17 (3.6) 17 (3.6) IVEF, n (%) Normal 35 (80.5) 382 (82.2) 39 (8.4) Moderately impaired 23 (5.2) 21 (4.5) 28 (8.2) Severely impaired 23 (5.2) 21 (4.5) 28 (8.2) Moderately impaired 23 (5.2) 118 (32.5) 160 (3.0) Mildly enlarged 115 (32.9) 118 (32.5) 160 (3.0) Mildly enlarged 115 (32.9) 118 (32.5) 160 (3.0) Moderately enlarged 61 (1.7) 28 (61.9) 160 (3.0) Procedural characteristics 18 (32.9) 18 (38.1)<	0.041
Ischemic heart disease 86 (18.2) 50 (10.6) Other vascular diseases 17 (3.6) 7 (1.5) Peripheral embolism 6 (1.3) 13 (2.7) Renal impairment 79 (16.7) 27 (5.8) Indwelling CIED, n (%) 9 9 (1.9) ICD or CRT 17 (3.6) 17 (3.6) LVEF, n (%) 70 (1.6) 90 (1.9) ICD or CRT 17 (3.6) 17 (3.6) LVEF, n (%) 382 (82.2) 31 (4.5) Midly impaired 35 (7.9) 39 (8.4) Moderately impaired 23 (5.2) 21 (4.5) Severely impaired 23 (5.2) 21 (4.5) Severely impaired 26 (7.4) 18 (32.5) Midly enlarged 115 (32.9) 118 (32.5) Midly enlarged 20 (7.4) 37 (10.2) Procedural characteristics 77 (1.1) 28 (6.19) Reablation, n (%) 327 (77.1) 28 (6.19) Cryballoon, n (%) 146 (22.9) 18 (43.1) Pulmonary vein isolation acute success, n (%) 428 (96.8) 445 (99.3) OC, n (%) 110 (33.1) 76 (16.7)	0.002
Other vascular diseases17 (3.6)7 (1.5)Peripheral embolism6 (1.3)13 (2.7)Renal impairment90 (16.7)27 (5.8)Indwelling CIED, n (%)50 (10.7)9 (1.9)ICD or CRT17 (3.6)17 (3.6)LVEF, n (%)17 (3.6)382 (82.2)Mildly impaired355 (80.5)382 (82.2)Mildly impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired15 (32.9)118 (32.5)Mildly enlarged61 (17.4)52 (14.3)Severely inpaired26 (7.4)37 (10.2)Procedural characteristics12 (77.1)289 (61.9)Readed characteristics21 (4.6)22 (14.3)Pulmonary vein isolation acute success, n (%)327 (77.1)289 (61.9)OAC, n (%)22 (80.0)18 (33.1)61 (6.7)Uninterrupted DOAC24 (6.7)22 (3.3)12 (3.3)Additional LA lines145 (30.8)123 (29.0)PWI12 (3.7)30.8)23 (29.0)PWI12 (3.7)30.8)23 (29.0)	0.006
Other vascular diseases17 (3.6)7 (1.5)Peripheral embolism6 (1.3)13 (2.7)Renal impairment90 (16.7)27 (5.8)Indwelling CIED, n (%)50 (10.7)9 (1.9)ICD or CRT17 (3.6)17 (3.6)LVEF, n (%)17 (3.6)382 (82.2)Normal355 (80.5)382 (82.2)Mildly impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)23 (4.9)Left atrial size, n (%)118 (32.5)118 (32.5)Middy enlarged61 (17.4)52 (14.3)Severely indrared26 (7.4)37 (10.2)Procedural characteristics12 (2.9)184 (38.1)R ablation, n (%)327 (77.1)289 (61.9)Cryoballoon, n(%)428 (96.8)445 (99.3)QC, n (%)118 (33.1)61 (6.7)Uninterrupted DOAC148 (33.1)76 (16.7)Interrupted OAC118 (33.1)76 (16.7)Interrupted OAC148 (50.8)123 (29.0)Additional LA lines145 (30.8)123 (29.0)PVI20.7)30.823 (29.0)	0.001
Peripheral embolism6 (1.3)13 (2.7)Renal impairment79 (16.7)27 (5.8)Indwelling CIED, n (%)PPM50 (10.7)9 (1.9)ICD or CRT17 (3.6)17 (3.6)LCD fr (%)17 (3.6)382 (82.2)Wormal355 (80.5)382 (82.2)Mildly impaired35 (7.9)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)23 (4.9)Left atrial size, n (%)115 (32.9)118 (32.5)Mildly enlarged115 (32.9)118 (32.5)Moderately enlarged61 (17.4)52 (14.3)Severely enlarged26 (7.4)37 (10.2)Procedural characteristics124 (60.1)28 (96.9)Cryoballoon, n(%)146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)425 (99.3)OAC, n (%)118 (33.1)76 (16.7)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted OAC214 (60.1)228 (50.0)Additional left atrial ablation, n (%)118 (33.1)76 (16.7)Additional left atrial ablation, n (%)123 (29.0)23 (29.0)PMI120 (30.7)30.8)23 (29.0)PMI120 (30.7)30.8)23 (29.0)	0.039
Renal impairment79 (16.7)27 (5.8)Indwelling CIED, n (%)PPM50 (10.7)9 (1.9)ICD or CRT50 (10.7)9 (1.9)ICD or CRT30 (0.7)30 (0.7)VEF, n (%)355 (80.5)382 (82.2)Normal355 (80.5)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)23 (4.9)Left artial size, n (%)156 (33.0)Mildly enlarged115 (32.9)118 (32.5)Moderately enlarged61 (17.4)52 (14.3)Severely enlarged26 (7.4)37 (10.2)Procedural characteristicsRr ablation, n (%)327 (77.1)289 (61.9)OAC, n (%)148 (0.1)228 (50.0)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted DOAC118 (33.1)76 (16.7)Interrupted OAC24 (67.)123 (3.9)Additional left atrial ablation, n (%)145 (30.8)123 (29.0)PMI20 AG145 (30.8)123 (29.0)PMI12 (3.7)3 (0.8)214 (20.7)PMI21 (2.3)30.8)213 (29.0)	0.105
Indeelling CIED, n (%) 50 (10.7) 9 (1.9) PPM 50 (10.7) 9 (1.9) ICD or CRT 17 (3.6) 17 (3.6) LVEF, n (%) 17 3.55 (80.5) 382 (82.2) Mildly inpaired 355 (80.5) 382 (82.2) 3.61 Mildly inpaired 23 (5.2) 21 (4.5) Severely impaired 28 (6.3) 23 (4.9) Left atrial size, n (%) 156 (43.0) 3.61 Normal 148 (42.3) 156 (43.0) Mildly enlarged 115 (32.9) 118 (32.5) Moderately enlarged 61 (17.4) 52 (14.3) Severely enlarged 62 (7.4) 37 (10.2) Procedural characteristics R R RF ablation, n (%) 327 (77.1) 289 (61.9) Cryoballoon, n(%) 146 (22.9) 184 (38.1) Pulmonary vein isolation acute success, n (%) 428 (96.8) 445 (99.3) OAC, n (%) 146 (22.9) 184 (38.1) Pulmonary vein isolation acute success, n (%) 428 (96.1) 228 (50.0) OAC, n (%) 118 (33.1) 76 (16.7) Uninterrupted DAC	< 0.001
PPM50 (10.7)9 (1.9)ICD or CRT17 (3.6)17 (3.6)LVEF, n (%)Normal355 (80.5)382 (82.2)Mildly impaired35 (7.9)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)33 (4.9)Left atrial size, n (%)Normal148 (42.3)156 (43.0)Mildly enlarged115 (32.9)118 (32.5)Moderately enlarged61 (17.4)52 (14.3)Severely enlarged62 (74.7)28 (96.9)Moderately enlarged327 (77.1)289 (61.9)Cryoballon, n (%)327 (77.1)289 (61.9)Cryoballon, n (%)428 (96.8)445 (99.3)OAC, n (%)146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%)214 (60.1)228 (50.0)Uninterrupted DACC118 (33.1)76 (16.7)Interrupted OAC183 (33.1)76 (16.7)Additional Left atrial ablation, n (%)145 (30.8)123 (29.0)Additional LA lines145 (30.8)123 (29.0)PWICAC64 (13.7)52 (12.8)	< 0.001
ICD or CRT17 (3.6)17 (3.6)LVEF, n (%)355 (80.5)382 (82.2)Normal35 (7.9)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)23 (4.9)Left atrial size, n (%)148 (42.3)156 (43.0)Midly enlarged115 (32.9)118 (32.5)Moderately enlarged61 (17.4)52 (14.3)Severely enlarged61 (17.4)52 (14.3)Severely enlarged26 (7.4)37 (10.2)Procedural characteristics146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)45 (99.3)OAC, n (%)118 (33.1)76 (16.7)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted OAC24 (6.7)152 (33.3)Additional LA lines145 (30.8)133 (29.0)PMI(20.7)3 (0.8)CFAE64 (13.7)52 (12.8)	
LVEF, n (%)Normal355 (80.5)382 (82.2)Mildly impaired35 (7.9)39 (8.4)Moderately impaired23 (5.2)21 (4.5)Severely impaired28 (6.3)23 (4.9)Left atrial size, n (%) X X Normal148 (42.3)156 (43.0)Mildly enlarged115 (32.9)118 (32.5)Moderately enlarged61 (17.4)52 (14.3)Severely enlarged26 (7.4)37 (10.2)Procedural characteristics X X RF ablation, n (%)327 (77.1)289 (61.9)Cryoballoon, $n(\%)$ 146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%) X Y Y Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted OAC24 (6.7)152 (33.3)Additional left atrial ablation, n (%) X Y Any additional LA lines145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	
Normal 355 (80.5) 382 (82.2) Mildly impaired 35 (7.9) 39 (8.4) Moderately impaired 23 (5.2) 21 (4.5) Severely impaired 28 (6.3) 23 (4.9) Left atrial size, n (%) Normal 148 (42.3) 156 (43.0) Mildly enlarged 115 (32.9) 118 (32.5) Moderately enlarged 61 (17.4) 52 (14.3) Severely enlarged 26 (7.4) 37 (10.2) Procedural characteristics 327 (77.1) 289 (61.9) Cryoballoon, n(%) 146 (22.9) 184 (38.1) 945 (99.3) Pulmonary vein isolation acute success, n (%) 24 (60.1) 228 (50.0) 210 (16.7) Uninterrupted DOAC 24 (67.7) 152 (33.3) 311 (16.7) 311 (16.7) 312 (29.0) Mitonal left atrial ablation, n (%) 24 (67.7) 152 (33.3) 312 (29.0) Mutitopal Left atrial ablation, n (%) 123 (29.0) 313 (29.0) 313 (29.0) PWI 12 (3.7) 3 (0.8) 32 (12.8)	0.765
Mildly impaired 35 (7.9) 39 (8.4) Moderately impaired 23 (5.2) 21 (4.5) Severely impaired 28 (6.3) 23 (4.9) Left atrial size, n (%)	
Moderately impaired 23 (5.2) 21 (4.5) Severely impaired 28 (6.3) 23 (4.9) Left atrial size, n (%)	
Severely impaired 28 (6.3) 23 (4.9) Left atrial size, n (%) 148 (42.3) 156 (43.0) Normal 148 (42.3) 156 (43.0) Mildly enlarged 115 (32.9) 118 (32.5) Moderately enlarged 61 (17.4) 52 (14.3) Severely enlarged 26 (7.4) 37 (10.2) Procedural characteristics 777.1) 289 (61.9) RF ablation, n (%) 327 (77.1) 289 (61.9) Cryoballoon, n(%) 146 (22.9) 184 (38.1) Pulmonary vein isolation acute success, n (%) 428 (96.8) 45 (99.3) OAC, n (%) 214 (60.1) 228 (50.0) Uninterrupted DOAC 24 (6.7) 152 (33.3) Additional Left atrial ablation, n (%) 24 (6.7) 152 (33.3) Additional Left atrial ablation, n (%) 145 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	
Left atrial size, n (%) 148 (42.3) 156 (43.0) Normal 115 (32.9) 118 (32.5) Moderately enlarged 61 (17.4) 52 (14.3) Severely enlarged 26 (7.4) 37 (10.2) Procedural characteristics 327 (77.1) 289 (61.9) Cryoballoon, n(%) 327 (77.1) 289 (61.9) Pulmonary vein isolation acute success, n (%) 428 (96.8) 445 (99.3) OAC, n (%) 118 (33.1) 76 (16.7) Uninterrupted DOAC 24 (6.7) 152 (33.3) Additional left atrial ablation, n (%) 24 (6.7) 152 (33.3) Additional LA lines 145 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	
Normal148 (42.3)156 (43.0)Mildly enlarged115 (32.9)118 (32.5)Moderately enlarged61 (17.4)52 (14.3)Severely enlarged26 (7.4)37 (10.2)Procedural characteristics27 (77.1)289 (61.9)Cryoballoon, n(%)146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%)214 (60.1)228 (50.0)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted VKA118 (33.1)76 (16.7)Interrupted OAC24 (67.7)123 (23.3)Additional left atrial ablation, n (%)145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	0.449
Mildly enlarged115 (32.9)118 (32.5)Moderately enlarged61 (17.4)52 (14.3)Severely enlarged26 (7.4)37 (10.2)Procedural characteristics27 (77.1)289 (61.9)Cryoballoon, n(%)327 (77.1)289 (61.9)Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%)214 (60.1)228 (50.0)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted VKA118 (33.1)76 (16.7)Interrupted OAC24 (6.7)152 (33.3)Additional left atrial ablation, n (%)145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	
Moderately enlarged61 (17.4)52 (14.3)Severely enlarged26 (7.4)37 (10.2)Procedural characteristics289 (61.9)RF ablation, n (%)327 (77.1)289 (61.9)Cryoballoon, n(%)146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%)214 (60.1)228 (50.0)Uninterrupted DOAC118 (33.1)76 (16.7)Interrupted OAC24 (6.7)152 (33.3)Additional left atrial ablation, n (%)145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	
Severely enlarged 26 (7.4) 37 (10.2) Procedural characteristics 327 (77.1) 289 (61.9) RF ablation, n (%) 327 (77.1) 289 (61.9) Cryoballoon, n(%) 146 (22.9) 184 (38.1) Pulmonary vein isolation acute success, n (%) 428 (96.8) 445 (99.3) OAC, n (%) 118 (33.1) 228 (50.0) Uninterrupted DOAC 214 (60.1) 228 (50.0) Uninterrupted OAC 24 (6.7) 152 (33.3) Additional left atrial ablation, n (%) 415 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	
Procedural characteristics RF ablation, n (%) 327 (77.1) 289 (61.9) Cryoballoon, n(%) 146 (22.9) 184 (38.1) Pulmonary vein isolation acute success, n (%) 428 (96.8) 445 (99.3) OAC, n (%) 214 (60.1) 228 (50.0) Uninterrupted DOAC 214 (60.1) 228 (50.0) Uninterrupted VKA 118 (33.1) 76 (16.7) Interrupted OAC 24 (6.7) 152 (33.3) Additional left atrial ablation, n (%) 145 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	
RF ablation, n (%)327 (77.1)289 (61.9)Cryoballoon, n(%)146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%)214 (60.1)228 (50.0)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted VKA118 (33.1)76 (16.7)Interrupted OAC24 (6.7)152 (33.3)Additional left atrial ablation, n (%)145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	
Cryoballoon, n(%)146 (22.9)184 (38.1)Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted VKA118 (33.1)76 (16.7)Interrupted OAC24 (6.7)152 (33.3)Additional left atrial ablation, n (%)Any additional LA lines145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	< 0.001
Pulmonary vein isolation acute success, n (%)428 (96.8)445 (99.3)OAC, n (%)214 (60.1)228 (50.0)Uninterrupted DOAC214 (60.1)228 (50.0)Uninterrupted VKA118 (33.1)76 (16.7)Interrupted OAC24 (6.7)152 (33.3)Additional left atrial ablation, n (%)145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	0.001
OAC, n (%) Uninterrupted DOAC 214 (60.1) 228 (50.0) Uninterrupted VKA 118 (33.1) 76 (16.7) Interrupted OAC 24 (6.7) 152 (33.3) Additional left atrial ablation, n (%) 145 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	0.006
Uninterrupted DOAC 214 (60.1) 228 (50.0) Uninterrupted VKA 118 (33.1) 76 (16.7) Interrupted OAC 24 (6.7) 152 (33.3) Additional left atrial ablation, n (%) 52 (32.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	< 0.001
Uninterrupted VKA 118 (33.1) 76 (16.7) Interrupted OAC 24 (6.7) 152 (33.3) Additional left atrial ablation, n (%) 145 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	0.001
Interrupted OAC 24 (6.7) 152 (33.3) Additional left atrial ablation, n (%) 145 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	
Additional left atrial ablation, n (%) Any additional LA lines 145 (30.8) 123 (29.0) PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	
Any additional LA lines145 (30.8)123 (29.0)PWI12 (3.7)3 (0.8)CFAE64 (13.7)52 (12.8)	
PWI 12 (3.7) 3 (0.8) CFAE 64 (13.7) 52 (12.8)	0.562
CFAE 64 (13.7) 52 (12.8)	0.011
	0.708
V_{0} (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	
-	0.438 0.868
Procedure time, min, median [IQR] 129.5 [90.0, 180.0] 130.0 [90.0, 180.0] Acute complication, n (%) 54 (11.4) 33 (7.0)	
Acute complication, n (%)54 (11.4)33 (7.0)Follow-up characteristics	0.018
AAD on 12-month follow-up, <i>n</i> (%)	0.151

	Octogenarians	Non-octogenarians	р
Flecainide or propafenone	20 (5.6)	10 (2.5)	
Amiodarone or dronedarone	17 (4.8)	24 (6.0)	
Sotalol	9 (2.5)	9 (2.2)	
Maximum rhythm monitoring during follow-up, <i>n</i> (%)			
CIED or ILR	75 (18.8)	28 (6.2)	
Holter or event recorder	133 (33.4)	205 (45.5)	
12 lead ECG	172 (43.2)	193 (42.8)	
Reported symptoms only	18 (4.5)	25 (5.5)	
Recurrence of atrial arrhythmia, n (%)			0.037
Atrial fibrillation	56 (12.9)	48 (11.2)	
Atrial tachycardia	35 (8.1)	18 (4.2)	
Recurrence documentation based only on symptoms, n (%)	5 (12.5)	3 (6.7)	0.358
Ablation for atrial arrhythmia on follow-up	71 (18.5)	105 (25.0)	0.026

AAD antiarrhythmic drugs, BMI body mass index, CHF congestive heart failure, CI confidence interval, CIED cardiovascular implantable electronic device, CFAE complex fractionated atrial electrogram, CVA/TIA cerebrovascular accident/transient ischemic attack, DOAC direct oral anticoagulant, ILR implantable loop recorder, IQR interquartile range, LVEF left ventricular ejection fraction, PWI posterior wall isolation, VKA vitamin K antagonist

follow-up time was significantly shorter for octogenarians at 281 [106, 365] days compared to non-octogenarians having a median follow-up of 354 [220, 365] days (p < 0.001). Over the 365-days follow-up period, 131 (28%) of the octogenarians had AF recurrence vs. 111 (23%) nonoctogenarians. AF recurrence based purely on symptom assessment with no documentation on ECG was observed in 5 (12.5%) patients in the octogenarians group and in 3 (3.7%) patients in the non-octogenarian group (p = 0.466). Octogenarians were at increased risk of atrial arrhythmia recurrence (odds ratio 1.49, 95% CI 1.15–1.92; p = 0.002; Fig. 1). Predefined subgroup analyses showed consistent results in 9 of 9 subgroups (interaction p-value = ns for all predefined subgroups, including patients with paroxysmal vs. non-paroxysmal AF (Supplemental Table 3)).

Previous AF ablation was more common in the group of octogenarian patients with recurrence of atrial arrhythmia (45 (34.4%) vs. 76 (22.4%), p=0.008). After excluding patients with previous AF ablation, 86 (24.6%) of the octogenarians had AF recurrence vs. 73 (20.9%) non-octogenarians, odds ratio 1.429, 95% CI 1.046–1.952; p=0.025 (Fig. 2).

Supplemental Table 4 illustrates the patients' characteristics according to their recurrence of arrhythmia status for the 365day follow-up. Patients who had a recurrence of arrhythmia

Fig. 1 Recurrence of atrial arrhythmia throughout 12-month follow-up in octogenarian and non-octogenarian patients plotted in Kaplan-Meier curves. Recurrence of atrial arrhythmia after an initial blanking period of 90 days (for detailed definition, see 5. Definition of atrial arrhythmia recurrence during 12-month follow-up); through day 365, the median follow-up time until reaching an event, completion of 365 follow-up, or patient lost to follow-up was 281 [106, 365] vs. 354 [220, 365] days for octogenarians vs. non-octogenarians (p < 0.001). CI, confidence interval

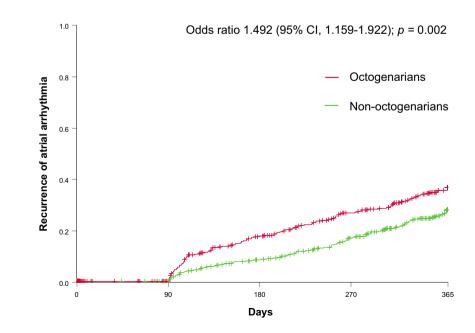
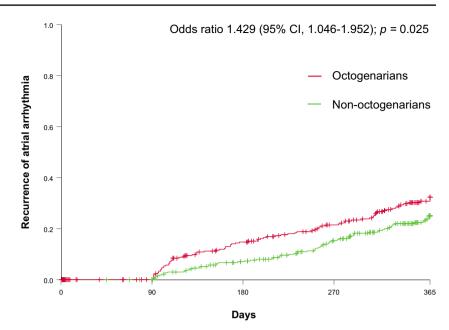


Fig. 2 Recurrence of atrial arrhythmia throughout 12-month follow-up in octogenarian and non-octogenarian patients after de novo atrial fibrillation ablation plotted in Kaplan–Meier curves. Recurrence of atrial arrhythmia after an initial blanking period of 90 days (for detailed definition, see 5. *Definition of atrial arrhythmia recurrence during 12-month follow-up*). CI, confidence interval



within the 365-day follow-up were older (80.0 [66.0, 82.0] vs. 77.0 [63.4, 81.0] years, p = 0.031), had a higher proportion of females (123 (50.8%) vs. 300 (42.6%), p = 0.027), and more often had a history of previous atrial fibrillation ablation (81 (33.8%) vs. 161 (22.9%), p = 0.001). Patients' characteristics of octogenarians with and without recurrence of atrial arrhythmia are presented in Supplemental Table 5.

All patients' characteristics described in Table 1 were entered into univariable Cox proportional hazards models to predict the recurrence of atrial arrhythmia throughout 365 days of follow-up. Significant variables for the model were then entered into a multivariable Cox proportional hazards model (including age over 80). Tables 2 and 3 present the results for the overall cohort; Tables 4 and 5 present the results for the subgroup of octogenarians. In the multivariable model for

Table 2 Predictors of atrial arrhythmia recurrence throughout12-month follow-up in the overall cohort

	Multivariable analysis*			
Variables	Odds ratio (95% CI)	р		
Octogenarian	1.473 (95% CI 1.011–2.147)	0.044		
Female gender	1.543 (95% CI1.116-2.133)	0.009		
Previous atrial fibrilla- tion ablation	1.843 (95% CI 1.349–2.517)	< 0.001		
Vascular disease**	2.194 (95% CI 1.109-4.339)	0.024		
Left atrial dilatation	1.381 (95% CI 1.010–1.889)	0.043		

*250 cases with missing values and not considered for the multivariable analysis

**Vascular disease other than coronary artery disease or CVA/TIA

 $C\!I$ confidence interval, $CV\!A/TI\!A$ cerebrovascular accident/transient ischemic attack

the overall cohort, among other variables, age over 80 was an independent predictor for atrial arrhythmia recurrence (odds ratio 1.47 (95% CI 1.01–2.15), p=0.044). In the multivariable analysis in the subgroup of octogenarians, female gender and previous AF ablation were independent predictors for recurrence of atrial arrhythmia (odds ratio 1.44 (95% CI 1.02–2.04) p=0.041 and odds ratio 1.88 (95% CI 1.31–2.69, p=0.001, respectively). Type of AF did not emerge as an independent predictor of AF recurrence in the multivariable models.

3.4 Sensitivity analysis

When excluding cases where AF recurrence was assessed solely based on symptoms without ECG documentation, octogenarians demonstrated significantly higher recurrence rates, with an odds ratio of 1.45 (95% CI 1.11–1.88, p=0.006). Similarly, when patients without any ECG follow-up were excluded, the recurrence rates among octogenarians were found to be higher, evidenced by an odds ratio of 1.44 (95% CI 1.11–1.88, p=0.006).

4 Discussion

This primary analysis within a large retrospective, international study aimed to evaluate the long-term outcomes of catheter ablation for atrial fibrillation in octogenarian vs. non-octogenarian patients. Among patients with paroxysmal and non-paroxysmal atrial fibrillation receiving a catheterbased therapy, age over 80 was associated with significantly higher atrial arrhythmia recurrence rates throughout 365 days of follow-up. Notably, the median follow-up duration was considerably shorter in the octogenarian group,

	Univariable analysis		Multivariable analysis*		
Variables	Odds ratio (95% CI)	р	Odds ratio (95% CI)	р	
Previous atrial fibrillation ablation	1.673 (95% CI 1.280–2.186)	< 0.001	1.823 (95% CI 1.333-2.492)	< 0.001	
Female gender	1.435 (95% CI 1.116-1.847)	0.005	1.597 (95% CI 1.147-2.224)	0.006	
Other vascular disease**	2.461 (95% CI 1.377-4.400)	0.002	2.179 (95% CI 1.101-4.315)	0.025	
Octogenarian	1.492 (95% CI 1.159–1.922)	0.002	1.470 (95% CI 1.009-2.142)	0.045	
Left atrial dilatation	1.402 (95% CI 1.040-1.891)	0.027	1.348 (95% CI 0.982-1.851)	0.064	
Chronic kidney disease	1.633 (95% CI 1.155-2.309)	0.006	1.266 (95% CI 0.816-1.965)	0.292	
CIED at baseline—any CIED	1.605 (95% CI 1.112-2.318)	0.012	1.301 (95% CI 0.840-2.017)	0.239	
Type of AF at baseline—PAF	0.900 (95% CI 0.698-1.159)	0.414	0.857 (95% CI 0.625-1.174)	0.337	
CHAD2S2 VASC score	1.108 (95% CI 1.025-1.197)	0.010	0.950 (95% CI 0.835-1.081)	0.438	

 Table 3
 Predictors of atrial arrhythmia recurrence throughout 12-month follow-up in the overall cohort, including atrial fibrillation type on multivariable analyses

*250 cases with missing values and not considered for the multivariable analysis

**Vascular disease other than coronary artery disease or CVA/TIA

CI confidence interval, CIED cardiovascular implantable electronic device, CVA/TIA cerebrovascular accident/transient ischemic attack, PAF paroxysmal atrial fibrillation

 Table 4
 Predictors of atrial arrhythmia recurrence throughout 12-month follow-up in octogenarians

	Multivariable analysis*			
Variables	Odds ratio (95% CI)	р		
Female gender	1.438 (95% CI 1.015–2.038)	0.041		
Previous atrial fibrillation ablation	1.877 (95% CI 1.307–2.694)	< 0.001		

*2 cases with missing values and not considered for the multivariable analysis

CI confidence interval

which contributes to the less marked apparent difference in the raw event numbers observed.

The disparity in long-term success rates of catheter ablation among octogenarians can be attributed to several factors. This age group typically presents with a higher prevalence of comorbidities and established risk factors for atrial fibrillation, implying a greater likelihood of atrial scarring and a pro-arrhythmic substrate [18, 19]. Additionally, the presence of extra-pulmonary atrial fibrillation triggers have been shown to be more common in octogenarians [20, 21]. Notably, continuous rhythm monitoring with an indwelling permanent pacemaker, ICD, or ILR was more common among octogenarians, and one might expect this to explain the higher detection rates of atrial arrhythmia within this age group [22]. Nevertheless, in a multivariable model for predicting the recurrence of atrial arrhythmia demonstrated that age over 80 was an independent predictor of recurrence, while the presence of an indwelling permanent pacemaker, ICD, or ILR at the time of the procedure was not.

Additionally, the demographic analysis revealed a predominance of females in the octogenarian group. This gender difference may be explained by the generally higher life expectancy and relatively better health status of females, making them more likely to undergo interventions at older age.

The procedural complication rate was higher in octogenarians compared to younger patients. The main complications observed were related to vascular access, bleeding, and cardiac tamponade. These complications are more common in older adults due to increased frailty and comorbidities.

In our multivariable analysis, several factors such as age over 80 and previous AF ablation were independent predictors of AF

 Table 5
 Univariable and multivariable predictors of atrial arrhythmia recurrence throughout 12-month follow-up, considering type of atrial fibrillation at baseline

	Univariable analysis		Multivariable analysis*		
Variables	Odds ratio (95% CI)	p	Odds ratio (95% CI)	р	
Female gender	1.463 (95% CI 1.033–2.073)	0.032	1.434 (95% CI 1.007–2.042)	0.046	
Previous atrial fibrillation ablation	1.883 (95% CI 1.312-2.703)	0.001	1.878 (95% CI 1.308-2.698)	< 0.001	
Type of AF at baseline—PAF	1.053 (95% CI 0.747-1.484)	0.769	1.017 (95% CI 0.718-1.441)	0.922	

*2 cases with missing values and not considered for the multivariable analysis

CI confidence interval; PAF paroxysmal atrial fibrillation

recurrence. Although type of AF (paroxysmal vs. non-paroxysmal) was considered in our analyses, it did not independently predict AF recurrence, indicating that other factors may play a more significant role in recurrence risk among octogenarians.

This study substantiates and builds upon previous research regarding atrial fibrillation ablation in patients over 80. [9, 11–14, 23, 24] Previous trials, while informative, involved a relatively small number of octogenarian patients. These studies suggested comparable long-term outcomes regarding arrhythmia recurrence among octogenarians and non-octogenarians. However, due to the limited sample size in these studies, comparisons should be made with care, as neutral results could be partially attributed to a lack of statistical power. A prior meta-analysis suggested limited efficacy of AF ablation in patients over 75, but due to insufficient statistical power and data inconsistency within the octogenarian group, no specific conclusions could be drawn for this age group. [25]

Importantly, this study is the first of its kind, being a large, multicentre, international cohort exploring the outcomes of AF ablation in octogenarian vs. non-octogenarian patients. It not only examined a representative sample of both octogenarian and non-octogenarian patients but also considered recent advances in catheter ablation technology.

However, the study also bears some limitations. Primarily, the results are particular to octogenarians deemed suitable for PVI. The sample size also varied substantially across different participating centres, reflecting diverse eligibility criteria and thresholds for performing AF ablation in octogenarians across different hospitals. Further prospective studies are warranted to clarify the selection criteria for this age group. Despite efforts to minimise confounding factors through matching and multivariable regression analyses, some confounders may still exist. In a small subset of both octogenarians and nonoctogenarians, arrhythmia recurrence was identified through typical symptoms reported and the treating physician's judgement. While introducing a subjective element, the few recurrences diagnosed by this criterion did not affected the study's overall findings as demonstrated in the sensitivity analyses that excluded these patients. One significant limitation of this study is the shorter median follow-up duration in the octogenarian group compared to the control group, with the follow-up period being approximately 20% shorter for octogenarians. This difference in follow-up duration is due to routine clinical followup procedures in observational settings, which could lead to shorter follow-up times in older patients who might have more frequent health issues or mobility constraints affecting their adherence to follow-up schedules. Although Cox regression and Kaplan-Meier analyses were used, employing censoring to deal with patients lost to follow-up, the shorter follow-up may still introduce bias by potentially underestimating the recurrence rates of atrial arrhythmia in this age group. To mitigate this bias, future prospective studies should strive to match follow-up durations more closely between age groups, ensuring

more accurate comparisons. Despite this limitation, the higher observed recurrence rates in octogenarians are consistent with clinical expectations, suggesting that even with longer followup, the increased recurrence in older patients would likely persist. Additionally, potential selection bias should be considered. Octogenarians selected for catheter ablation in this study may have fewer comorbidities compared to the broader octogenarian population, which could limit the generalizability of our findings. Furthermore, while this manuscript provides an overview of procedural complications, a detailed examination of these complications is beyond the scope of the current analysis focused on long-term outcomes. A separate, in-depth analysis of the short-term outcomes and safety of AF catheter ablation in octogenarians is warranted to fully address the procedural risks associated with this intervention. This study predated the advent of Pulsed Field Ablation (PFA). Data was collected during a period of considerable advancements in cardiac ablation technology. Although technological diversity may have affected our findings, technological advancements should have similarly impacted the outcomes of both octogenarians and younger controls. Notably, beyond arrhythmia recurrence rates, the effect of AF on of cardiac function and quality of life in octogenarians must be addressed in future research. Importantly, while the primary outcome focuses on arrhythmia recurrence rates, the broader implications of AF ablation on cardiac function and quality of life in octogenarians warrant further investigation. Despite observing higher recurrence rates, AF ablation demonstrated favourable outcomes in this age group. Future research is needed to evaluate its impact on quality of life and patientreported outcomes, particularly when comparing catheter ablation to the use of antiarrhythmic drugs, in octogenarians mostly limited to amiodarone, which is noted for its challenging safety and tolerance profile in this frail patient population.

In summary, our large international study comparing the outcomes of octogenarians vs. non-octogenarians undergoing catheter ablation for AF suggests that octogenarians experience higher recurrence rates of atrial arrhythmia and the potential causes behind this are multifactorial and need further study. Despite this, the long-term success rates for octogenarian patients are promising, affirming that AF ablation can be an effective treatment option for select individuals within this age group. Future research should focus on further refining patient selection criteria for this procedure in the octogenarian population, considering individual patient risk factors and the potential for improved quality of life and patient reported outcomes.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10840-024-01879-8.

Acknowledgements We would like to thank the patients who participated in the study, the staff of the participating cardiology departments, the research coordinators, and the laboratory technicians for their most valuable efforts. **Funding** Open access funding provided by University of Bern. Dr. Kozhuharov acknowledges research grants from the Swiss National Science Foundation (grant Nr P400PM-194477 and grant Nr P5R5PM_210856), Gottfried und Julia Bangerter-Rhyner-Stiftung, Freiwillige Akademische Gesellschaft, L. & Th. La Roche Stiftung, and the European Society of Cardiology.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

- Romero J, Ogunbayo G, Elayi SC, Darrat Y, Rios SA, Diaz JC, et al. Safety of catheter ablation for atrial fibrillation in the octogenarian population. J Cardiovasc Electrophysiol Blackwell Publishing Inc. 2019;30:2686–93.
- Hindricks G, Potpara T, Dagres N, Bax JJ, Boriani G, Dan GA, 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;42:373–498.
- Calkins H, Hindricks G, Cappato R, Kim Y-H, 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. J Arrhythm. 2017;33:369–409.
- Siontis KC, Ioannidis JPA, Katritsis GD, Noseworthy PA, Packer DL, Hummel JD, et al. Radiofrequency ablation versus antiarrhythmic drug therapy for atrial fibrillation meta-analysis of quality of life, morbidity, and mortality. JACC Clin Electrophysiol Elsevier. 2016;2:170–80.
- Parameswaran R, Al-Kaisey AM, Kalman JM. Catheter ablation for atrial fibrillation: current indications and evolving technologies. Nat Rev Cardiol Nature Publishing Group. 2021;18:210–25.
- 6. Lloyd-Jones DM, Wang TJ, Leip EP, Larson MG, Levy D, Vasan RS, et al. Lifetime risk for development of atrial fibrillation: the framingham heart study. Circulation. 2004;110:1042–6.
- Go AS, Hylek EM, Phillips KA, Chang Y, Henault LE, Selby JV, et al. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the AnTicoagulation and Risk Factors In Atrial Fibrillation (ATRIA) study. JAMA Am Med Assoc. 2001;285:2370–5.
- Krijthe BP, Kunst A, Benjamin EJ, Lip GYH, Franco OH, Hofman A, et al. Projections on the number of individuals with atrial fibrillation in the European Union, from 2000 to 2060. Eur Heart J Eur Heart J. 2013;34:2746–51.
- Bunch TJ, Weiss JP, Crandall BG, May HT, Bair TL, Osborn JS, et al. Long-term clinical efficacy and risk of catheter ablation for atrial fibrillation in octogenarians. PACE - Pacing Clin Electrophysiol John Wiley & Sons, Ltd. 2010;33:146–52.

- Santangeli P, Di BL, Al-Ahmad A, Horton R, Burkhardt JD, Sanchez JE, et al. Ablation for atrial fibrillation: termination of atrial fibrillation is not the end point. Card Electrophysiol Clin Card Electrophysiol Clin. 2012;4:343–52.
- Santangeli P, Di BL, Mohanty P, Burkhardt JD, Horton R, Bai R, et al. Catheter ablation of atrial fibrillation in octogenarians: safety and outcomes. J Cardiovasc Electrophysiol John Wiley & Sons, Ltd. 2012;23:687–93.
- Tan HW, Wang XH, Shi HF, Yang GS, Zhou L, Gu JN, et al. Efficacy, safety and outcome of catheter ablation for atrial fibrillation in octogenarians. Int J Cardiol Elsevier Ireland Ltd. 2010;145:147–8.
- Liu YY, Du X, He L, Liu T, Chen N, Hu R, et al. Evaluation of safety and effectiveness of catheter ablation of atrial fibrillation in patients aged ≥80 years. Heart Lung Circ Heart Lung Circ. 2022;31:1006–14.
- Lawin D, Lawrenz T, Chun KRJ, Lim HE, Obidigbo V, Selma JM, et al. Cryoballoon ablation of atrial fibrillation in octogenarians: one year outcomes from the cryo global registry. Journal of Interventional Cardiac Electrophysiology. 2023. https:// doi.org/10.1007/s10840-023-01680-z
- 15. Chen J, for the Scientific Initiative Committee EHRA, Hocini M, for the Scientific Initiative Committee EHRA, Larsen TB, for the Scientific Initiative Committee EHRA, et al. Clinical management of arrhythmias in elderly patients: results of the European Heart Rhythm Association survey. EP Europace Oxford Academic. 2015;17:314–7.
- von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Int J Surg. 2014;12:1495.
- 17. Andrade JG. Cryoablation for atrial fibrillation. Heart Rhythm O2 Elsevier. 2020;1:44–58.
- 18. Bin Lin K, Chen KK, Li S, Cai MQ, Yuan MJ, Wang YP, et al. Impaired left atrial performance resulting from age-related arial fibrillation is associated with increased fibrosis burden: insights from a clinical study combining with an in vivo experiment. Front Cardiovasc Med. 2021;7:615065.
- Calvert P, Lip GYH, Gupta D. Radiofrequency catheter ablation of atrial fibrillation: a review of techniques. Trends Cardiovasc Med. 2023;33:405.
- Yang SY, Cha M-J, Oh HJ, Cho MS, Kim J, Nam G-B, et al. Role of non-pulmonary vein triggers in persistent atrial fibrillation. Int J Arrhythmia. 2023;24:7.
- Della RDG, Tarantino N, Trivedi C, Mohanty S, Anannab A, Salwan AS, et al. Non-pulmonary vein triggers in nonparoxysmal atrial fibrillation: implications of pathophysiology for catheter ablation. J Cardiovasc Electrophysiol. 2020;31:2154.
- Wechselberger S, Kronborg M, Huo Y, Piorkowski J, Neudeck S, Päßler E, et al. Continuous monitoring after atrial fibrillation ablation: the LINQ AF study. EP Europace Europace. 2018;20:f312–20.
- 23. Kanda T, Masuda M, Kurata N, Asai M, Iida O, Okamoto S, et al. Efficacy and safety of the cryoballoon-based atrial fibrillation ablation in patients aged ≥80 years. J Cardiovasc Electrophysiol J Cardiovasc Electrophysiol. 2019;30:2242–7.
- Tabaja C, Younis A, Santangeli P, Madden R, Taigen T, Farwati M, Hayashi K, Braghieri L, Rickard J, Klein BM, Paul A, Dresing TJ, Martin DO, Bhargava M, Kanj M, Sroubek J, Nakagawa H, Saliba WI, Wazni OM, Hussein AA. Catheter ablation of atrial fibrillation in elderly and very elderly patients: safety, outcomes, and quality of life. Journal of Interventional Cardiac Electrophysiology; 2024;67(5):1083–1092. https://doi.org/10. 1007/s10840-023-01659-w. Epub 17 Oct 2023.

25. Lee W-C, Wu P-J, Chen H-C, Fang H-Y, Liu P-Y, Chen M-C. Efficacy and safety of ablation for symptomatic atrial fibrillation in elderly patients: a meta-analysis. Front Cardiovasc Med Frontiers. 2021;8:734204.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Authors and Affiliations

Additional investigators and contributors to this manuscript to be listed in PUBMED include the following:

Dr. Steve Furniss, MD, Eastbourne District General Hospital, Eastbourne, UK.

- Nikola Kozhuharov Nikola.Kozuharov@insel.ch
- Dhiraj Gupta Dhiraj.Gupta@lhch.nhs.uk
- ¹ Liverpool Heart and Chest Hospital NHS Foundation Trust, Liverpool, UK
- ² Inselspital, University Hospital Bern, Bern, Switzerland
- ³ Royal Brompton Hospital, London, UK
- ⁴ Harefield Hospital, London, UK
- ⁵ The Barts Heart Centre, London, UK
- ⁶ . George's Hospital, London, UK

- ⁷ Eastbourne District General Hospital, Eastbourne, UK
- ⁸ Queen Elizabeth Hospital Birmingham, Birmingham, UK
- ⁹ University Hospitals Dorset, Bournemouth, UK
- ¹⁰ Oxford University Hospitals, Oxford, UK
- ¹¹ University Hospitals Southampton, Southampton, UK
- ¹² University Hospital Basel, Basel, Switzerland
- ¹³ Bordeaux University Hospital, Bordeaux, France
- ¹⁴ Royal Papworth Hospital, Cambridge, UK

Nikola Kozhuharov^{1,2} · Nabeela Karim^{3,4} · Antonio Creta⁵ · Lisa W. M. Leung⁶ · Rick Veasey⁷ · Armin Osmanagic⁸ · Anna Kefala⁹ · Mike Pope^{10,11} · Apostolos Vouliotis¹¹ · Sven Knecht¹² · Philipp Krisai^{12,13} · Pierre Jaïs¹³ · Claire Martin¹⁴ · Christian Sticherling¹¹ · Matthew Ginks¹⁰ · Waqas Ullah¹¹ · Richard Balasubramaniam⁹ · Manish Kalla⁸ · Mark M. Gallagher⁶ · Ross J. Hunter⁵ · Tom Wong^{3,4} · Dhiraj Gupta¹