Should concomitant surgical ablation for atrial fibrillation be performed in elderly patients?

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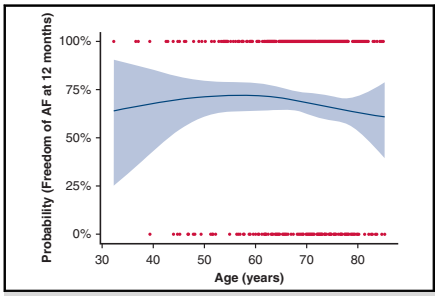
ABSTRACT

Objective: The incidence of atrial fibrillation increases with age, and therefore many elderly patients presenting for cardiac surgery have atrial fibrillation. In recent publications, increasing age has been recognized as a predictor for ablation failure. Furthermore, many surgeons are reluctant to perform a surgical ablation in elderly patients. We investigated the safety and efficacy of concomitant surgical atrial fibrillation ablation in elderly patients.

Methods: Between 2003 and 2013, 556 patients underwent concomitant surgical atrial fibrillation ablation at the University Heart Center Hamburg and served as our primary study cohort. During follow-up, rhythm monitoring was established by 24-hour Holter electrocardiogram (70.5%) or an implantable loop recorder (29.5%) at 3, 6, and 12 months postoperatively. The primary end point of the study was freedom from atrial fibrillation at 12 months follow-up and the detection of deviations from a linear association between age and risk of atrial fibrillation recurrence. A multiple logistic regression model including age as a linear term was used to identify predictors for rhythm outcome.

Results: Mean patients' age was 68.4 ± 9.07 years, and 67.3% of the patients were male. Mean duration of atrial fibrillation was 3.5 ± 3.3 years, and mean left atrium diameters were enlarged with 50.5 ± 8.8 mm. There were no major ablation-related complications. The 30-day and 1-year survivals were 97.7% and 95.8%, respectively. The overall rate of freedom from atrial fibrillation ranged from 62% to 72% and was independent of age. The age-dependent risk of atrial fibrillation at 12 months was significantly increased in elderly patients undergoing a concomitant coronary artery bypass grafting surgery. Multiple logistic regression model revealed double valve procedures (odds ratio, 3.48; $P = .020$), preoperative persistent atrial fibrillation (odds ratio, 2.43; $P = .001$), and coronary artery bypass grafting surgery in elderly patients (odds ratio, 2.03; $P = .009$) as risk factors for recurrence of atrial fibrillation. Sinus rhythm at discharge (odds ratio, 0.39; $P < .001$) and bipolar ablation (odds ratio, 0.32; $P < .001$) were significant predictors for successful ablation.

Conclusions: Surgical atrial fibrillation ablation was safe and effective independently of age. Sinus rhythm at discharge and bipolar ablation were significant predictors for successful ablation, whereas double valve procedures, preoperative persistent atrial fibrillation, and coronary artery bypass grafting surgery in elderly patients were risk factors for recurrence of atrial fibrillation. (J Thorac Cardiovasc Surg 2021;161:1816-23)



Age-dependent freedom of AF at 12 months.

CENTRAL MESSAGE

Surgical AF ablation is safe and effective independently of age. Double valve procedures, preoperative persistent AF, and CABG surgery in elderly patients are risk factors for recurrence of AF.

PERSPECTIVE

Concomitant surgical AF ablation should be performed in patients regardless of age. Only in elderly patients with concomitant CABG, surgical AF ablation might be associated with a higher rate of AF recurrence. Therefore, this patient cohort should be evaluated carefully for concomitant AF ablation.

See Commentaries on pages 1824 and 1825.

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Abbreviations and Acronyms

AF = atrial fibrillation
CABG = coronary artery bypass grafting
CI = confidence interval
ECG = electrocardiogram
FU = follow-up
ILR = implantable loop recorder
OR = odds ratio

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With a prevalence of 2%, atrial fibrillation (AF) is the most common arrhythmia in western countries and has emerged, especially because of demographic changes, as one of the most important healthcare burdens in the last decades.[1] The prevalence of AF increases with age and is present in 10% to 17% at age 80 years or older.[1,2] AF can lead to heart failure, thromboembolic events, stroke, increased number of hospitalization, and, especially in elderly patients, to reduction in quality of life.[3] Therefore, the 2014 Guidelines for the management of AF issued by the American College of Cardiology, American Heart Association, and Heart Rhythm Society, as well as the 2017 Heart Rhythm Society and European Heart Rhythm Association Consensus document, recommend surgical ablation in patients with AF undergoing cardiac surgery for other indications.[3,4] However, according to the Society of Thoracic Surgeons National Cardiac Database, only 38% of patients with AF undergoing cardiac surgery have received an AF ablation.[5] Different studies have reported that increasing age has been a risk factor for ablation failure.[6] Especially, when concomitant mitral valve surgery is performed, an increasing age is associated with recurrence of AF.[7,8] Therefore, many surgeons are reluctant to perform concomitant AF ablation in older patients. However, no clear evidence exists about the risk of mortality and morbidity in elderly patients undergoing concomitant surgical ablation. Furthermore, currently few data are available about the freedom of AF at 1-year follow-up (FU) after surgical AF in elderly patients. Therefore, we investigated the age-dependent effect on the safety and efficacy of concomitant surgical AF ablation.

MATERIALS AND METHODS

Study Cohort

Between January 2003 and December 2013, 556 patients underwent concomitant surgical AF ablation at the University Heart Center Hamburg and served as our primary study cohort. Some 56.4% of the patients had persistent or long-standing persistent AF defined as AF, and 43.6% had paroxysmal AF. AF classifications were used according to previously published guidelines.[4] All data were prospectively collected in our institutional database and retrospectively analyzed. The investigation has been approved by the Institutional Review Board.

Follow-up

Rhythm at discharge was recorded by using a 12-lead electrocardiogram (ECG). During FU, rhythm monitoring was established by 24-hour Holter ECG (70.5% of the patients) or an implantable loop recorder (ILR) (29.5% of the patients) at 3, 6, and 12 months postoperatively. Successful ablation was defined by AF burden less than 0.5% in ILR or absence of AF episode longer than 30 seconds in 24-hour Holter ECG. According to our hospital protocol, the patients received antiarrhythmic drugs and anticoagulation therapy for at least 3 months after surgery. Beyond the 3 months, the treatment depended on the rhythm results. If no contraindication was present, amiodarone was the first-line antiarrhythmic drug therapy. Otherwise, class I or III antiarrhythmic drugs were used. Anticoagulation was performed using warfarin.

Statistical Analysis

The potential dependency of AF occurrence at 12 months on age was visualized by locally smoothed estimates using natural cubic splines. We used them to detect deviations from a linear association between age and risk of AF, which in turn would make it necessary to use a more complex model of age dependency. Freedom of AF at 12 months was analyzed using a multiple logistic regression model including age as linear term and other factors suspected to modify the risk of AF. Group-specific age effects were investigated by including bivariate interaction terms of age and the other predictors. Interactions were stepwise removed if their inclusion did not improve model fit. Odds ratios (ORs) of the final model were presented as risks, for example, an OR greater than 1 identifies a condition increasing risk of AF at 12 months. For 21 of 30 patients with missing AF information at 12 months, death within the first year could be verified, and we used this information to conduct an analysis for time to first AF accounting for death as competing risk using a cause-specific Cox PH model. Data on AF were also available at intermediate visits. For these, a mixed logistic regression model was used to account for the dependency structure introduced by repeated measures of the same patients. The statistical software used throughout the analysis was R 3.5.2 (R Core Team, Vienna, Austria) with the lme4 package.[9]

RESULTS

Preoperative and Intraoperative Data

The baseline data are displayed in Table 1. The mean age of the study cohort was 68.4 ± 9.07 years, and 67.3% of the patients were male. Overall, 251 of the patients were aged more than 70 years. Mean duration of AF was 3.5 ± 3.3 years, and mean left atrial diameters were enlarged with 50.5 ± 8.8 mm. Left ventricular ejection fraction was 52.4 ± 10.9 mm, with 43 patients having a left ventricular ejection fraction less than 40%. Some 10.4% of the patients had a previous stroke, and 4.3% had already a permanent pacemaker before surgery. The study cohort had the usual cardiovascular risk factors (eg, 18.2% had diabetes mellitus type 2). Some 46.6% of the patients had a coronary artery disease, with 9.4% having a previous myocardial infarction. Therefore, 35.3% of the patients received a concomitant coronary artery bypass grafting (CABG) surgery, 49.6%

TABLE 1. Patient characteristics at baseline

	Study cohort (n = 556)
Age, y	68.4 ± 9.07
Male gender	374 (67.3%)
AF duration (y)	3.5 ± 3.3
Paroxysmal AF	242 (43.5%)
LA diameter	50.5 ± 8.8
Prior stroke	58 (10.4%)
Prior pacemaker	24 (4.3%)
Diabetes mellitus type 2	101 (18.2%)
Renal insufficiency	45 (8.1%)
COPD	55 (9.9%)
Coronary artery disease	259 (46.6%)
Previous MI	52 (9.4%)

Sata presented as numbers (%) or as mean ± standard deviation (range). *AF*, Atrial fibrillation; *LA*, left atrial; *COPD*, chronic obstructive pulmonary disease; *MI*, myocardial infarction.

underwent a concomitant mitral valve surgery, and 37.2% underwent a concomitant aortic valve surgery (Table 2).

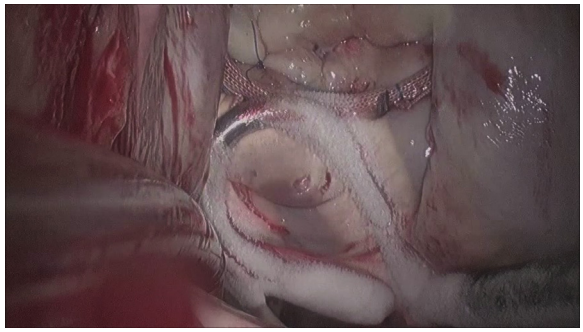
Surgical Ablation-Specific Data

Most of the patients (67.8%) received a complete left atrial ablation (including pulmonary vein isolation, box lesion, and left atrial appendage and isthmus isolation). In 13.9%, an isolated pulmonary vein ablation was performed, and 18.3% received a biatrial ablation, which included a right atrial intercaval lesion, isolation of the cavotricuspid isthmus, right atrial appendage and terminal crest, in addition to left atrial lesions. An isolated pulmonary vein ablation was primarily used in patients with paroxysmal AF, whereas a biatrial lesion set was performed only in patients with persistent or long-standing persistent AF. The applied energy sources were cryoablation (Video 1) in 21.2% of the cases (cryoICE cryo-ablation probe, AtriCure Inc, West Chester, Ohio; Cardioblate CryoFlex Surgical Ablation Probe, Medtronic Inc, Minneapolis, Minn), unipolar radiofrequency ablation (Cardioblate Unipolar RF Pen, Medtronic Inc) in 59.6% of the cases, and bipolar ablation (Cardioblate BP2 device and Cardioblate Surgical Ablation System Generator, Medtronic Inc) in 30.6% of the cases.

TABLE 2. Intraoperative data

Concomitant procedures	Study cohort (n = 556)
CABG	196 (35.3%)
Aortic valve surgery	207 (37.2%)
Mitral valve surgery	276 (49.6%)
Valve surgery and CABG	114 (20.5%)
Mitral and tricuspid valve surgery	61 (10.9%)
Aortic surgery	25 (4.5%)

CABG, Coronary artery bypass grafting.



VIDEO 1. Minimally invasive left atrial cryoablation during concomitant mitral valve repair in an elderly patient. Video available at: https://www.jtcvs.org/article/S0022-5223(19)33107-1/fulltext.

Perioperative Outcome and Follow-up

There were no major ablation-related complications (eg, bleeding) in any of the patients, and there was no intraoperative death. Postoperative pacemaker implantation rate was 8.5%. Overall, 30-day survival was 97.7%, and 1-year survival was 95.8%. During 1-year FU, permanent pacemaker implantation rate was 2.2%. During FU, 4.7% of the patients received a catheter-based ablation and 7.7% received a cardioversion.

Rhythm Results

The age-dependent freedom of AF at 12 months is outlined in Figure 1, showing a linear trend regardless of age. The mean probability for freedom of AF at 12 months ranged from 62% to 72%. A similar linear trend was seen in rhythm monitoring, with a higher probability in patients with an ILR (Figure 2). There was a significant interaction between age and concomitant CABG in regard to freedom of AF at 12 months. In patients aged more than 75 years, the freedom of AF was significantly lower

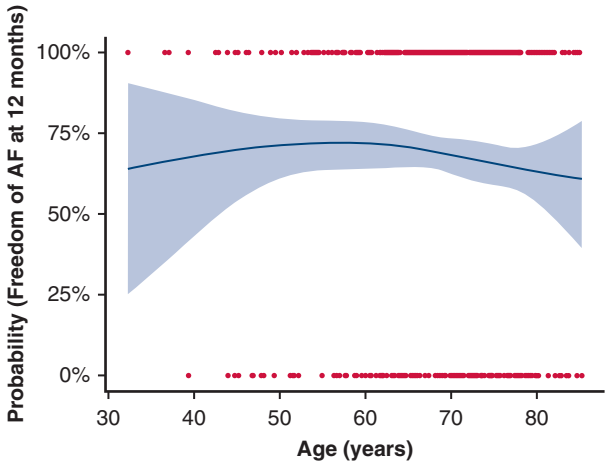


FIGURE 1. Age-dependent freedom of AF at 12 months. *AF*, Atrial fibrillation.

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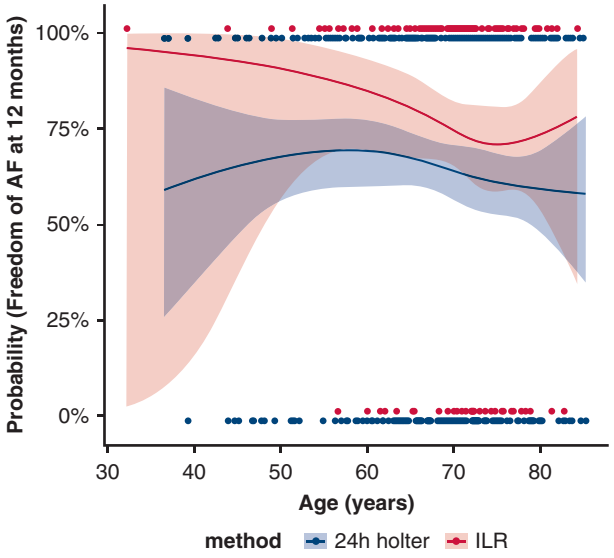

FIGURE 2. Age-dependent freedom of AF at 12 months according to the rhythm monitoring: ILR versus 24-hour Holter ECG. *AF*, Atrial fibrillation; *ILR*, implantable loop recorder.

compared with patients who received other concomitant procedures (Figure 3). In Figure 4 and Table 3, the age-dependent incidence of AF separated for concomitant CABG is outlined. In patients without concomitant CABG surgery, the prevalence of AF at 12 months varies from 33.1% at age 40 years to 23.8% at age 80 years. However, in patients with concomitant CABG, the incidence of AF significantly increases from 3.2% at age 40 years to 36.5% at age 80 years.

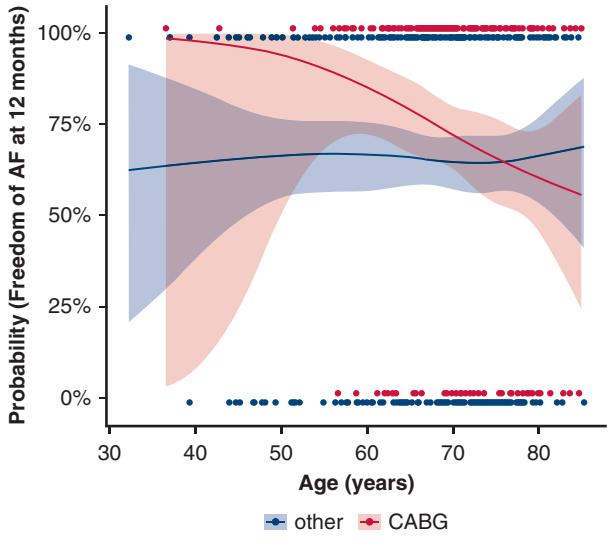

FIGURE 3. Freedom of AF dependent on age and CABG intervention. *AF*, Atrial fibrillation; *CABG*, coronary artery bypass grafting.

Predictors for Freedom of Atrial Fibrillation

The adjusted odds ratio (OR) for risk of AF at 12 months was analyzed using a multiple logistic regression model with age as the linear term and is outlined in Figure 4 and Table E1. A risk of AF at 12 months was associated with double valve procedures (OR, 3.48; 95% confidence interval [CI], 1.53-8.15; $P = .020$) and preoperative persistent AF (OR, 2.43; 95% CI, 1.53-3.90; $P = .001$). Furthermore, there was a significant interaction seen between age and concomitant CABG surgery showing a risk of AF at 12 months with increasing age (per 10 years) if a concomitant CABG procedure was performed (OR, 2.03; 95% CI, 1.09-3.78; $P = .009$). Associated with a significant prediction for freedom of AF at 12 months was a sinus rhythm at discharge (OR, 0.39; 95% CI, 0.24-0.64; $P < .001$) and the completion of a bipolar ablation (OR, 0.32; 95% CI, 0.17-0.58; $P < .001$). The use of antiarrhythmic drugs did not influence the risk of AF at 12 months (beta-blocker: $P = .442$; amiodarone: $P = .777$). The FU procedures (catheter-based ablation, cardioversion, and pacemaker during FU) showed no impact on the risk of AF at 12 months.

The adjusted OR for risk of AF during FU was analyzed by using a mixed logistic regression model and is outlined in Figure 5. Likewise, risk of AF during FU was dependent on preoperative AF (OR, 4.74), double valve surgery (OR, 8.48), and increasing age (per 10 years) in concomitant CABG (OR, 3.09). Further, patients with an ILR were at higher risk of detection of AF at 3 months of FU (OR, 3.54; 95% CI, 1.20-10.44). Associated with freedom of AF during FU were also the conduction of bipolar ablation (OR, 0.20) and sinus rhythm at discharge (OR, 0.08).

DISCUSSION

This large study analyzed the impact and safety of AF ablation according to patients' age. The data show a linear age effect on freedom of AF overall but a significant impact of concomitant CABG in elderly patients (Figure 6). Besides the effect of concomitant CABG surgery in older patients, predictors for risk of AF recurrence were double valve surgery and preoperative persistent AF, whereas bipolar ablation and sinus rhythm at discharge were predictors for freedom of AF.

Prevalence of AF is increasing with age, and therefore because of demographic changes an increasing number of patients with AF are presenting for cardiac surgery.[2] Gillinov and colleagues[8] analyzed the cut-and-sew Cox maze procedure with combined mitral valve surgery and suggested an older age as a risk factor for recurrence of AF. However, rhythm FU was only obtained by postoperative ECGs, although recent guidelines suggest at least a 24-Holter ECG for FU.[4] Another analysis of the modified Maze procedure by Kim and colleagues[7] proposed age more than 60 years at surgery as a risk factor for recurrence

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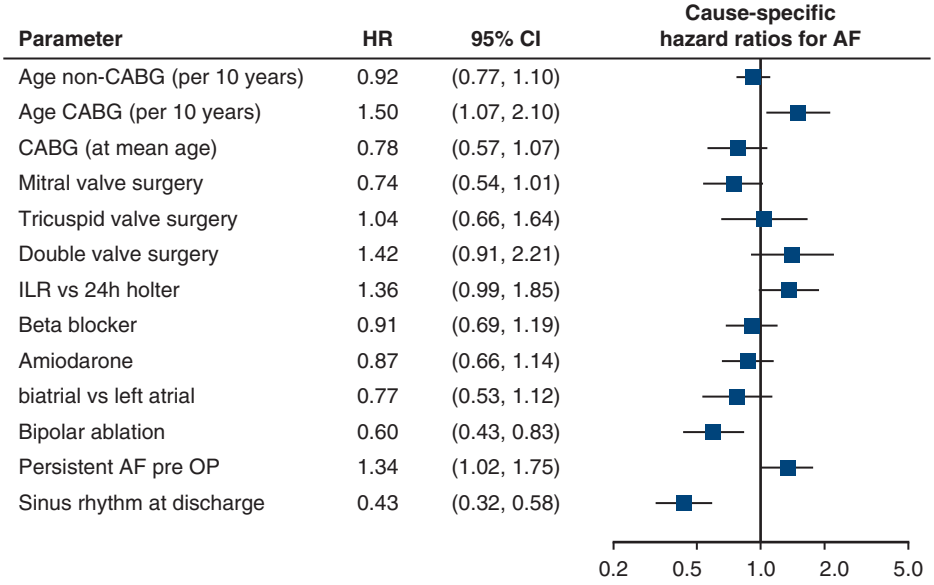

FIGURE 4. Adjusted ORs for risk of AF at 12 months from multiple logistic regression model including age as a linear term and other factors suspected to modify the risk of AF. *AF*, Atrial fibrillation; *CABG*, coronary artery bypass grafting; *FU*, follow-up; *ILR*, implantable loop recorder.

of AF. In this study, the used energy sources included cryothermia or microwave. In contrast to our study, those patients presented predominantly with mitral valve disease. In our study population, only 49.6% of the patients received a mitral valve procedure. Because of the different energy sources used, and the different concomitant procedures, a comparison with our data is difficult.

In case of AF, mitral valve disease is present in 30% to 50% of the cases,[10] resulting in enlarged left atrial diameters, which is recognized as a risk factor for recurrence of AF.[11-13] However, in our analysis isolated concomitant mitral valve procedure did not influence the rhythm outcome. Nevertheless, if 2 valve procedures were performed (eg, mitral and tricuspid valve or aortic and mitral valve), the risk of recurrence of AF was high. However, the impact of double valve procedures was independent of age. Of note, only concomitant CABG surgery influenced the freedom of AF in elderly patients. It is possible that with increasing age, the development of atrial fibrosis[14] influenced by ischemic heart disease is a more important risk factor for AF persistence than the atrial remodeling due to the mitral valve regurgitation. As in previous published studies,[6,15] we also observed an influence of the applied energy sources and the lesion set on freedom from AF. In our multiple logistic regression, model bipolar ablation showed a significant impact on freedom of AF, which was independent of age.

In previous studies, freedom of AF rate at 1 year after surgical ablation has been reported between 61% and 90%.[16-18] The freedom of AF rate at 1 year FU was comparable to our studied patients, ranging between 62% and 72%. Overall, the age did not have an impact on freedom of AF in the studied group. Those results suggest that regardless of age, concomitant surgical ablation can be performed with reasonable 1-year rhythm outcome. Further, our study showed in multiple logistic regression model that sinus rhythm at discharge was a significant predictor for freedom from AF at 12 months regardless of age. This outlines the importance of establishing a sinus rhythm before discharge. The patients in our study with an ILR were at higher risk of AF at 3 months. This effect was not seen at further FU visits (6 and 12 months). However, this might be explained by the higher detection rate of an ILR, which then resulted in consecutive ablation procedures (catheter-based ablation and cardioversion) helping to restore a stable sinus rhythm at the following visits. Those findings are in line with a previous study from our institution[19] that showed implantation of an ILR in combination

TABLE 3. Model-based estimated age-dependent incidence of atrial fibrillation separated for coronary artery bypass grafting

Age	Prevalence of AF at 12 mo (%)	
	Other	CABG
40	33.1 (17.4-53.9)	3.2 (0.5-17.9)
50	30.6 (19.3-44.9)	6.3 (1.8-20.3)
60	28.2 (20.6-37.3)	12.1 (5.8-23.7)
70	26.0 (19.8-33.3)	22.0 (15.2-30.7)
80	23.8 (16.2-33.6)	36.5 (23.1-52.4)

Data presented as percentage (%) with 95% CI. *AF*, Atrial fibrillation; *CABG*, coronary artery bypass grafting.

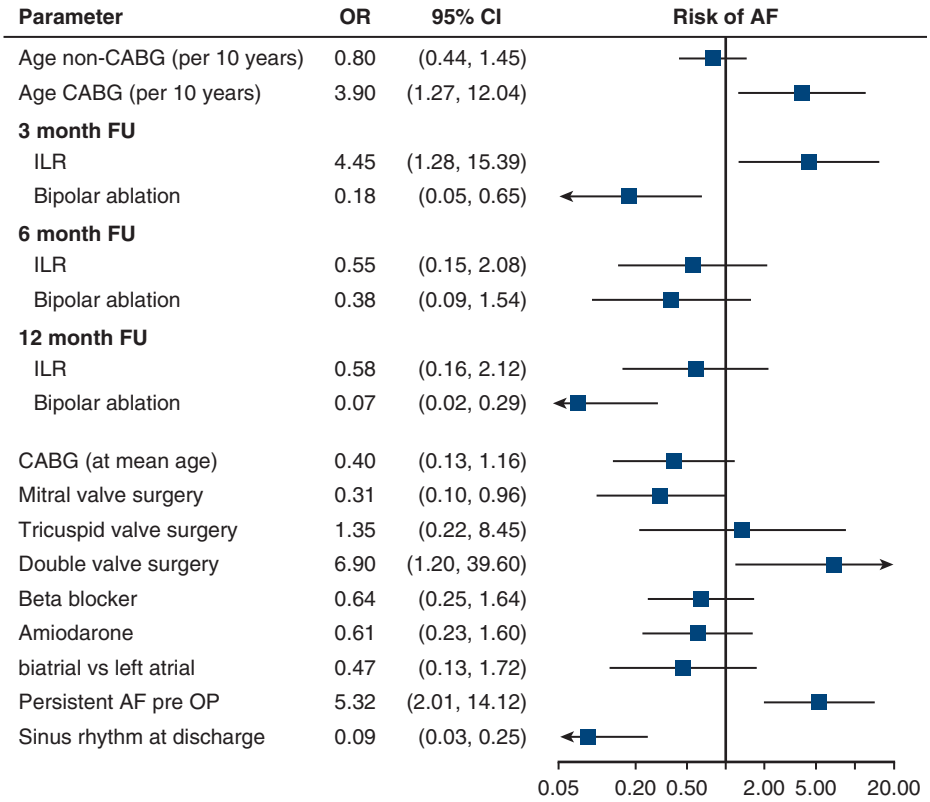

FIGURE 5. Adjusted ORs for risk of AF during FU from a mixed logistic regression model. *CABG*, Coronary artery bypass grafting; *FU*, follow-up; *ILR*, implantable loop recorder.

with a link-up to a cardiology or electrophysiology provides optimized antiarrhythmic drug management and higher rates of consecutive procedures such as cardioversion or additional catheter-based ablation. Consecutively, this results in a higher sinus rhythm conversion rate at 1-year FU.[19] In addition, there were no ablation-related complications, and perioperative morbidity and mortality were low in this elderly patient cohort. This finding is in line with a study by Ad and colleagues,[20] in which surgical AF ablation, concomitant to CABG and AVR surgery, did not increase perioperative morbidity and mortality. Furthermore, Ad and colleagues[20] analyzed high-risk patients with a European System for Cardiac Operative Risk Evaluation greater than 6 and showed that the addition of AF ablation did not increase perioperative morbidity and mortality. Favorable results were also published in a large Society of Thoracic Surgeons database analysis by Badhwar and colleagues.[21] In their propensity score 1:1 matched analysis, 28,739 patients with AF receiving surgical ablation were compared with patients with no arrhythmia treatment. The surgical ablation group showed reduced 30-day mortality and significantly lower neurologic events, proving AF surgery as a safe and effective treatment. Even more, studies reported an increased morbidity and mortality in patients with AF undergoing cardiac surgery without arrhythmia treatment.[22-24] This was documented in patients undergoing CABG[23] and aortic valve surgery.[24] In consideration of the excellent results after surgical AF in an older population, which are comparable to a younger patient cohort, and the increased risk of morbidity and mortality if AF is not being treated, our study highly suggests that surgeons should not hesitate to treat AF in elderly patients.

Study Limitations

This study has a nonrandomized retrospective study design in which unknown confounders and selection bias cannot be completely avoided. Furthermore, the present study was a single-center analysis. Therefore, the patient cohort is heterogeneous with different lesion sets and energy sources being used, and final conclusions can only be drawn carefully. Rhythm monitoring during FU was established with ILR only by one-third of the patients, and therefore an undiagnosed paroxysmal AF is possible in patients with a 24-hour Holter ECG at FU. However, current guidelines confirmed a 24-hour Holter ECG as sufficient for FU after AF ablation.[4]

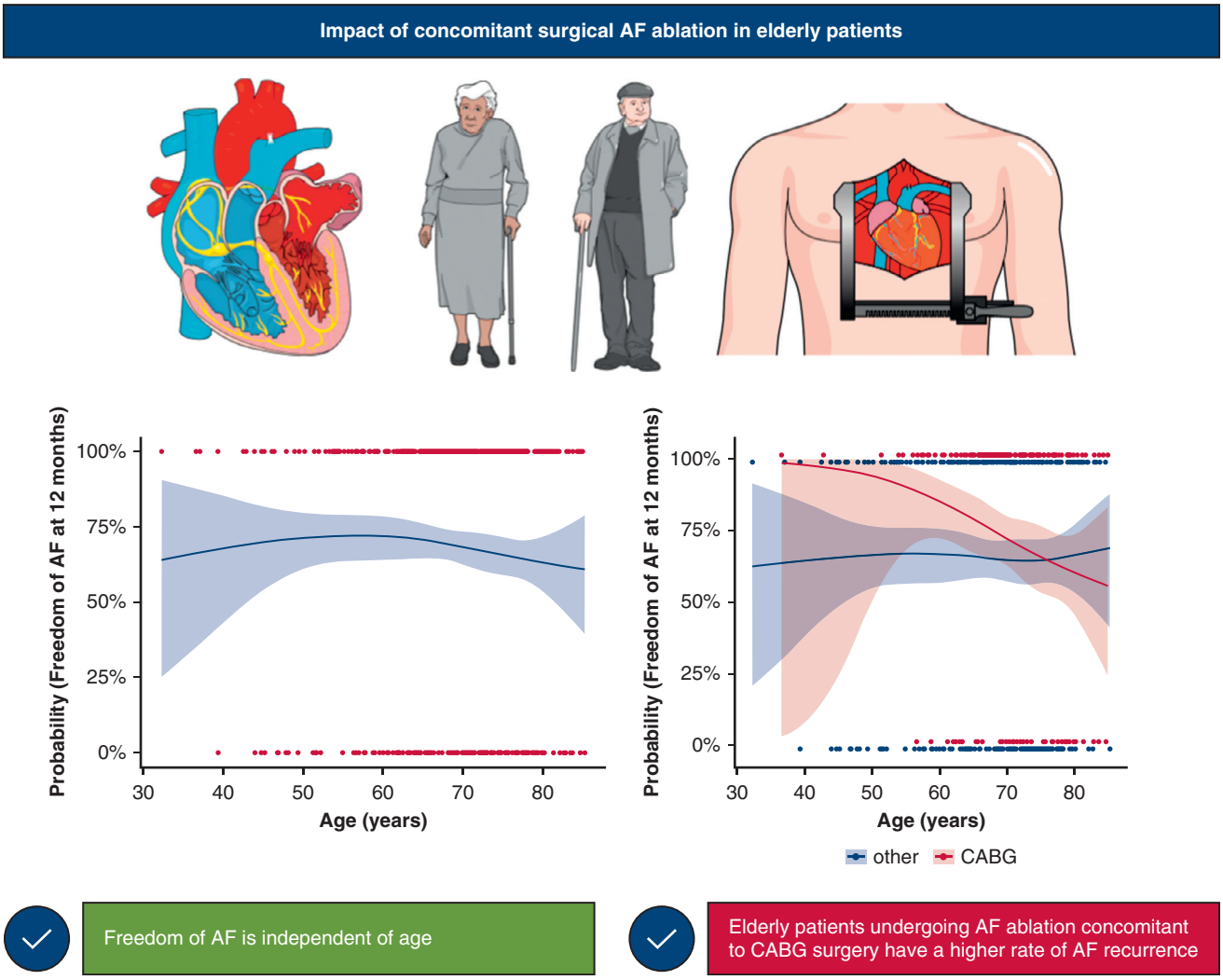

FIGURE 6. Analysis of concomitant surgical AF ablation in elderly patients showed no impact of age on freedom of AF. However, elderly patients undergoing AF ablation concomitant to CABG surgery have a higher risk for recurrence of AF. *AF*, Atrial fibrillation; *CABG*, coronary artery bypass grafting.

CONCLUSIONS

Surgical AF ablation was safe, effective, and independent of age. No ablation-related complications were seen. Only in elderly patients with concomitant CABG, surgical AF ablation might be associated with a higher rate of AF recurrence. Therefore, a concomitant surgical AF ablation procedure can be performed without additional risk in elderly patients and should be offered to this patient cohort. Sinus rhythm at discharge and bipolar ablation were significant predictors for successful ablation, and double valve procedures, preoperative persistent AF, and CABG surgery in elderly patients were risk factors for recurrence of AF.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: surgical ablation, atrial fibrillation, age, elderly patients

TABLE E1. Tests of between subject effects (analysis of variance table from logistic regression model): One significant interaction between age and coronary artery bypass grafting

Parameter	HR (95% CI)
Age non-CABG (per 10 y)	0.92 (0.77-1.10)
Age CABG (per 10 y)	1.50 (1.07-2.10)
CABG (at mean age)	0.78 (0.57-1.07)
Mitral valve surgery	0.74 (0.54-1.01)
Tricuspid valve surgery	1.04 (0.66-1.64)
Double valve surgery	1.42 (0.91-2.21)
ILR vs 24-h Holter	1.36 (0.99-1.85)
Beta-blocker	0.91 (0.69-1.19)
Amiodarone	0.87 (0.66-1.14)
Biatrial vs left atrial	0.77 (0.53-1.12)
Bipolar ablation	0.60 (0.43-0.83)
Persistent AF preoperatively	1.34 (1.02-1.75)
Sinus rhythm at discharge	0.43 (0.32-0.58)

HR, Hazard ratio; *CI*, confidence interval; *CABG*, coronary artery bypass grafting; *ILR*, implantable loop recorder; *AF*, atrial fibrillation.