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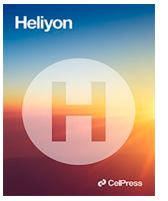

Same-day discharge after atrial fibrillation ablation

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ABSTRACT

Background: Atrial fibrillation (AF) catheter ablation has become an increasingly effective and safe strategy for the management of AF. With increased safety of catheter ablation, same-day discharge (SDD) is a potential way to minimize health care resource utilization and improve patient experience.
Objective: To evaluate the safety and patient satisfaction of SDD after contemporary AF ablation.
Methods: Consecutive patient undergoing AF ablation at our institution between 1/2020 and 10/2021 were enrolled in registry for clinical, quality, procedural and outcomes data. Patients were considered for SDD per physician discretion and patients' preference based upon clinical evaluation. Adjudicated ninety-day major complications, thirty-day adverse events, and thirty-day re-admissions were collected in a prospective registry for all patients.
Results: A total of 2142 consecutive patients underwent elective AF ablation during the study period. After excluding cases with missing data, 1830 patients were included in the analysis. Of those, 350 (19 %) patients were discharged the same day (SDD group) and 1480 (81 %) stayed overnight. Patients in the SDD group compared to overnight stay group were younger, more likely to be male, White patients, lower CHA2DS2-VASc score and to be on lower rates of warfarin as an anticoagulation strategy. After propensity score matching, SDD was associated with lower rate of major complications and higher patient satisfaction. The majority of life-treating complications occurred interprocedurally or within 6 h of procedure termination.
Conclusion: The present study demonstrated that SDD after contemporary AF ablation is feasible, safe and associated with higher patient satisfaction using a proposed SDD pathway and criteria.

1. Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia and is associated with significant morbidity and mortality [1,2]. Increasingly, a rhythm control strategy is preferred; especially in patients with refractory symptomatic AF, heart failure, and early AF (diagnosed within 12 months) [3–5]. There is growing evidence that AF catheter ablation is more effective than anti-arrhythmic drug therapy in maintaining sinus rhythm; [6–8] hence the volume of catheter ablation of AF has increased over time.

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While more effective, AF ablation has the disadvantage of being more costly due to both the need for specialized tools and technology as well as patient hospitalization. As the volume of AF ablation continues to rise, there is an expected increase in healthcare utilization [9]. Same day discharge (SDD) after AF ablation is a potential way of minimizing health care resource utilization while providing a better patient experience. However, AF ablation has been historically a long and complex procedure often requiring general anesthesia and overnight stay, unlike shorter electrophysiology procedures [10]. Fortunately, recent advances have made AF ablation more efficient and safe. Examples of these advances are the use of contact force sensing catheters, steerable sheaths, ventilation strategies, and venous vascular closure system (VVCS) devices which have reduced post-procedural time to ambulation and improved the patient experience [11–13].

Small observational studies have shown that SDD after AF ablation is possible and has been adapted in certain patients from different institutions and countries [14]. However, most of these studies were done with less contemporary AF management (i.e. <50 % direct oral anticoagulant use (DOACs), low use of intracardiac echocardiogram and no use of VVCS). Our study objective was to evaluate the clinical outcomes, safety, and patient satisfaction of SDD after AF ablation in a large tertiary care center and outline patients that may be appropriate candidates for SDD.

2. Methods

This was a retrospective study conducted at single tertiary center. We included all consecutive patients undergoing elective AF ablation at our institution between January 2020 and September 2021 (Fig. 1). Baseline patient characteristics, procedural information, complications, adverse events and re-admissions were collected retrospectively from electronic medical records. Adjudicated outcomes including procedural complication were obtained from a quality and outcomes internal registry. The study was reviewed and approved by the Institutional Review Board.

2.1. Ablation procedure and post-ablation follow up

Our ablation protocol has been described previously in detail [15,16]. In brief, antiarrhythmic medications were generally held 4 to 5 half-lives before the procedure whenever possible, and all procedures were performed with uninterrupted anticoagulation. General anesthesia was used in every procedure. Venous sheaths were inserted with assistance of ultrasound. An intravascular ultrasound probe placed in the right atrium was used to guide *trans*-septal access, assess catheter position, and monitor for procedural complications. A high-definition mapping catheter was used to assist with both pulmonary veins (PV) and non-PV ablations. Contact force sensing or cryoablation catheters were used for ablation. The main target for the ablation procedures was isolation of PVs. Additional ablation was at operators' discretion and included posterior wall ablation, septal to the right PVs, roof, appendage, coronary sinus, and superior vena cava in areas without phrenic capture. Concomitant arrhythmia ablation such as atrial flutter or atrial tachycardia was also performed as clinically indicated. Vascular hemostasis at the end of the procedure was used at discretion of physician and included manual hemostasis, figure of eight suture, or VVCS. Preferred VVCS was VASCADE MVP (Cardiva Medica, Santa Clara, California). After the procedure, patients were transferred to the post-procedural care unit, where they were continuously monitored on telemetry. Patients were evaluated by the physician and nursing team after 4 h of bedrest to determine if SDD criteria were met. Patients requiring overnight stay were typically discharged the following day unless complications or additional inpatient medical management was required.

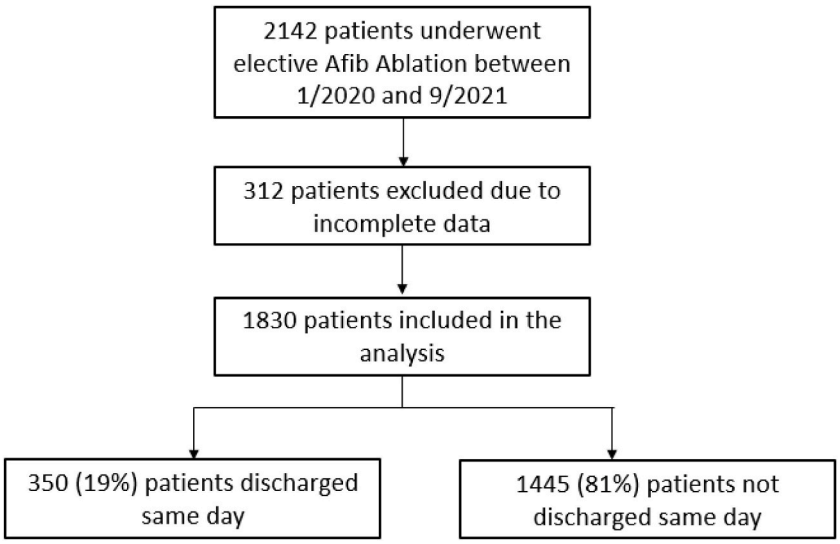


Fig. 1. Flowchart diagram of study design.

2.2. Same day discharge criteria

Patients were deemed to be candidates for SDD based on comorbidities, procedural characteristics, patient comfort and social support. Fig. 2 shows inclusion, exclusion and discharge criteria. The attending electrophysiologist made the final decision about SDD vs overnight stay after patient evaluation in the post-procedure area.

2.3. Follow up

Patients discharged the same day had a telephone call the following day by their electrophysiologist who performed the procedure to assess for complications and answer questions. In the absence of complications, patients had in-person follow up at 3-, 6-, and 12-months post-procedure and on a yearly basis thereafter. If complications were suspected during the telephone call, the electrophysiologist instructed the patient to take further steps (i.e. emergency room, outpatient appointment, etc). Patients who stayed overnight, had routine follow up including in-person follow up at 3-, 6-, and 12-months post-procedure and on a yearly basis thereafter. Every patient, regardless of discharge day group were provided with rhythm transmitters and were instructed to send transtelephonic ECG transmissions on a weekly basis and whenever symptomatic for a minimum of 3 months after the procedure. Additional event monitoring was obtained beyond the 3-month period for patients with documented arrhythmia and those who developed symptoms suggestive of arrhythmia during this time period.

2.4. Outcomes

Outcomes data was obtained from electronic medical records including clinical visits, emergency room visits, re-admissions, communication with referring physicians, telephone calls and clinical letters. Complications and adverse events were defined based on the definitions from the 2017 HRS/EHRA/ECAS/APHRSSOLAECE expert consensus statement on catheter ablation of atrial fibrillation.6 Every adverse event or complication was revised and adjudicated by a dedicated safety and quality control team, who is also in charge of monitoring re-admissions and emergency department visits. The pre-specified primary outcome was a composite of major complications at 90 days; or 30-days adverse events, re-admissions, ED visits and mortality. Secondary outcomes were the individual components of primary outcome.

Major complications were categorized based on onset into intraprocedural (during the procedure), immediate (0–6 h post-procedural), early (6 h–7 days post-procedural), late (7–30 days post-procedural) or very late (more than 30 days post-procedural).

Quality of life (QoL) metrics were collected during follow up through web-based survey (Atrial Fibrillation Tracker™) that collects longitudinally patient reported outcomes (PRO) [17]. We then calculated the AF severity scale (AFSS), a validated questionnaire for QoL assessment in AF patients. The AFSS consists of 7 symptom-related questions. A score of 0 (no symptoms) to 5 (worst symptoms) is reported for each question. The overall score is a sum of the 7 AF-related symptoms. Total scores range between 0 and 35 with higher scores indicating worse symptoms and increasing negative impact on QoL [18].

2.5. Statistical analysis

Continuous variables are expressed as mean ± standard deviation (SD) or median (interquartile range), as appropriate. Categorical

Inclusion Criteria	Patients must be accompanied by a responsible adult for at least 24 hours. If travelling greater than 2 hours, patient expected to stay at local hote.
	Adequate hemostasis achieved in the EP lab
	Complexity of case and safety of same day discharge to be determined by staff
	Oral anticoagulation and/or antiplatelet either taken chronically or new prescription filled and in hand
Exclusion Criteria	Comorbidities: • EF <40% • Coagulopathy, thrombocytopenia < 100,000 • BMI >40 • COPD requiring home oxygen
	Residual vascular injury and/or hematoma
	Intraprocedural complications or adverse events
Discharge criteria	Patient ambulating with stable vital signs
	Adequate Hemostasis on re-examination of groin
	Able to tolerate PO intake and to urinate
	Evaluation by physician prior to discharge

EF: Ejection fraction, BMI: Body Mass Index, COPD: Chronic Obstructive Pulmonary Disease

Fig. 2. Key criteria for same day discharge after AF Ablation
EF: Ejection fraction, BMI: Body Mass Index, COPD: Chronic Obstructive Pulmonary Disease.

variables are expressed as absolute numbers and frequency. The Chi-square test was used for comparison of categorical variables. The Student T test or the non-parametric Wilcoxon Rank Sum test were used for continuous variables, as appropriate. A two-sided p-value <0.05 was considered statistically significant.

We used propensity score matching to address for selection bias using a multivariable logistic regression model which included the following covariates: age, sex, race, body mass index (BMI), AF type, coronary artery disease, diabetes mellitus, dialysis need, hypertension, congenital heart disease, cerebrovascular disease, cardiomyopathy, pulmonary disease, peripheral arterial disease, CHA2DS2-VASc Score, left ventricular ejection fraction (EF), re-do procedure, use of antiplatelet medication, use of betablocker, use of calcium channel blockers, use of anti-arrhythmic drugs, radiofrequency or cryoablation as energy source of ablation and use of vascular closure device. One-to-one matching was performed using the nearest-neighbor method without replacement with the caliper within 0.1 times the pooled standardized difference of the logit of the propensity scores.

3. Results

3.1. Study population

Between January 2020 and September 2021, a total of 2142 consecutive patients underwent elective AF ablation. Of these, 312 were excluded due to missing data (left ventricular ejection fraction 13 %, CHAD2S2-VASc score 2 %, atrial fibrillation type 1 %, medication use 0.4 %, total stay 0.1 % and post-procedural stay 0.04 %). A total of 1830 patients were included in the main analysis. Of those, 350 (19.1 %) patients were discharged the same day (SDD group) and 1480 (80.8 %) stayed overnight (overnight stay group). Baseline characteristics of the entire cohort and stratified by discharge group are summarized in Table 1. Patients in the SDD group compared to the overnight stay group were significantly younger (63.59 ± 9.52 vs 66.3 ± 9.9; P = 0.01), more likely to be men (78.6 % vs 66.3 %; P=<0.001), lower prevalence of hypertension (56.3 % vs 63.9 %; P = 0.018), lower CHA2DS2-VASc score (2.03 ± 1.41 vs 2.73 ± 1.48; P=<0.001), less use of warfarin as anticoagulant of choice (7.2 % vs 11.3 %; P = 0.03) and lower use of antiplatelet therapy (20 % vs 31.5 %; P=<0.001).

3.2. Procedural characteristics

Procedural characteristics of the entire cohort and based on discharge group are summarized in Table 2. Patients in the SDD group had higher use of VVCS device (VASCADE MVP ®) (97 % vs 52 %; P=<0.001), were more likely to have cryoablation as primary energy source (11.1 % vs 6.8 %; P = 0.007), and were more likely to have the procedure done in the morning vs afternoon (98.6 % vs 57.7 %; P=<0.001). A total of 33.6 % of procedures were re-do procedures, without difference between groups.

Table 1
Baseline characteristics of patient population based on discharge day.

	Overall N = 1830	Same-day discharge group N = 350 (19 %)	Overnight stay N = 1480 (81 %)	P - value
Age in years	65.87 ± 9.9	63.62 ± 9.61	66.42 ± 9.9	<0.001
Male	1256 (69.7 %)	278 (78.1 %)	978 (67.7 %)	<0.001
White Race	1558 (86.5 %)	317 (89 %)	1241 (85.9 %)	0.13
CAD	391 (21.7 %)	61 (17.4 %)	328 (22.2 %)	0.061
Cardiomyopathy	420 (22 %)	66 (18.9 %)	354 (23.9 %)	0.051
Ejection Fraction in %	55.47 ± 9.95	56.4 ± 8.75	55.23 ± 10	0.037
Non-paroxysmal AF	1052 (57.4 %)	188 (53.7 %)	864 (58.4 %)	0.127
CHA2DS2-VASc Score	2.49 ± 1.54	2.03 ± 1.41	2.73 ± 1.48	<0.001
Diabetes Mellitus	296 (16.2 %)	43 (12.3 %)	243 (16.4 %)	0.067
Dialysis	6 (0.3 %)	1 (0.3 %)	5 (0.3 %)	1
Hypertension	1143 (62.4 %)	197 (56.3 %)	946 (63.9 %)	0.01
History of CVA	139 (7.59 %)	29 (8.3 %)	110 (7.4 %)	0.66
COPD	89 (4.9 %)	13 (3.7 %)	76 (5.3 %)	0.22
PAD	52 (2.9 %)	9 (2.5 %)	43 (3 %)	0.78
Anticoagulant use	100 %	100 %	100 %	NA
• Apixaban	1181 (63.2 %)	219 (62.9 %)	915 (63.1 %)	0.74
• Rivaroxaban	363 (20.5 %)	90 (25.9 %)	285 (19.7 %)	0.013
• Dabigatran	32 (1.8 %)	7 (2 %)	24 (1.7 %)	0.68
• Warfarin	185 (10.5 %)	25 (7.2 %)	163 (11.3 %)	0.03
Single Antiplatelet	529 (29 %)	70 (20 %)	466 (31.5 %)	<0.001
DAPT	33 (2.7 %)	2 (0.6 %)	30 (2 %)	0.1
Beta-blocker	1244 (69.1 %)	237 (66.6 %)	1007 (69.7 %)	0.28
Antiarrhythmic use	902 (49.2 %)	154 (44 %)	748 (50 %)	0.02
• Amiodarone	262 (29.6 %)	28 (18.2 %)	238 (31.8 %)	
• Dofetilide	282 (31.9 %)	54 (35.1 %)	234 (31.3 %)	
• Flecainidine	197 (22.3 %)	48 (31.2 %)	152 (20.3 %)	
• Sotalol	99 (11.2 %)	16 (10.4 %)	86 (11.5 %)	
• Propafenone	25 (2.8 %)	5 (3.2 %)	20 (2.7 %)	
• Others	20 (2.2)	3 (1.9 %)	18 (2.4 %)	

Table 2
Procedural characteristics.

	Overall N = 1830	Same-day discharge group N = 350 (19 %)	Overnight stay N = 1480 (81 %)	P - value
General anesthesia	1801 (100 %)	100 %	100 %	NA
Re-do Procedure	609 (33 %)	113 (32.3 %)	496 (33.5 %)	0.7
Radiofrequency	1705 (93.1 %)	311 (88.9 %)	1394 (94.2 %)	<0.001
Cryoablation	140 (7.7 %)	39 (11.1 %)	101 (6.8 %)	0.009
Morning Procedure	1199 (65.6 %)	345 (98.6 %)	854 (57.7 %)	<0.001
Vascular Hemostasis				
• Vascular Closure Device	1120 (61 %)	339 (97 %)	781 (52 %)	<0.001
• Manual Compression	34 (1.8 %)	0	34 (2.1 %)	NA
• External suture	532 (29 %)	9 (2.5 %)	523 (35.4 %)	<0.001
Intracardiac echocardiogram use	1801 (100 %)	100 %	100 %	NA
Post-procedure stay (in hours)	25.02 ± 45.2	6.37 ± 1.24	29.61 ± 49.43	<0.001

3.3. Outcomes

The primary composite endpoint was observed in a total of 218 patients in the matched cohort (12 %). After propensity score matching, SDD was associated with a lower risk of the primary composite endpoint (OR 0.63; 95 % CI 0.40–0.99). Fig. 3.

In terms of the individual components of the composite endpoint, major complications were observed in a total of 40 patients in the matched cohort (2.1 %). This was less likely to occur in the SDD group (OR 0.17; 95 % CI 0.04–0.74). Re-admissions, adverse events and ER visits occurred in 96 (5.2 %), 61 (3.3 %) and 97 (5.3 %) patients respectively of the entire cohort without significant differences between groups. There were no deaths.

After matching, covariate balance was appropriate for all covariates except for age (standardized difference of 22 %).

3.4. Timing and types of complications

Table 3 shows the breakdown of major complications and adverse events in the entire unadjusted cohort. Fig. 4 shows observed frequency of complications based on timing and demonstrates that pericardial effusion was more likely to occur intraprocedurally (p = 0.01), vascular injury more likely to occur immediately post procedure (p = 3.5e-03), stroke or TIA occurred more commonly in the late post-procedural phase (p = 0.02) and pulmonary vein stenosis only occurred in the very late phase (4.99e-04).

3.5. Patient satisfaction

Patients in the SDD group had a higher AFSS score at follow up compared to the overnight group (5.06 vs 3.9; p = 0.01).

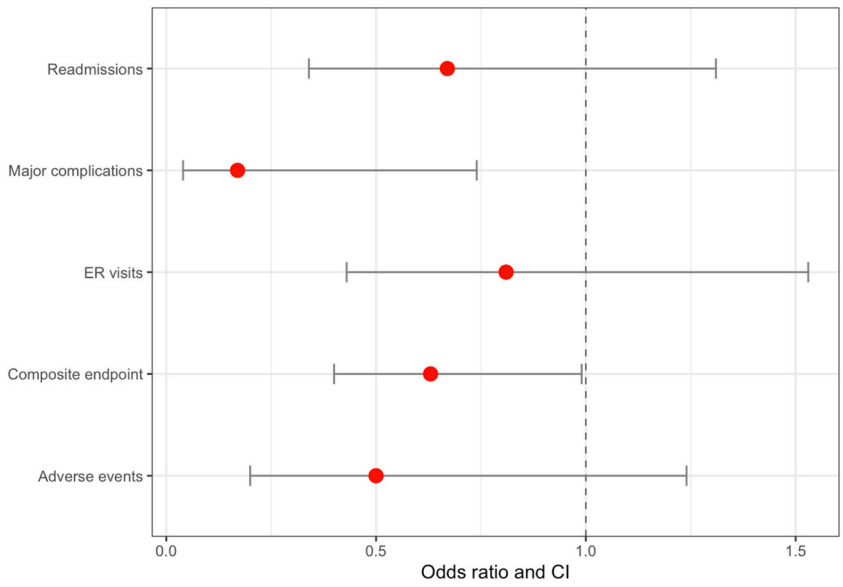


Fig. 3. Effect of same day discharge and adjusted outcomes.

Table 3
Types of major complications and adverse events.

	Overall N = 1830	Same-day discharge group N = 350 (19 %)	Overnight stay N = 1480 (81 %)
Total Major Complications	**40 (2.1 %)**	**2 (0.5 %)**	**38 (2.5 %)**
Cardiogenic Shock	1	0	1
Hemothorax	1	0	1
Pericardial Effusion requiring evacuation	10	0	10
Phrenic Nerve Injury	5	1	4
Pseudoaneurysm	3	0	3
Stroke or Transient Ischemic Attack	3	0	3
Urinary Tract Infection with Sepsis	4	0	4
Vascular Injury Requiring Intervention	6	0	6
Other	6	1	5
Total Adverse Events	**60 (3.2 %)**	**7 (2 %)**	**53 (3.5 %)**
Volume Overload	23	2	21
Anesthesia Complications	1	0	1
Arrhythmia	14	2	12
Bleeding	3	0	3
Pericarditis requiring treatment	17	3	14
Urinary Tract Infection without Sepsis	2	0	2

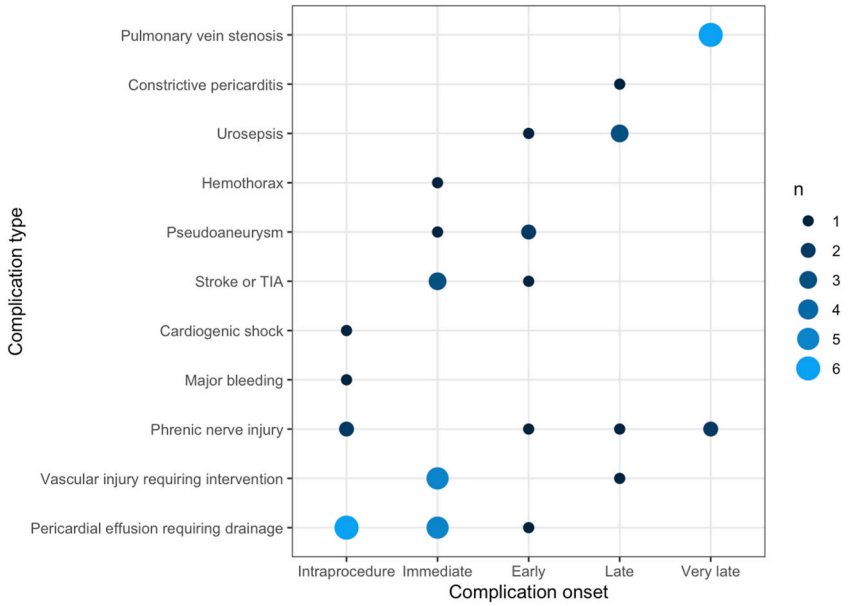


Fig. 4. Major complications timeline
Immediate (0–6 h), Early (6 h–7 days), Late. (7–30 days), Late (>30 days).

4. Discussion

Our study showed that SDD after contemporary AF ablation is feasible and safe in a carefully selected patient population. SDD was not associated with increased risk of major complications, adverse events, re-admissions or emergency room visits. In fact, we found that major complications were significantly lower in patients discharged the same day after AF ablation compared to patients that stayed overnight, which remained true after propensity score matching. We also found that most of the major life-threating complications happen intraprocedurally or within 6 h of finishing the procedure. Additionally, we found higher patient satisfaction in patients that were discharged the same day.

Lately, there has been an increased interest in same-day discharge after different cardiac procedures, not only due to conscious healthcare utilization but also in the setting of the COVID-19 pandemic. Furthermore, the inpatient setting can increase the risk of hospital-acquired complications, which are potentially reduced with the SDD approach [19]. Recently, ACC published an Expert Consensus on SDD after percutaneous coronary intervention [20] which highlights that most patients prefer SDD and emphasizes the importance of adequate patient selection based on clinical and procedural characteristics; as well as appropriate post-discharge follow up. An additional benefit of SDD is the lower overall cost, as this has been demonstrated in other electrophysiology procedures such as

left atrial appendage occlusion. In terms of SDD after AF ablation data is more limited. Several observational studies have demonstrated that in a selected population, SDD after AF ablation is feasible, safe and decrees health care utilization [21–23]. The largest observational study evaluating the safety of SDD after AF ablation included 3000 patients from two hospital in British Columbia, Canada and showed that SDD after AF ablation was feasible and not-associated with higher hospital re-admission or complications, this study was done in less contemporary AF ablation practice including low use of DOACs and no use of intracardiac echocardiogram [24]. Our study adds to the literature by being the largest single-center study in the United States evaluating the safety of SDD after AF ablation in the current era. Additionally, our SDD pathway provides guidance in patient selection and discharge criteria Fig. 1.

Our study showed that patients in the SDD group had significantly fewer major complications compared to the overnight stay group. While there is a clear selection bias from the SDD criteria, findings remained consistent after propensity score matching. We think that our SDD criteria were appropriate in identifying patients at higher risk for major complications in addition to our streamline SDD pathway that includes next-day telephone call and close follow up to prevent or to identify potential complications early. It is important to mention, that based on our observation and practice, we do not think that every patient should be in SDD group, we think that those with higher risk of complications (i.e. do not meet SDD criteria) should be monitor for an additional extra night in the hospital post-procedure.

An important finding of our study was that most of the major complications were identified intraprocedural or shortly after the procedure was finished, so these patients were admitted for further management. In fact, we demonstrate that life-threatening complications such as pericardial effusion and vascular injury requiring intervention occurred almost exclusively within 6 h after AF ablation. This findings provides important insight into the safety of SDD after AF ablation and suggests that as long as no complications have occurred within 6 h, SDD is safe.

As AF ablation technology continues to evolve and procedures become more efficient, SDD after AF ablation will become the standard of care in most centers. Thus, risk stratification of these patients will be essential to guarantee safe outcomes. With our current pathway and criteria, we were able to provide SDD to 20 % of patients who underwent AF ablation at our institution. We believe this percentage will increase as we become more familiar with this practice and with potential expansion of the SDD criteria to include more patients. Future recommendations from electrophysiology societies should provide guidance and pathways for SDD after AF ablation to better standardize and improve this practice.

Our study is not without limitations. The most significant one being the single center and retrospective nature of the study. Hence the present data may not be directly generalized to institution with less procedural experience. An important limitation is that albeit we have an established protocol for SDD, the ultimate decision for SDD is made between the physician and the patient, that means even if a patient meets the SDD criteria, he or she can ultimately stay overnight for different reasons, including patient personal preferences which is not uncommon, this reflects real life practice. Another limitation is that despite the positive results found after propensity matching, it is possible that unmeasured covariates are present resulting in bias, additionally, age remained imbalanced after propensity score matching and is a possible confounder.

5. Conclusion

SDD after cardiac procedures is a potential way of reducing healthcare utilization and improve patient satisfaction. The present study demonstrates that SDD after contemporary AF ablation is safe, yields no excess of major complication and is associated with higher patient satisfaction. Major life threating complications occurs almost solely within 6 h of AF ablation, suggesting that 6 h of post-procedural monitoring is an appropriate strategy. We provide a SDD pathway to guide the selection of patients that will likely be safely discharged the same day.

Declaration

This study was reviewed and approved by the Cleveland Clinic IRB (#19–500). Informed consent was not needed because date collection was obtained retrospectively from medical records.

Additional information

No additional information is available for this paper.

Data availability statement

Question: Sharing research data helps other researchers evaluate your findings, build on your work and to increase trust in your article. We encourage all our authors to make as much of their data publicly available as reasonably possible. Please note that your response to the following questions regarding the public data availability and the reasons for potentially not making data available will be available alongside your article upon publication.

Has data associated with your study been deposited into a publicly available repository?

Answer: No. The data belongs to Cleveland Clinic Foundation and will be made available on request to the corresponding author (Tyler Taigen).

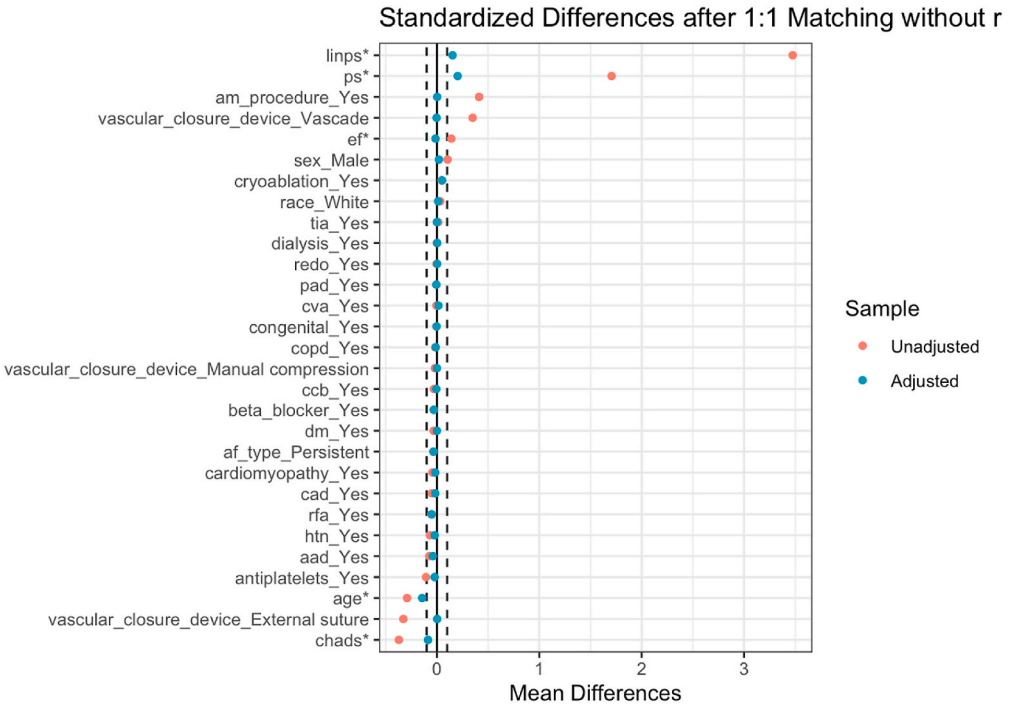
CRediT authorship contribution statement

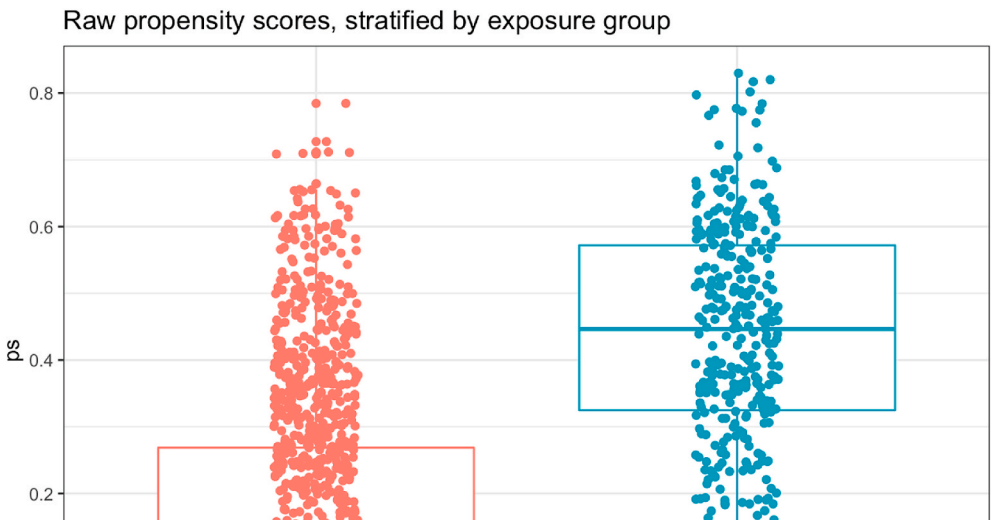
Jose Aguilera: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Erika Hutt:** Writing – original draft, Writing – review & editing. **Ruth Madden:** Data curation, Methodology. **Mohamed Kanj:** Conceptualization, Writing – review & editing. **Walid Saliba:** Conceptualization, Writing – review & editing. **John Rickard:** Conceptualization, Writing – review & editing. **Jakub Sroubek:** Conceptualization, Writing – review & editing. **Thomas Callahan:** Conceptualization, Writing – review & editing. **Mina Chung:** Conceptualization, Writing – review & editing. **Brian Baranowski:** Conceptualization, Writing – review & editing. **David Martin:** Conceptualization, Writing – review & editing. **Thomas Dresing:** Conceptualization, Writing – review & editing. **Oussama M. Wazni:** Conceptualization, Writing – review & editing. **Ayman Hussein:** Conceptualization, Writing – review & editing. **Daniel Cantillon:** Conceptualization, Writing – review & editing. **Divyang Patel:** Conceptualization, Writing – original draft, Writing – review & editing. **Shady Nakhla:** Conceptualization, Writing – review & editing, Patrick Tchou, Conceptualization, Writing – review & editing. **Tyler Taigen:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix





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