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The 30-day readmission rate of same-day discharge protocol following catheter ablation for atrial fibrillation: a propensity score-matched analysis from National Readmission Database

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Aims The effectiveness and safety of same-day discharge (SDD) for catheter ablation (CA) for atrial fibrillation (AF) has not been fully elucidated using a large nationwide database. This study aimed to evaluate the all-cause readmission rates within 30-days among patients receiving CA for AF with an SDD protocol compared with a conventional overnight stay (ONS).

Methods and results We performed a retrospective cohort study using the US Nationwide Readmission Database. The primary outcome was all-cause 30-day readmission following discharge in patients receiving CA and a secondary outcome was requiring total healthcare cost. A 1 : 3 propensity score matching was conducted to compare the safety and efficacy within both SDD and ONS group. Among 30 776 patients [mean 67.2 ± 11.4 years, 12 590 female (41.5%)] who received CA from 2016 through 2018, 440 (1.42%) patients were discharged on the same-day following CA (SDD group), and the remaining 30 336 patients stayed at least one night in the hospital (ONS group). A propensity score analysis generated 1751 matched pairs (440 in the SDD group; 1311 in the ONS group). The 30-day readmission following discharge was not significantly higher in the SDD group than the ONS group (SDD vs. ONS: 12.7% vs. 9.7%; hazard ratio: 1.17, 95% confidence interval: 0.76–1.81, $P = 0.47$). Healthcare cost was significantly higher in the ONS group ($25 237 ± 14 036 vs. $30 749 ± 16 383; $P < 0.01$).

Conclusion In this nationwide database study, there was no significant difference in the all-cause 30-day readmission following SDD for CA compared with ONS.

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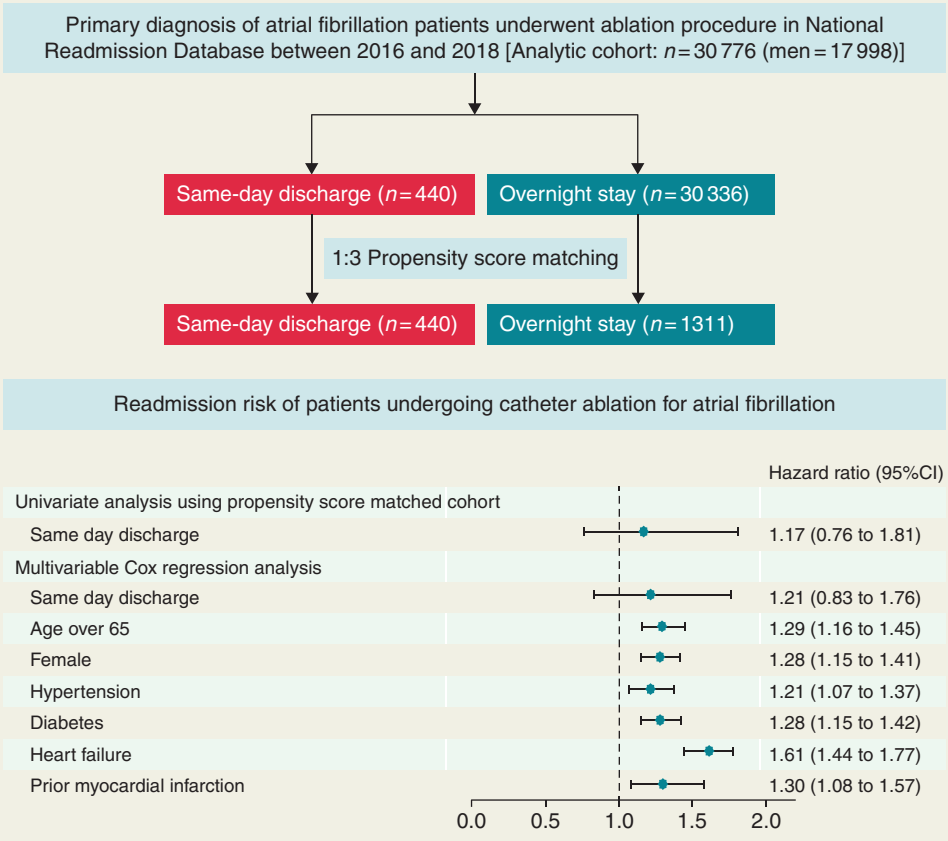
Graphical Abstract



Keywords Atrial fibrillation • Same-day discharge • Readmission • Catheter ablation • Health care cost

What's new?

- This retrospective study using the contemporary Nationwide Readmission Database from the USA evaluated the safety and efficacy of the same-day discharge for all-cause 30-day readmission rate after catheter ablation.
- Approximately 10% of patients were readmitted with any causes during the 30-day after the discharge. A history of heart failure, prior myocardial infarction, hypertension, diabetes, gender female, and age over 65 was associated with all-cause 30-day readmission; however, a same-day discharge protocol was not associated with 30-day readmissions compared to overnight stayed patients.
- Medical costs requiring both hospitalization and procedure were significantly lower in the same-day discharged group.

Introduction

In the past decades, pulmonary vein isolation (PVI) for patients with atrial fibrillation (AF) has been increasingly performed worldwide.[1] Its efficacy, safety, and risk factors for complications have been extensively studied.[2,3] While treatment technologies have been advancing and catheter ablation (CA) is reported to be superior as an initial treatment for rhythm control in paroxysmal AF,[4] healthcare costs have continued to rise due to the increasing number of patients receiving CA.[5] As the prevalence and incidence of AF increase, the volume of CA will continue to rise, leading to growing demands on health care expenditures. Recently, based on shorter procedure times and lower complication rates of PVI combined with the understanding that a shorter length of hospital stay will reduce healthcare costs, same-day discharge (SDD) for CA has been implemented in many European and North American centres.[6,7] While a previous meta-analysis which summarized studies conducted in European and North American centres demonstrated lower mortality, complication rates, and rehospitalization rates in the SDD protocol following CA,[8] comparing the safety and efficacy of both SDD and overnight

stay (ONS) protocol based on previous observational studies might be difficult due to limitations including selection bias, loss of follow-up, and variable follow-up duration.

In order to support SDD, it is necessary to confirm the safety and efficacy of the protocol in the current clinical setting using a large and diverse database. Currently, no randomized controlled trials comparing both protocols are available and observational studies that adequately adjusted for confounding to examine safety between both protocols were limited. In addition, previous observational studies have been conducted in a small number of institutions, limiting the generalizability of SDD protocol to the current clinical practice.

This study aimed to compare all-cause 30-day readmission and hospital costs of CA for patients with AF in the SDD protocol with the ONS group and examine the risk factors for readmission following CA using the National Readmission Database (NRD).

Methods

Data source

For this retrospective cohort study, the Nationwide Readmission Database (NRD), a database of inpatient information designed for readmission analyses developed by the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP), was used. The NRD contains approximately 18 million discharge data each year in the USA from 28 geographically dispersed states, including patients' payment information, age, sex, comorbidity, hospital bed size, length of hospital stay, procedures they received.[9] Additionally, the NRD includes data regarding their readmission in the same year and the in-hospital mortality using a unique patient linkage identification number. Similarly, medical cost for hospitalization and emergency room visit are linked to a unique patient linkage identification number, and NRD data contains the total hospital costs calculated by multiplying total hospital charges with the corresponding cost-to-charge ratio.[10,11] Diagnoses on admission and readmission were based on International Classification of Disease-10 (ICD-10) codes. The NRD for hospitalizations between 1 January 2016 and 31 November 2018 was used for this study.

Inclusion/exclusion criteria

Inclusion criteria were as follows: (i) adult patients aged over 18 years diagnosed with AF (ICD-10 code: I48.0, I48.1, I48.2, and I48.91) and (ii) patients who underwent CA for AF from 1 January 2016 through 31 November 2018. Exclusion criteria were as follows: (i) Patients without data on sex, age, and mortality outcome, (ii) diagnosis with other tachycardia based on the ICD-10 codes [atrial flutter (I48.3 and I48.4), supraventricular tachycardia (I47.0, I47.1, and I47.9), ventricular tachycardia (I47.2), and ventricular fibrillation (I46 and I49.0)] to exclude those who experienced CA not for AF but for these arrhythmias, (iii) patients experienced any periprocedural complications including haematoma, pericarditis, pericardial effusion, stroke, and cardiogenic shock, (iv) patients died before their discharge, and (v) patients receiving CA in December given that the NRD is a yearly database; therefore, readmission data occurring in the following year cannot be integrated. This study was performed in accordance with the reporting guideline of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) for cohort studies.[12]

Primary and secondary outcomes

The primary outcome of this study was the 30-day all-cause readmission rate following the discharge among patients receiving CA for AF. The secondary outcomes were total hospital costs required from admission to the end of 30-day follow-up and primary reasons for readmissions after discharge. The primary reasons for readmission were based on the ICD-10 code.

Definitions of exposure, variables, bias, and confounding

The collected variables were as follows: age, gender, body mass index, income, length of hospital stay, smoking status, hospital, number of hospital beds, oxygen use during admission, comorbidity including hypertension, diabetes, chronic kidney disease, heart failure, previous stroke, and previous myocardial infarction. Patients receiving CA with an SDD protocol and ONS protocol were defined as those who were discharged same-day following CA and those who stayed at least one night in the hospital following CA, respectively.

Statistical method

Propensity score matching was performed to compare the SDD protocol and ONS protocol outcomes using a propensity score calculated based on a multivariable logistic regression for undergoing CA in the SDD protocol. Predictor variables comprised several pre-treatment variables, including age, sex, admission date (year), income, the number of beds in a hospital, and body mass index at admission (listed in *Table 1*). Propensity score matching without a replacement was performed in a 1 : 3 nearest-neighbour fashion with a calliper width of 20% of the estimated propensity scores' standard deviation.[13] To assess the performance of the matching, mean standardized differences were calculated. Using the matched cohort, we next performed a univariate Cox proportional-hazards regression to evaluate the association between SDD and 30-day readmission following CA. To confirm the robustness of the results using a matched-cohort, a multivariate Cox proportional-hazards regression was performed to estimate the hazard ratio (HR) of SDD for 30-day readmission. Additionally, the independent predictors of 30-day readmission were calculated based on the multivariable logistic regression. Covariates for multivariate regression were as follows; age $\geq$ 65, sex, history of heart failure, diabetes, hypertension, prior history of myocardial infarction, and SDD.

Hazard ratio with 95% confidence intervals (CI) was evaluated using Cox regression analysis. Continuous variables are presented as mean ± standard deviation. Categorical variables are presented as numbers and percentages. Continuous variables were compared using the Student's *t*-test and categorical variables were compared using the Pearson χ^2 test. The two-sided significance level with $P < 0.05$ was considered as a significant difference. All result was analysed using STATA (ver 16.1, StataCorp LLC, College Station, TX, USA) and R Core Team (2020) (Vienna, Austria).

Ethical considerations

Given that the NRD is a publicly available deidentified database, this study was exempt from the need for Institutional Review Board approval.

Results

Baseline characteristics

Among 65 940 patients enrolled in the NRD who underwent CA, 35 164 patients were excluded from analysis with following reasons: patients with a diagnosis of atrial tachycardia, atrial flutter, supraventricular tachycardia, ventricular tachycardia, and ventricular fibrillation: 30 573 patients, date of procedure was December: 3040 patients, Patients without information on mortality: 53 patients,

Table 1 Baseline characteristics before and after propensity score matching between same-day discharge group and overnight stay group

	Unmatched group			Propensity score-matched group		
	Another day discharge $n = 30\,336$	Same day discharge $n = 440$	*P*-value	Another day discharge $n = 1311$	Same day discharge $n = 440$	*P*-value
Age	67.2 (11.4)	66.9 (11.2)	0.683	66.2 (11.2)	66.9 (11.2)	0.507
Sex (female)	12590 (41.5%)	188 (42.7%)	0.741	599 (45.7%)	188 (42.7%)	0.463
Hypertension	23136 (76.3%)	329 (74.9%)	0.636	996 (76%)	329 (74.9%)	0.737
Dyslipidaemia	15781 (52.0%)	245 (55.7%)	0.315	709 (54.1%)	245 (55.7%)	0.680
Diabetes	7681 (25.3%)	108 (24.5%)	0.728	308 (23.5%)	108 (24.5%)	0.767
Obesity	7990 (26.3%)	97 (22.1%)	0.133	349 (26.7%)	97 (22.1%)	0.147
Previous PCI	3042 (10.0%)	42 (9.6%)	0.813	94 (7.2%)	42 (9.6%)	0.254
Previous myocardial infarction	2239 (7.4%)	24 (5.4%)	0.386	56 (4.3%)	24 (5.4%)	0.558
Heart failure	13181 (43.5%)	138 (31.4%)	0.002	409 (31.2%)	138 (31.4%)	0.960
CKD or ESRD	4768 (15.7%)	43 (9.8%)	0.036	130 (9.9%)	43 (9.8%)	0.976
Chronic pulmonary disease	6717 (22.1%)	68 (15.6%)	0.010	249 (19.0%)	68 (15.6%)	0.204
Oxygen use	935 (0.5%)	11 (0.3%)	0.004	11 (0.83%)	11 (0.3%)	0.615
Previous stroke	2978 (9.8%)	24 (5.4%)	0.029	66 (5%)	24 (5.4%)	0.814
Peripheral vascular disease	3518 (11.6%)	50 (11.3%)	0.889	164 (12.5%)	50 (11.3%)	0.639
Anaemia	774 (2.6%)	6 (1.3%)	0.347	16 (1.3%)	6 (1.3%)	0.965
Tobacco use	10405 (31.5%)	144 (32.8%)	0.633	413 (31.5%)	144 (32.8%)	0.686
Hospital bedsize (small)	1925 (6.3%)	21 (4.9%)	0.383	52 (4.0%)	21 (4.9%)	0.596
Hospital bedsize (medium)	8160 (26.9%)	142 (32.3%)	0.232	440 (33.6%)	142 (32.3%)	0.781
Hospital bedsize (large)	20 251 (66.8%)	276 (62.9%)	0.405	818 (62.4%)	276 (62.9%)	0.928
Teaching hospital	25 573 (84.3%)	372 (84.6%)	0.923	1088 (83.0%)	372 (84.6%)	0.611
Cancer	483 (1.6%)	4 (0.8%)	0.324	13 (1.0%)	4 (0.8%)	0.841
Liver disease	624 (2.1%)	3 (0.6%)	0.069	15 (1.1%)	3 (0.6%)	0.429
Insurance						
Medicare	18 596 (61.3%)	268 (60.8%)	0.69	760 (58.1%)	268 (60.8%)	0.30
Medicaid	1396 (4.6%)	22 (5.1%)		71 (5.4%)	22 (5.1%)	
Private	9435 (31.1%)	129 (29.4%)		450 (34.3%)	129 (29.4%)	
Others	909 (3.0%)	21 (4.7%)		30 (2.2%)	21 (4.7%)	

Data are expressed as number (percentage), continuous variables as mean (standard deviation).
CKD, chronic kidney disease; ESRD, end-stage renal disease; PCI, percutaneous coronary intervention.

patients experienced any periprocedural complications: 1348 patients, and patients died before discharge: 150 patients (*Figure 1*). Of a total number of 30 776 patients in a final analytic cohort, the mean age was 67.2 ± 11.4, 41.5% were female, and 440 patients (1.42%) who underwent CA were discharged with the SDD protocol (2016: 122 cases/2017: 174 cases/2018: 144 cases). Compared to patients discharged with an ONS protocol, patients in SDD-group were less likely to have a history of heart failure (31.4% vs. 43.5%, $P = 0.002$), pulmonary disease (15.6% vs. 22.1%, $P = 0.02$), and a history of stroke (5.4% vs. 9.8%, $P = 0.03$). The mean age and the proportion of a history of hypertension, dyslipidaemia, diabetes, obese patients, prior history of percutaneous coronary intervention, a history of myocardial infarction, anaemia, and cancer was not significantly different in both groups (*Table 1*). In the ONS group, the median length of hospital stay was 2 days (inter-quartile range: 1–4 days). Baseline characteristics and comparison after 1 : 3 propensity score matching are shown in *Table 1*. The post-matching cohort comprised 440 and 1311 patients in each SDD group and ONS group.

A standardized mean difference of covariates using propensity score matching was summarized in Supplementary material online, *Figure S2*, showing that all standardized mean differences were within 10%. A histogram of propensity score using matching is described in Supplementary material online, *Figure S1*.

Unadjusted analysis and propensity-matched analysis

In the pre-matching baseline cohort, a total of 3361 patients (10.9%) were readmitted within 30 days of discharge. 3306 patients (12.6%) in the SDD group and 55 (10.9%) in the ONS group were readmitted within 30 days after discharge ($P = 0.46$). Hospitalization costs were significantly lower in the SDD group ($25 237 ± 14 034 vs. $31 448 ± 17 681, $P < 0.001$) (*Table 2*). In the matched cohort, no significant difference in the 30-day readmission rate was observed between both SDD and ONS groups (12.6% vs. 9.7%, $P = 0.23$). Hospitalization costs were significantly lower in an SDD group ($25 237 ± 14 036 vs. $30 749 ± 16 383; $P < 0.01$) (*Table 2*).

Independent risk factors for 30-day readmission

Figure 2 demonstrated the independent risk factors for 30-day readmission following PVI using a univariate Cox regression for the matched cohort and multivariate Cox regression for the unmatched cohort. The SDD was not associated with 30-day readmission using univariate analysis for the matched cohort (HR: 1.17, 95% CI 0.76–1.81) (*Figure 2*). In a multivariate Cox proportional-hazards analysis using unmatched-cohort, a history of heart failure (HR 1.61, 95% CI 11.47–1.77), age ≥ 65 (HR 1.29, 95% CI 1.16–1.45), hypertension (HR 1.21, 95% CI 1.07–1.37), prior myocardial infarction (HR 1.30, 95% CI 1.08–1.57) and diabetes mellitus (HR: 1.61, 95% CI 1.47–1.77) were independently associated with 30-day readmission, while the SDD was not associated with 30-day readmission (HR 1.21, 95% CI 0.83–1.76).

Reasons for readmissions

Among all 191 readmissions of the 1751 patients in the overall matched cohort (59 in SDD protocol and 132 patients in ONS protocol, respectively), the followings were the major readmission causes; cardiac causes (SDD vs. ONS; 73.3% vs. 56.6%, $P < 0.001$) were the most prevalent cause of readmissions. Readmissions due to either AF or atrial flutter were the most common among cardiac causes (40.0% vs. 30.1%, $P < 0.001$), followed by heart failure (13.3% vs. 16.9%, $P < 0.001$) and pericardial complications (10.0% vs. 3.6%, $P < 0.001$). Other reasons included stroke or transient ischaemic attack (3.3% vs. 1.0%, $P < 0.001$), bleeding events (6.1% vs. 5.9%, $P = 0.9$), or infections (6.7% vs. 10.8%, $P < 0.001$).

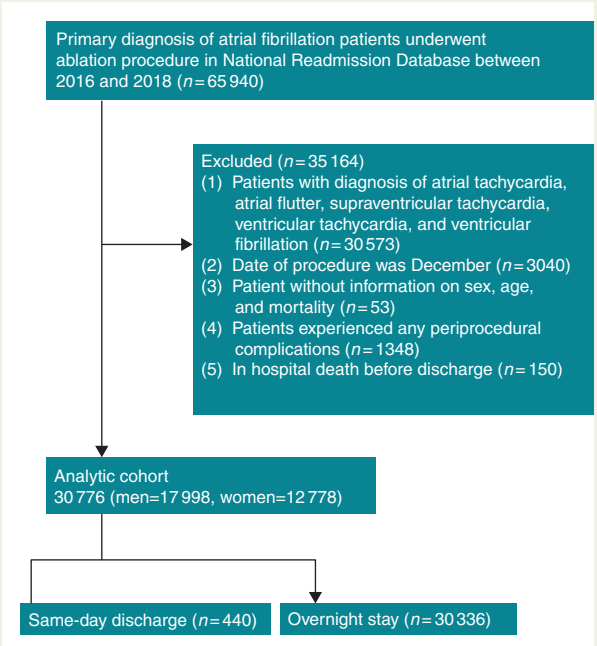


Figure 1 The flow diagram of this study.

Discussion

In this study using a contemporary nationwide readmission database from the USA, ~10% of overall patients receiving CA were readmitted within 30-day after discharge. In the matched cohort, an SDD protocol was not associated with 30-day readmissions compared to the ONS group. Hospital cost was significantly lower in the SDD group.

Previous studies have shown no statistical difference in the safety of the SDD protocol compared to the ONS protocol,[7,8,14] and a lower rate of life-threatening adverse events using an SDD protocol in the current era.[15] However, confounding, selection bias, and reporting bias inherent in the design of these studies make it difficult to compare the safety and effectiveness of both protocols as patients in the SDD groups were pre-selected as being lower risk of adverse outcome.[8] In some studies, patients with periprocedural complications were excluded from the SDD group and instead incorporated into the overnight observation group biasing the result in favour of SDD[16,17]

On the other hand, a study conducted in North America routinely introduced the SDD protocol for a large number of patients, in which patients who were discharged on the same day and patients who had no complications but stayed overnight were compared.[7] In the study with a relatively little confounding by indication, there was no difference in the 30-day readmission rate between the two groups. Additionally, previous studies investigating the safety and effectiveness of SDD protocol for CA for AF were conducted in a few institutes.[6,7,17–19] Instead, the study used the data from across the USA, which would have provided many generalized results.

Complications (severe haematoma, cardiac tamponade, phrenic nerve injury, congestive heart failure, systemic embolism, etc.) sometimes occur following CA for AF. There were several cases of rehospitalization within 30 days with ~10% of patients, consistent results with a previous study using another dataset.[20] Generally, the most common reason for readmission was palpitations due to recurrent AF caused by myocardial damage.[7,20] As the CA for AF becomes

Table 2 Comparison of readmission and hospital cost within 30-day following catheter ablation between both same-day discharge group and overnight stay group

	Unmatched group			Propensity score matched group		
	Same-day discharge	Overnight stay	*P*-value	Same-day discharge	Overnight stay	*P*-value
Readmission rate	59 (12.9%)	3563 (10.9%)	0.469	59 (12.9%)	132 (9.7%)	0.171
Hospital cost	$25 237 ($14 034)	$31 448 ($17 681)	<0.001	$25 237 ($14 034)	$30 749 ($16 383)	<0.001

Data are expressed as number (percentage), continuous variables as mean (standard deviation).

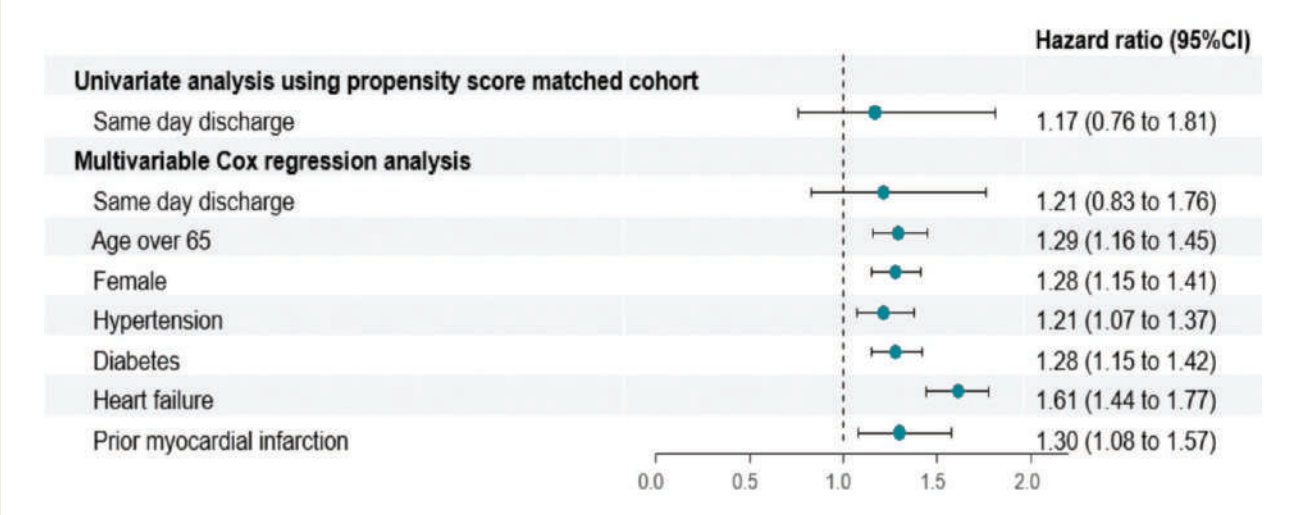


Figure 2 Readmission risk of patients undergoing catheter ablation for atrial fibrillation. CI, confidential interval.

more widespread, improvements in resource utilization and cost-effectiveness analysis are necessary given the increasing hospital cost worldwide. The large-scale questionnaire survey conducted in European countries demonstrated that several hospitals, mainly in high-volume centres, already introduced the SDD protocol for PVI.[21] The protocol was highly recommendable in that study because of better hospital resource utilization, a shorter hospital stay, and patient satisfaction. Similar to other cardiovascular procedures, including percutaneous coronary intervention, left atrial appendage occulusion,[22,23] the SDD protocols may reduce the total health care costs of treatment with similar readmission rates as a usual overnight observation protocol. Our data showed that the SDD protocol reduced the total required medical costs by ~20% without significantly increasing the readmission rate. This may provide a clue to solving the problem of increasing healthcare costs.

A history of heart failure and diabetes were independent risk factors for readmission in the present study. These results are consistent with previous studies[24,25] and plausible for the following reasons. First, patients with diabetes mellitus have some cardiac diseases, and more comorbidity and diabetes are associated with early recurrence after PVI.[26] Secondly, patients with a history of heart failure are likely to require hospitalization for respiratory distress induced by early AF recurrence after PVI. In addition to those risk factors, low AF ablation hospital volume, female gender, chronic pulmonary disease, and renal failure were considered high risk for readmission, subsequent complications, and mortality.[24,25,27] Given these analyses, it might be better to have careful patient selection and a close follow-up to introduce the SDD protocol safely. Additionally, the SDD protocol should be initially introduced only for patients without periprocedural complications and patients with few comorbidities considering that procedure-associated readmissions are less common among those patients.

There are several strengths in our study. First, this study examined the safety and effectiveness of 30-day readmission and mortality rates after SDD following CA for AF using a large and contemporary nationwide database. Secondly, an appropriate confounding adjustment using propensity score matching has been made to properly assess the two groups' differences. Since the SDD is generally not considered in patients with complications in the clinical settings, analysis in patients without complications to deal with confounding does not limit much external validity. Thirdly, a limited number of studies have examined individual factors associated with readmission after CA for AF using large datasets. In the present analysis, a history of heart failure and diabetes were associated with 30-day readmission. This finding could contribute to identifying patients at high risk for readmission following PVI and the safe introduction of an SDD protocol. Finally, this study using a nationwide comprehensive large-scale database can emphasize the impact of SDD protocol on a reduction in the total health care costs required without significantly increasing the readmission.

Limitations

This study includes several limitations: first, selection bias needs to be considered. In routine practice, clinicians may avoid SDD protocol in patients with some comorbidities in clinical settings. In the present study, we balanced both groups using a propensity score matching to minimize differences between groups. However, there were differences in some covariates (i.e. heart failure, chronic pulmonary disease, and anaemia) in an unmatched population, suggesting the presence of selection bias. Randomized controlled trials will be warranted to demonstrate the efficacy and safety of the protocol. The results presented in this study will help in designing studies for randomized controlled trials. Secondly, the NRD lacks information on the used devices (either radiofrequency or balloon ablation), race/ethnicity, time requiring procedure, the finished time, detailed procedure (ablation strategy such as only circumferential PVI, additional left atrial ablation, additional cavotricuspid isthmus, etc.), whether general anaesthesia was used during the procedure, patient's frailty, income or drugs used for anaesthesia. The proportion of AF recurrence varies based on AF duration, type of AF (paroxysmal, chronic, long persistent), the ablation procedures, and early recurrence after CA is sometimes associated with rehospitalization due to palpitation and

subsequent heart failure.[24] However, the NRD similarly does not include detailed AF duration, type, and detailed procedure or patients' frailty. The impact of SDD protocol on 30-day readmission will be more accurately estimated by adjusting these confounding. Thirdly, external validity was slightly reduced due to excluding patients with any periprocedural complications to minimize selection bias. Considering that patients who experienced procedural complications were at high risk for subsequent complications,[27] the 30-day readmission rate in this study, which excluded patients with any complications, might be lower than that of an overall population. The results of the present study will need to be interpreted appropriately when introduced the protocol into daily practice. Additionally, due to the nature of propensity-score matching, the impact of SDD on the 30-day readmission in the overall study population cannot be estimated entirely. Finally, in this study, patients with specific disease codes for supraventricular tachycardia, accessory pathway syndrome, atrial flutter, and ventricular tachycardia were excluded to eliminate those who experienced CA solely for these diseases. In the clinical setting, several patients with AF have concomitant other arrhythmias. Therefore, excluding patients with other arrhythmias may have excessively reduced the number of patients with AF and limited generalizability.

Conclusion

The proportion of 30-day readmission following SDD among complication-free patients receiving CA for AF was similar to patients staying overnight. Further prospective research and the establishment of best practices, including for choice of patients with lower risk for readmission after CA and the methods for follow-up after discharge, is warranted to confirm the safety of SDD following CA among patients with AF.

Supplementary material

Supplementary material is available at *Europace* online.

Conflict of interest: RP is an advisory board Medtronic, research support AHA, Abbott, royalties UpToDate.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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