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Outcomes Following Non-Emergent Electrical Cardioversion for Atrial Arrhythmias

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Abstract

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Electrical cardioversion (ECV) is recommended for rhythm control in atrial arrhythmia patients, yet ECV use and outcomes in contemporary practice are unknown. We reviewed all non-emergent ECVs for atrial arrhythmias at a tertiary care center (2010–2013), stratifying patients by transesophageal echocardiography (TEE) use pre-ECV and comparing demographics, history, vitals, and laboratory studies. Outcomes included post-procedure success and complications, and repeat cardioversion, rehospitalization, and death within 30 days. Overall, 1017 patients underwent ECV; 760 (75%) for atrial fibrillation and 240 (24%) for atrial flutter; 633 underwent TEE pre-ECV and 384 did not. TEE recipients were more likely to be inpatients (74% vs. 44%, $p<0.001$), have higher mean CHADS₂ scores (2.6 vs. 2.4, $p=0.03$), and lower mean international normalized ratios (1.2 vs. 2.1, $p<0.001$). Overall, 89 (8.8%) did not achieve sinus rhythm and 14 experienced procedural complications (1.4%). Within 30 days, 80 (7.9%) underwent repeat ECV, 113 (11%) were rehospitalized, and 14 (1.4%) died. Although ECV success was more common in patients who underwent TEE pre-ECV (77% vs. 68%, $p=0.01$), there were no differences in 30-day death or rehospitalization rates (11.1% vs. 13.0%, $p=0.37$). In multivariable analyses, higher pre-ECV heart rate was associated with increased rehospitalization or death (adjusted HR 1.15/10 bpm, 95% CI 1.07–1.24, $p<0.001$), while TEE use was associated with lower rates (adjusted HR 0.58, 95% CI 0.39–0.86, $p=0.007$). In conclusion, failures, complications, and rehospitalization following non-emergent ECV are common, and associated more with patient condition than procedural characteristics. TEE use was associated with better clinical outcomes.

Keywords

Atrial fibrillation; Cardioversion; Transesophageal echocardiography; Outcomes

In hopes of better understanding ECV use and outcomes, we sought to: 1) describe a contemporary cohort of patients undergoing non-emergent cardioversion at a major tertiary care hospital, with or without pre-procedure transesophageal echocardiography (TEE); 2) explore the outcomes in patients undergoing cardioversion; and 3) identify factors associated with adverse outcomes following cardioversion.

Methods

We included consecutive patients who underwent non-emergent ECV at Duke University Medical Center from January 2010 to March 2013. Both inpatient and outpatient procedures were included, as long as they occurred in the cardioversion “suite,” which is a unified location for all non-emergent ECVs at our institution (pharmacologic cardioversions are not performed in this setting). For patients with multiple cardioversions during the study period, the first procedure was included in the analysis as the index event. In order to identify non-emergent cardioversions unrelated to invasive cardiac procedures or catastrophic protracted hospitalizations, several exclusion criteria were used. Cardioversions performed in the electrophysiology laboratories and those for ventricular arrhythmias were not included. Additionally, to provide more clinically-relevant insights, we excluded patients with cardiac surgery or catheter ablation for AF within 90 days prior to cardioversion, those with metastatic cancer, and inpatients with hospitalizations for >14 days prior to cardioversion.

Baseline demographics, medical history, laboratory results, administrative data, and clinical outcomes were derived from the electronic health record and based on clinical diagnosis, including both laboratory and billing systems, via the Decision Support Repository at Duke University. Risk scores for stroke in patients with AF (Congestive heart failure, Hypertension, Age ≥ 75 years, Diabetes mellitus, Stroke or TIA or thromboembolism [CHADS₂] and Congestive heart failure, Hypertension, Age ≥ 75 years, Diabetes mellitus, Stroke or TIA or thromboembolism, Vascular disease, Age 65–74 years, Sex category [CHA₂DS₂-VASc]) were calculated using previously-described methods.^{1,2} Periprocedural data on the cardioversion procedure and immediate outcomes were analyzed from the clinical cardioversion procedure log, which is a database that includes pre-procedure vital signs and rhythm, inpatient status, anesthesia details, cardioversion approach, post-cardioversion vital signs and rhythm, and immediate complications. The procedure log is part of the medical documentation and record for each patient undergoing ECV at Duke University. Detailed ambulatory and inpatient medication use were not available.

Patient outcomes included immediate periprocedural complications, failed cardioversion, repeat cardioversion, thromboembolic events, rehospitalization (with cause), or death within 30 days. Periprocedural complications were derived from the procedure log and defined as bradycardia requiring treatment (medical or electrical), cardiac arrest, hypotension requiring treatment, significant hypoxia, or additional arrhythmia requiring treatment (e.g., ventricular tachycardia, ventricular fibrillation). Failed cardioversion was defined as any periprocedural complication (as above), or a post-cardioversion rhythm of AF, atrial flutter, atrial tachycardia, or low atrial rhythm. All repeat hospitalizations and death within the Duke University Health System were captured through the Decision Support Repository, which is an electronic clearinghouse for clinical data within the health system. Cause of hospitalizations and deaths were identified through primary review of the medical record with categorization of events using the primary clinical diagnosis for the hospitalization and cause of death in the death summaries. To identify factors associated with adverse clinical outcomes, we used the composite endpoint of rehospitalization or death within 30 days of the procedure.

In order to capture TEEs most likely to be performed in anticipation of cardioversion, we stratified baseline and procedural characteristics by the use of TEE within 7 days prior to cardioversion. Distribution of TEE timing was assessed to confirm the validity of this approach. Categorical variables are described as number and percentage and compared using Pearson Chi-square tests; continuous variables are described as median and 25th–75th percentiles and compared using Wilcoxon rank-sum tests.

Immediate post-cardioversion characteristics and cardioversion success is described and compared by TEE use, CHADS₂ scores, and CHA₂DS₂-VASc scores using similar chi-square tests. Thirty-day rehospitalization or death was evaluated with Kaplan-Meier curves and log-rank tests by these same key variables.

Multivariate Cox proportional hazards regression was used to identify and describe factors associated with death or rehospitalization within 30 days in this patient cohort. Models were derived using backward selection, with a stay criterion of $p < 0.10$. Candidate variables for

selection included baseline patient characteristics, medical history, pre-procedure vital signs, pre-procedure rhythm, use of pre-procedure TEE, inpatient status, and cardioversion shock mechanism. All candidate variables were assessed for linearity and proportional hazards assumptions. There were no relevant proportional hazards violations; linearity was addressed using linear splines when needed. Subsequently, we added pre-procedural laboratory data as candidate covariates using the same modeling approach; however, this was limited to the subset of 896 patients (88%) with laboratories available within 30 days prior to the procedure. We further assessed the impact of including immediate post-cardioversion results in the model of 30-day outcomes, using the same backward-selection procedure with the added consideration of post-cardioversion vitals, post-cardioversion rhythm, or immediate post-cardioversion complication, as candidate covariates.

This analysis was approved by the Institutional Review Board of Duke University, which granted a waiver of informed consent. All statistical analyses of aggregate, de-identified data were performed at the Duke Clinical Research Institute using SAS software (version 9.2 or higher, SAS Institute, Cary, NC). No extramural funding support was used.

Results

A total of 1229 patients undergoing non-emergent cardioversion were identified, with a total of 1663 cardioversion procedures recorded. After applying exclusion criteria, this yielded a final study cohort of 1017 patients undergoing their first cardioversion during the study period (Figure 1). Overall, 60% (n=608) of patients were hospitalized as inpatients at the time of their index procedure; the mean time from cardioversion to discharge was 3.5 days.

Baseline characteristics and procedural details, stratified by TEE use, are shown in Table 1. Imaging findings within the cohort are shown in Table 2, with unadjusted, immediate post-cardioversion outcomes in Table 3. Overall, 8.8% of patients (n=89) failed to achieve sinus rhythm following cardioversion and there were 14 immediate complications (1.4%) in 13 patients (1.3%). Rates of ECV failure or complication were not significantly different between patients with versus without TEE (9.5% vs. 9.6%, $p=0.93$), or by CHADS₂ (9.8% for ≥ 2 vs. 8.7% for 0–1, $p=0.59$) or CHA₂DS₂-VASc scores (9.7% for ≥ 2 vs. 8.2% for 0–1, $p=0.61$).

In total, 80 patients (7.9%) underwent repeat cardioversion within 30 days; these included 23 patients (24%) with a cardioversion failure or immediate complication during the index procedure. The incidence of repeat cardioversion tended to be higher in patients with prior TEE versus those without (8.5% vs. 6.8%, $p=0.31$), and in those with higher CHADS₂ (8.4% for ≥ 2 vs. 6.6% for 0–1, $p=0.34$) and CHA₂DS₂-VASc scores (8.3% for ≥ 2 vs. 4.6% for 0–1; $p=0.17$).

Among 113 rehospitalization events within 30 days, there was 1 stroke (0.1% overall), 2 transient ischemic attacks (TIAs; 0.2% overall), and 2 admissions for bleeding (0.2% overall). The remaining 65 hospitalizations were for atrial arrhythmias (64 for AF), 1 for ventricular tachycardia, 10 for heart failure, 8 for other cardiovascular causes, and 24 for non-cardiovascular and non-bleeding reasons. Fourteen patients (1.4%) died within 30 days

of cardioversion: 5 due to heart failure, 2 due to respiratory failure, 2 from septic shock, and for 5 patients, a cause was not available.

Kaplan-Meier event curves for the first occurrence of death or rehospitalization, stratified by use or non-use of TEE were not significantly different and are shown in Figure 2A (11.1%, 95% confidence interval [CI] 8.9%–13.9% with TEE vs. 13.0%, 95% CI 10.0%–16.9% without TEE; $p_{\log\text{-rank}}=0.4$ comparison between TEE vs. no TEE). Kaplan-Meier rates of death or hospitalization were significantly higher in patients with CHADS₂ scores ≥ 2 (event rate 13.4%, 95% CI 11.1%–16.0% vs. 7.6%, 95% CI 5.0%–11.6% for scores 0–1; $p_{\log\text{-rank}}=0.02$, Figure 2B), and in patients with CHA₂DS₂-VASc scores ≥ 2 (event rate 12.8%, 95% CI 10.8%–15.2% vs. 3.8%, 95% CI 1.4%–9.8% for scores 0–1; $p_{\log\text{-rank}}=0.009$, Figure 2C). Additional, subgroup analyses demonstrated worse outcomes in those with prior heart failure, compared to no prior heart failure (Supplemental Data).

Results of multivariable, Cox proportional hazards regression models are shown in Table 4. Clinical factors associated with 30-day outcomes were similar in models that did or did not include pre-procedural laboratory data. The use of pre-procedure TEE was associated with lower 30-day rehospitalization or death in models excluding (adjusted HR 0.67, 95% CI 0.46–0.97, $p=0.04$) and including (adjusted HR 0.58, 95% CI 0.39–0.86, $p=0.007$) laboratory data. However, neither immediate post-cardioversion outcomes (vital signs, rhythm, or complications) nor inpatient status was associated with 30-day rehospitalization or death.

Discussion

We believe our analysis of more than 1,000 cardioversions is the largest cohort describing clinical outcomes of ECV in the United States. We found that TEE was used in the majority (62%) of these procedures. Approximately 1 in 10 patients experienced an immediate adverse outcome or a failed cardioversion, and more than 1 in 10 patients were either rehospitalized or died within 30 days of the procedure. In multivariable analysis, several factors were associated with increased 30-day death or rehospitalization, and may provide opportunities for interventions to reduce such events following ECV.

To date, contemporary data on the use and outcomes of ECV have been limited to international cohorts, or subgroups of clinical trials. The International Registry on Cardioversion of Atrial Fibrillation (RHYTHM-AF) enrolled 3,940 patients with recent AF who were referred for cardioversion in Australia, Brazil, and Europe.³ The clinical outcomes of this study have recently been published.⁴ Among the 75% of patients who ultimately underwent cardioversion in RHYTHM-AF, conversion to normal sinus rhythm was successful in 90%, with very low rates of adverse clinical events. Our analysis was performed using data from a single high volume center in the United States, and included patients undergoing ECV with new recent AF (as in RHYTHM-AF), as well as those patients with chronic arrhythmia and other comorbidities. Our study confirms the high rate of immediate cardioversion success that was observed in RHYTHM-AF, yet our data also demonstrate a high burden of healthcare utilization following cardioversion.

Other studies of clinical outcomes following cardioversion have predominantly focused on thromboembolic events. The Finnish CardioVersion (FinCV) study, which was the largest study of post-cardioversion outcomes, identified a significant risk of thromboembolism, particularly in patients undergoing cardioversion without post-procedure anticoagulation.⁵ In contrast, several subgroup analyses of cardioversion in clinical trials of non-vitamin K oral anticoagulants yielded low rates of adverse events,^{6–8} as anticoagulation in these patients was carefully managed; nonetheless, only 1 of these analyses included rates of post-cardioversion hospitalization.⁸ Data from the Rivaroxaban Once Daily Oral Direct Factor Xa Inhibition Compared with Vitamin K Antagonism for Prevention of Stroke and Embolism (ROCKET-AF) trial demonstrated an approximate 6.8% hospitalization rate within 30 days following cardioversion.

Our cohort demonstrates that hospitalization within 30 days post-cardioversion is not specific to a clinical trial population; rather, hospitalization following cardioversion is likely to be even higher in clinical practice. Hospitalization after cardioversion appears to be driven by specific patient characteristics; in addition to medical comorbidities (e.g., ischemic heart disease, hyperlipidemia, kidney disease, etc.), pre-cardioversion heart rate and blood pressure were independently and significantly associated with events at 30 days. While vital signs may reflect generally poor stability prior to cardioversion, they also likely represent a high hemodynamic burden of arrhythmia. There is some debate regarding the intensity of chronic heart rate control in patients with AF,^{9–11} yet our data suggest that patients with better-controlled heart rates prior to cardioversion are less likely to be readmitted following the procedure.

Importantly, patients undergoing TEE prior to cardioversion had a small numerical increase in the number of periprocedural complications (likely related to increased anesthesia and esophageal intubation), but the use of TEE was associated with a lower risk of death or rehospitalization at 30 days. This finding likely reflects selection biases and/or residual confounding in the use of TEE: patients have more recent-onset arrhythmia, they may be a more carefully-treated population, and their subsequent referral for ECV likely indicates benign TEE findings. While a diagnostic test like TEE is rarely causally linked to improved outcomes, it does appear to be a valid marker. Similarly, stratification by stroke risk score yielded differences in outcomes, as patients with higher CHADS₂ and CHA₂DS₂-VASc scores had significantly higher event rates; this finding is consistent with prior data demonstrating the applicability of these scores to predict a broad range of clinical outcomes.^{12–15}

Our study had several limitations. First, our data are based on a retrospective, observational analysis that took place during a specific period of time at a single tertiary referral institution, and used electronic health record and administrative data. As a result, there may be selection and follow-up biases, as well as residual and/or unmeasured confounding.¹⁶ Second, details of medical therapy at the time of cardioversion—specifically anticoagulation and antiarrhythmics—are not available. Third, rehospitalization events are limited to a single health system, which likely means that these data underestimate true rehospitalization rates. Fourth, specific events, such as thromboembolism and death, are relatively rare, consequently limiting our ability to draw inferences about predictive factors. Finally,

findings from TEEs are not provided, since this was not the primary focus of our analysis. Furthermore, TEEs and other tests performed prior to ECV are principally used to assess the presence of left atrial or left atrial appendage thrombus; as a result, there were unlikely to be thrombogenic findings precluding the procedure since all patients underwent a cardioversion.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Gage BF, Waterman AD, Shannon W, Boechler M, Rich MW, Radford MJ. Validation of clinical classification schemes for predicting stroke: results from the National Registry of Atrial Fibrillation. *JAMA*. 2001; 285:2864–2870. [PubMed: 11401607]
2. Lip GY, Nieuwlaat R, Pisters R, Lane DA, Crijns HJ. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the euro heart survey on atrial fibrillation. *Chest*. 2010; 137:263–272. [PubMed: 19762550]
3. Crijns HJ, Bash LD, Chazelle F, Le Heuzey JY, Lewalter T, Lip GY, Maggioni AP, Martin A, Ponikowski P, Rosenqvist M, Sanders P, Scanavacca M, Bernhardt AA, Unniachan S, Phatak HM, Gitt AK. RHYTHM-AF: design of an international registry on cardioversion of atrial fibrillation and characteristics of participating centers. *BMC Cardiovasc Disord*. 2012; 12:85. [PubMed: 23031215]
4. Crijns HJ, Weijs B, Fairley AM, Lewalter T, Maggioni AP, Martin A, Ponikowski P, Rosenqvist M, Sanders P, Scanavacca M, Bash LD, Chazelle F, Bernhardt A, Gitt AK, Lip GY, Le Heuzey JY. Contemporary real life cardioversion of atrial fibrillation: Results from the multinational RHYTHM-AF study. *Int J Cardiol*. 2014; 172:588–594. [PubMed: 24556445]
5. Airaksinen KE, Gronberg T, Nuotio I, Nikkinen M, Ylitalo A, Biancari F, Hartikainen JE. Thromboembolic complications after cardioversion of acute atrial fibrillation: the FinCV (Finnish CardioVersion) study. *J Am Coll Cardiol*. 2013; 62:1187–1192. [PubMed: 23850908]
6. Flaker G, Lopes RD, Al-Khatib SM, Hermosillo AG, Hohnloser SH, Tinga B, Zhu J, Mohan P, Garcia D, Bartunek J, Vinereanu D, Husted S, Harjola VP, Rosenqvist M, Alexander JH, Granger CB. Committees A Investigators. Efficacy and safety of apixaban in patients after cardioversion for atrial fibrillation: insights from the ARISTOTLE Trial (Apixaban for Reduction in Stroke and Other Thromboembolic Events in Atrial Fibrillation). *J Am Coll Cardiol*. 2014; 63:1082–1087. [PubMed: 24211508]
7. Nagarakanti R, Ezekowitz MD, Oldgren J, Yang S, Chernick M, Aikens TH, Flaker G, Brugada J, Kamensky G, Parekh A, Reilly PA, Yusuf S, Connolly SJ. Dabigatran versus warfarin in patients with atrial fibrillation: an analysis of patients undergoing cardioversion. *Circulation*. 2011; 123:131–136. [PubMed: 21200007]
8. Piccini JP, Stevens SR, Lokhnygina Y, Patel MR, Halperin JL, Singer DE, Hankey GJ, Hacke W, Becker RC, Nessel CC, Mahaffey KW, Fox KA, Califf RM, Breithardt G. Committee RAS, Investigators. Outcomes After Cardioversion and Atrial Fibrillation Ablation in Patients Treated With Rivaroxaban and Warfarin in the ROCKET AF Trial. *J Am Coll Cardiol*. 2013; 61:1998–2006. [PubMed: 23500298]

9. Packer DL, Bardy GH, Worley SJ, Smith MS, Cobb FR, Coleman RE, Gallagher JJ, German LD. Tachycardia-induced cardiomyopathy: a reversible form of left ventricular dysfunction. *Am J Cardiol.* 1986; 57:563–570. [PubMed: 3953440]
10. Van Gelder IC, Groenveld HF, Crijns HJ, Tuininga YS, Tijssen JG, Alings AM, Hillege HL, Bergsma-Kadijk JA, Cornel JH, Kamp O, Tukkie R, Bosker HA, Van Veldhuisen DJ, Van den Berg MP. Lenient versus strict rate control in patients with atrial fibrillation. *N Engl J Med.* 2010; 362:1363–1373. [PubMed: 20231232]
11. Van Gelder IC, Wyse DG, Chandler ML, Cooper HA, Olshansky B, Hagens VE, Crijns HJ. Race Investigators A. Does intensity of rate-control influence outcome in atrial fibrillation? An analysis of pooled data from the RACE and AFFIRM studies. *Europace.* 2006; 8:935–942. [PubMed: 16973686]
12. Coppens M, Eikelboom JW, Hart RG, Yusuf S, Lip GY, Dorian P, Shestakovska O, Connolly SJ. The CHA2DS2-VASc score identifies those patients with atrial fibrillation and a CHADS2 score of 1 who are unlikely to benefit from oral anticoagulant therapy. *Eur Heart J.* 2013; 34:170–176. [PubMed: 23018151]
13. Hoshino T, Ishizuka K, Shimizu S, Uchiyama S. CHADS2 score predicts functional outcome of stroke in patients with a history of coronary artery disease. *J Neurol Sci.* 2013; 331:57–60. [PubMed: 23714421]
14. Lane DA, Lip GY. Use of the CHA(2)DS(2)-VASc and HAS-BLED scores to aid decision making for thromboprophylaxis in nonvalvular atrial fibrillation. *Circulation.* 2012; 126:860–865. [PubMed: 22891166]
15. Puurunen MK, Kiviniemi T, Schlitt A, Rubboli A, Dietrich B, Karjalainen P, Nyman K, Niemela M, Lip GY, Airaksinen KE. CHADS2, CHA2DS2-VASc and HAS-BLED as predictors of outcome in patients with atrial fibrillation undergoing percutaneous coronary intervention. *Thromb Res.* 2014; 133:560–566. [PubMed: 24461143]
16. Birman-Deych E, Waterman AD, Yan Y, Nilasena DS, Radford MJ, Gage BF. Accuracy of ICD-9-CM codes for identifying cardiovascular and stroke risk factors. *Med Care.* 2005; 43:480–485. [PubMed: 15838413]

Figure 1. Study cohort

This figure displays the derivation of the study cohort.

TEE = transesophageal echocardiogram

Figure 2. Death or hospitalization
Kaplan-Meier events curves for death or hospitalization, stratified by use of TEE within 7 days prior to cardioversion (Panel A), by CHADS₂ scores (Panel B), and by CHA₂DS₂-VASc scores (Panel C).
TEE = transesophageal echocardiogram

Table 1
Baseline Characteristics, Stratified by Use of TEE Within 7 Days Prior to Cardioversion

	Overall (n=1017)	TEE Prior to Cardioversion (n=633)	Cardioversion without TEE (n=384)	p-value
Age, median (IQR)	68 (59–76)	68 (60–76)	69 (59–76)	0.7
Female	351/1016 (35%)	232/632 (37%)	119/384 (31%)	0.06
Inpatient	632/1017 (62%)	465/633 (74%)	167/384 (44%)	<0.001
Hypertension	858/1017 (84%)	531/633 (84%)	327/384 (85%)	0.6
Diabetes	342/1017 (34%)	232/633 (37%)	110/384 (29%)	0.009
Renal failure	265/1017 (26%)	187/633 (30%)	78/384 (20%)	0.001
Smoker	315/1017 (31%)	199/633 (31%)	116/384 (30%)	0.7
Hyperlipidemia	659/1017 (65%)	417/633 (66%)	242/384 (63%)	0.4
Heart failure*	578/1017 (57%)	381/633 (60%)	197/384 (51%)	0.006
Coronary heart disease*	510/1017 (50%)	319/633 (50%)	191/384 (50%)	0.8
Prior myocardial infarction	229/1017 (23%)	145/633 (23%)	84/384 (22%)	0.7
Prior cerebrovascular disease	244/1017 (24%)	160/633 (25%)	84/384 (22%)	0.2
Peripheral vascular disease	128/1017 (13%)	86/633 (14%)	42/384 (11%)	0.2
Chronic obstructive pulmonary disease	79/1017 (7.8%)	57/633 (9.0%)	22/384 (5.7%)	0.06
Prior liver disease	37/1017 (3.6%)	23/633 (3.6%)	14/384 (3.6%)	1.0
CHADS ₂ score, mean (SD)	2.5 (1.5)	2.6 (1.5)	2.4 (1.5)	0.03
CHA ₂ DS ₂ score 2	742/1017 (73%)	472/633 (75%)	270/384 (70%)	0.1
CHA ₂ DS ₂ -VAsC score, mean (SD)	4.0 (2.1)	4.1 (2.1)	3.9 (2.1)	0.07
CHA ₂ DS ₂ -VAsC score 2	906/1016 (89%)	574/632 (91%)	332/384 (87%)	0.03
TEE same day as cardioversion	575/1017 (57%)	575/633 (91%)	-	-
Pre-cardioversion vital signs				
Diastolic blood pressure (mm Hg), median (IQR)	76 (66–86)	75 (66–86)	76 (67–86)	0.6
Systolic blood pressure (mm Hg), median (IQR)	128 (114–144)	128 (114–143)	129 (114–145)	0.7
Heart rate, median (IQR)	89 (74–110)	91 (77–113)	83 (71–102)	<0.001
Labs prior to cardioversion				
Hemoglobin (g/dL), median (IQR)	14 (12–15)	13 (12–15)	14 (12–15)	0.06
Platelets (x10 ³), median (IQR)	210 (172–253)	213 (173–260)	205 (170–238)	0.01
International normalized ratio, median (IQR)	1.4 (1.1–2.3)	1.2 (1.0–1.9)	2.1 (1.2–2.7)	<0.001

	Overall (n=1017)	TEE Prior to Cardioversion (n=633)	Cardioversion without TEE (n=384)	p-value
aPTT (seconds), median (IQR)	35 (29–42)	32 (29–39)	39 (35–44)	<0.001
Creatinine (mg/dL), median (IQR)	1.1 (0.9–1.4)	1.1 (0.9–1.4)	1.1 (0.9–1.4)	0.04
Potassium (mmol/L), median (IQR)	4.2 (3.9–4.5)	4.2 (3.8–4.5)	4.3 (4.0–4.5)	0.03
Magnesium (mg/dL), median (IQR)	2.1 (1.9–2.2)	2.1 (1.9–2.2)	2.1 (1.9–2.2)	0.4
Pre-cardioversion rhythm				0.007
Atrial fibrillation	760/1017 (75%)	452/633 (71%)	308/384 (80%)	
Atrial flutter	240/1017 (24%)	170/633 (27%)	70/384 (18%)	
Atrial tachycardia	17/1017 (1.7%)	11/633 (1.7%)	6/384 (1.6%)	
Cardioversion via implanted device	12/949 (1.3%)	6/593 (1.0%)	6/356 (1.7%)	0.4
Cardioversion sedation				
Propofol	973/1017 (96%)	608/633 (96%)	365/384 (95%)	0.4
Propofol dose (mg), median (IQR)	110 (80–160)	140 (100–200)	80 (60–100)	<0.001
Midazolam	7/1017 (0.7%)	4/633 (0.6%)	3/384 (0.8%)	1.000
Fentanyl	11/1017 (1.1%)	6/633 (0.9%)	5/384 (1.3%)	0.8

aPTT = activated partial thromboplastin time; CHADS₂ = ; CHA₂D₂-VASc = ; IQR = interquartile range; mg, milligram; SD = standard deviation; TEE = transesophageal echocardiogram

* Based on clinical diagnosis codes in the electronic health record, as documented by the treating physician.

Table 2

Imaging findings among patients undergoing cardioversion.*

	Overall (n=1017)	TEE Prior to Cardioversion (n=633)	Cardioversion without TEE (n=384)	p-value
LA Size				0.691
Normal	142/691 (20.5%)	94/448 (21.0%)	48/243 (19.8%)	
Small	1/691 (0.1%)	1/448 (0.2%)	0/243 (0.0%)	
Mildly enlarged	331/691 (47.9%)	220/448 (49.1%)	111/243 (45.7%)	
Moderately enlarged	196/691 (28.4%)	120/448 (26.8%)	76/243 (31.3%)	
Severely enlarged	21/691 (3.0%)	13/448 (2.9%)	8/243 (3.3%)	
MV Leaflets				<.001
Normal	784/879 (89.2%)	563/613 (91.8%)	221/266 (83.1%)	
Abnormal	95/879 (10.8%)	50/613 (8.2%)	45/266 (16.9%)	
MV Mobility				0.525
Fully mobile	846/877 (96.5%)	591/611 (96.7%)	255/266 (95.9%)	
Partially mobile	31/877 (3.5%)	20/611 (3.3%)	11/266 (4.1%)	
Completely immobile	0/877 (0.0%)	0/611 (0.0%)	0/266 (0.0%)	
LVEF				0.750
<15%	33/826 (4.0%)	23/568 (4.0%)	10/258 (3.9%)	
20%	30/826 (3.6%)	18/568 (3.2%)	12/258 (4.7%)	
25%	35/826 (4.2%)	25/568 (4.4%)	10/258 (3.9%)	
30%	25/826 (3.0%)	18/568 (3.2%)	7/258 (2.7%)	
35%	29/826 (3.5%)	16/568 (2.8%)	13/258 (5.0%)	
40%	49/826 (5.9%)	35/568 (6.2%)	14/258 (5.4%)	
45%	53/826 (6.4%)	36/568 (6.3%)	17/258 (6.6%)	
50%	88/826 (10.7%)	65/568 (11.4%)	23/258 (8.9%)	
>55%	484/826 (58.6%)	332/568 (58.5%)	152/258 (58.9%)	
Preserved LVEF (≥ 50)	572/826 (69.2%)	397/568 (69.9%)	175/258 (67.8%)	0.551

LA: left atrium; MV: mitral valve; LVEF: left ventricular ejection fraction

* Based on most recent transthoracic or transesophageal echocardiogram within the prior year.

Table 3

Unadjusted Immediate Post-cardioversion Outcomes

Variable	Overall (n=1017)	TEE Prior to Cardioversion (n=633)	Cardioversion without TEE (n=384)	p-value
Post-cardioversion vital signs				
Diastolic blood pressure (mm Hg), median (IQR)	63 (56–72)	62 (55–70)	65 (58–74)	<0.001
Systolic blood pressure (mm Hg), median (IQR)	111 (98–127)	109 (96–124)	117 (103–130)	<0.001
Heart rate, median (IQR)	67 (59–76)	69 (60–78)	65 (55–74)	<0.001
Post-cardioversion rhythm				
				0.01
Atrial fibrillation	65/1017 (6.4%)	39 (6.2%)	26 (6.8%)	
Atrial flutter	11/1017 (1.1%)	6 (0.9%)	5 (1.3%)	
Atrial tachycardia	1/1017 (0.1%)	1 (0.2%)	0 (0.0%)	
Low atrial rhythm	12/1017 (1.2%)	7 (1.1%)	5 (1.3%)	
Normal sinus rhythm	748/1017 (74%)	488 (77%)	260 (68%)	
Sinus bradycardia	180/1017 (18%)	92 (15%)	88 (23%)	
Any complication*	13/1017 (1.3%)	11/633 (1.7%)	2/384 (0.5%)	0.1
Bradycardia requiring treatment	4 (0.4%)	4 (0.6%)	0	
Cardiac arrest	1 (0.1%)	1 (0.2%)	0	
Hypotension requiring treatment	4 (0.4%)	3 (0.5%)	1 (0.3%)	
Hypoxia	2 (0.2%)	2 (0.3%)	0	
VT/VF requiring treatment	1 (0.1%)	0	1 (0.3%)	
Other arrhythmia	2 (0.2%)	2 (0.3%)	0	

Table 4

Factors Associated with Rehospitalization or Death Following Cardioversion *

Model Using Only Clinical Characteristics (n=1017)			Model Including Laboratory Data (n=896)		
	HR (95% CI)	p-value		HR (95% CI)	p-value
Ischemic heart disease	0.61 (0.38 – 0.97)	0.04	Simultaneous TEE	0.58 (0.39 – 0.86)	0.007
Simultaneous TEE	0.67 (0.46 – 0.97)	0.04	Ischemic heart disease	0.65 (0.40 – 1.07)	0.09
SBP per 10mmHg >120mmHg	0.86 (0.76 – 0.99)	0.03	SBP per 10mmHg >120mmHg	0.82 (0.71 – 0.96)	0.01
Age per 10 years	1.14 (0.98 – 1.34)	0.1	Platelets per 10k (up to 150)	0.85 (0.77 – 0.94)	0.001
Heart rate per 10 bpm	1.17 (1.09 – 1.25)	<0.001	Platelets per 10k (above 150)	1.03 (1.00 – 1.05)	0.06
Chronic kidney disease	1.44 (0.96 – 2.16)	0.08	Heart rate per 10 bpm	1.15 (1.07 – 1.24)	<0.001
Hypertlipidemia	1.60 (1.00 – 2.54)	0.049	Age per 10 years	1.21 (1.02 – 1.43)	0.03
COPD	1.68 (0.98 – 2.89)	0.06	Hypertlipidemia	1.48 (0.90 – 2.41)	0.1
Prior MI	1.68 (1.06 – 2.69)	0.03	Prior MI	1.53 (0.94 – 2.49)	0.09
CHF	1.74 (1.11 – 2.74)	0.02	COPD	1.61 (0.90 – 2.86)	0.1
			CHF	1.63 (1.00 – 2.65)	0.048
			Chronic kidney disease	1.67 (1.10 – 2.55)	0.02

* Vital signs and lab values are all prior to cardioversion.

bpm = beats per minute; CHF = congestive heart failure; CI = confidence interval; HR = hazard ratio; All other abbreviations can be found in Table 1.