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Clinical paper

Post cardiac arrest left ventricular ejection fraction associated with survival to discharge

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Abstract

Background: Post cardiac arrest left ventricular ejection fraction (LVEF) is routinely assessed, but the implications of this are unknown. This study aimed to assess the association between post cardiac arrest LVEF and survival to hospital discharge.

Methods: In this retrospective cohort study, all in-hospital and out of hospital cardiac arrests at our tertiary care center between January 2012 and September 2015 were included. Baseline demographics, clinical data, characteristics of the arrest, and interventions performed were collected. Earliest post cardiac arrest echocardiograms were reviewed with LVEF documented. The primary outcome was survival to discharge.

Results: A total of 736 patients were included in the analysis (mean age 58 years, 44% female). 15% were out of hospital cardiac arrest (24% shockable rhythm). After adjusting for covariates, patients with LVEF < 30% had 36% lower odds of surviving to hospital discharge than those with LVEF $\geq$ 52% (p = 0.014). Shockable initial rhythm and targeted temperature management were associated with improved survival.

Conclusion: After a cardiac arrest, an initial LVEF < 30% is associated with significantly lower odds of survival to hospital discharge.

Keywords: Cardiac arrest, Post arrest care, Left ventricular ejection fraction, Survival to hospital discharge

Introduction

In 2015, approximately 350,000 adults in the United States experienced non-traumatic out-of-hospital cardiac arrest (OHCA) attended by emergency medical services (EMS) personnel.[1] Approximately 10.4% of patients with OHCA survive their initial hospitalization, and 8.2% survive with good functional status. The key drivers of successful resuscitation from OHCA are lay rescuer cardiopulmonary resuscitation (CPR) and public use of an automated external defibrillator (AED).[2] Approximately 1.2% of adults admitted to US hospitals suffer in-hospital cardiac arrest (IHCA).[1] Of these patients, 25.8% were discharged from the hospital alive, and 82% of survivors have good functional status at the time of discharge.[2] In the year 2020 alone, 436,000 Americans die from cardiac arrest. According to AHA Heart Disease and Stroke Statistics 2024, survival to hospital discharge was 9.3% for all EMS-treated non-traumatic out-of-hospital cardiac arrests. If performed immediately, CPR can double or triple the chance of survival from an out-of-hospital cardiac arrest.[3]

According to 2015 American Society of Echocardiography guideline for cardiac chamber quantification, LVEF of at least 52% is considered normal in men, at least 54% is considered normal in women. LVEF of 41–51% in men and 41–53% in women are considered mildly abnormal. LVEF od 30–40% is considered moderately abnormal and less than 30% is considered severely abnormal for both genders.[4] To minimize the confusion in the analyses of this study, we chose LVEF of at least 52% as normal, 41–51% as mildly abnormal, 30–40% as moderately abnormal, and less than 30% as severely abnormal.

Post-cardiac arrest care is a critical component of the Chain of Survival and demands a comprehensive, structured, multidisciplinary system that requires consistent implementation for optimal patient outcomes. Multiple factors were implicated in the prognostication of patients post cardiac arrest, including but not limited to targeted temperature management particularly in patients with an initial shockable rhythm, presence of pupillary light reflex at 72 h or more, and certain findings on electroencephalography and neuro-imaging studies.[2] LVEF has been ubiquitously used as a predictor of outcomes across multiple cardiovascular pathologies and routinely performed after cardiac arrests for many clinical reasons. There are studies demonstrating that post cardiac arrest LVEF,[5,6] especially less than 45%, is associated with poor outcomes,[7–9] but they were all in either OHCA

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or IHCA separately, and the implications of this in all-comers are unknown or recently assessed. Furthermore, it is not clear if there is a graded impact on survival based on degree of ventricular dysfunction.

This study aims to assess the association between post cardiac arrest LVEF and survival to hospital discharge.

Methods

This is a retrospective cohort study. Patients were initially screened using a multi-faceted approach to identify all cardiac arrests. This included a review of all the code sheets in our hospital system, ICD9 and 10 codes for cardiac arrest, VT/VF arrest, therapeutic hypothermia database, and cardiac catheterization lab records on our electronic medical records, Sunrise Clinical Manager and EPIC. These were then manually reviewed for appropriateness of inclusion. An arrest was defined as "cessation of. cardiac activity, confirmed by the absence of a detectable pulse, unresponsiveness, and apnea".[10] Duplicate patient entries were excluded and when code data was not available or incomplete (brief arrests occurring in the catheterization lab or during surgery, for instance).

Definitions

The definitions and parameters used during this document comply with the "in-hospital Utstein style" consensus guidelines published by the AHA.[11] Pulseless ventricular tachycardia and ventricular fibrillation were classified as shockable rhythms. Pulseless electrical activity and asystole were classified as non-shockable rhythms. Re-arrest was defined as a recurrent arrest after sustained ROSC for > 20 min during the course of same admission. All relevant clinical variables, including demographic data, history of cardiovascular diseases, cardiovascular risk factors and laboratory values, were obtained from review of the electronic medical record. Laboratory values of interest were the closest values recorded after ROSC was achieved.

Code response team

The code response team at our institution was described in prior manuscripts on in-hospital cardiac arrests.[7] Briefly, the code team at our institution consists of a senior medical resident, two to three junior medical residents, registered nurses, a senior anesthesia or emergency medicine resident, a respiratory therapist, and a pharmacist. All participants are certified in advanced cardiac life support (ACLS). All the information about the arrest is documented on a "code sheet" containing information such as: location of the code, time and date, patient demographics, medications administered, duration of the code, shocks delivered, and whether ROSC was achieved. Following ROSC, standard post-resuscitation measures are done, including obtaining laboratory investigations and transfer to a higher level of care if needed. The code leader then reviews the "code sheet" and confirms the documented information. For scenarios where code sheets were not available, the pertinent variables were identified through EMS records, chart review or charts were excluded if data was missing.

Echocardiographic parameters

All echocardiograms were obtained as a part of routine patient care. Two-dimensional transthoracic echocardiography was obtained by certified sonographers at University of Kentucky per standard protocol according to the American Society of Echocardiography.[12] The echocardiographic parameters were measured and verified by COCATS Level II and III board-certified imaging cardiologists. The measurements include left ventricular ejection fraction, regional wall motion abnormalities, right ventricular size and function, presence and size severity of pericardial effusion, and presence and severity of valvular pathologies. The left ventricular ejection fraction was measured using modified Simpson's biplane method of disc technique, and recorded as a continuous variable, but also categorized based on ASE guideline.[6] Due to the variability of the echocardiographic reports with different ranges of LVEF, LVEF categories were utilized in the final analyses. Regional wall motion abnormalities were reported using the 16-segment model and the representing coronary artery territories as was recommended at the time the studies were performed.[13] The right ventricular size was measured using basal, mid, and longitudinal diameter according to ASE guideline.[4] The presence and severity of pericardial effusion were measured according to ASE guideline and categorized into severe and non-severe (which includes trace, mild, and moderate) according to the pericardial disease guideline.[14] Left-sided valvular abnormalities (aortic and mitral stenosis and regurgitation) were recorded and categorized into severe (severe aortic stenosis, severe aortic regurgitation, severe mitral stenosis, and severe mitral regurgitation) according to the ACC/AHA valvular heart disease guideline.[15] All the outliers were reviewed independently by a COCATs level 3 echocardiography cardiologist (Vedant Gupta, MD) during data collection.

Outcomes

Patient charts were reviewed to assess prespecified outcomes. Since the cerebral performance category (CPC) score was inconsistently documented, we chose survival to hospital discharge as a primary outcome and favorable discharge disposition as a secondary outcome. A favorable discharge disposition was determined if the patient was discharged to a skilled nursing facility (for rehabilitation purposes) or home with or without home health support. An unfavorable disposition was recorded if the patient passed away during the index hospitalization, was discharged to a long-term acute care facility (requiring prolonged hospitalization or mechanical ventilatory support), or hospice.

All patients included in this evaluation were assessed in the emergency department or hospitalized setting. For patients of which care were withdrawn, the decision was made after being deemed futile by the primary medical team(s), or discussion with next of kin, and documented in electronic medical records.

Statistical analysis

Patient characteristics were summarized overall and compared by survival to discharge. Categorical variables were summarized using frequencies and column percentages, with p-values calculated using chi-squared and Fisher's exact tests, as appropriate. Continuous variables were assessed for normality using the Shapiro-Wilk normality test along with histograms. Those exhibiting departures from normality were summarized using medians and first/third quartiles, and *p*-values were calculated using Wilcoxon ranked sum tests. All statistical tests were two-sided with statistical significance defined as $p \leq 0.05$.

Logistic regression models were used to assess the association between LVEF categories (<30%, 31–40%, 41–51%, $\geq$52%) and survival to hospital discharge, including adjustment for age, sex, shockable rhythm, witnessed cardiac arrest, in/out-of-hospital arrest, recurrent arrest, and temperature management. Odds ratios and p-values are presented. Similar analyses were performed for the secondary outcomes: favorable disposition at discharge and 30-day readmission, among those who were discharged alive.

For any primary or secondary outcomes exhibiting a significant association with the LVEF category, the association between severe LV dysfunction (defined as LVEF < 30%) and the outcome was examined within pre-specified subgroups, with subgroups defined by patients with vs. without shockable rhythm and patients who experienced their cardiac arrest in vs. out of the hospital. Logistic regression was used for these models, including severe LV dysfunction, shockable rhythm or arrest location, and their interaction as predictors.

All analyses were performed in R programming language, version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

Ethics

University of Kentucky Human Research/Institutional Review Board approved the protocol for the study (approval number: 71253).

Results

A total of 931 cardiac arrests were observed during the study period. After excluding those missing echocardiography (n = 137) or missing LVEF (n = 58), 736 patients comprised the overall cardiac arrest patient cohort (Fig. 1).

Table 1 shows demographic and clinical characteristics of patients overall and stratified by survival status. The median age was 59.4 years (1Q, 3Q = 49.5, 69.2), and 41.8% were female (Table 1). Of the 736 patients, 338 (45.9%) survived the index cardiac arrest event. The majority of cardiac arrests occurred in the hospital (n = 614, 84.5%), and n = 175 (24.2%) had an initial shockable rhythm (Table 1). The percentage of patients in each LVEF category was 21.6% with LVEF < 30%, 11.7% with LVEF 30–40%, 13.2% with LVEF 41–51%, and 53.5% with LVEF ≥52% (Table 1).

Primary outcome

The unadjusted rate of survival to hospital discharge was lower among patients with LVEF < 30% (survival = 39.0%) compared to those with LVEF between 30–40% (survival = 52.3%), between 41–51% (survival = 52.6%), or LVEF ≥52% (survival = 45.7%) (Supplemental Figure 1). Patients with severely reduced LV systolic function (LVEF < 30%) had 48% lower odds of survival to discharge compared to those with LVEF ≥52%, after adjusting for age, sex, initial shockable rhythm, witnessed cardiac arrest, out-of-hospital arrest, recurrent arrest, and temperature management (p = 0.015, Table 2, Fig. 2). The adjusted odds of survival to discharge did not differ significantly between those with moderately reduced LV systolic function (LVEF 30–40%) and ≥52% (p = 0.783) or between those with mildly reduced LV systolic function (LVEF 41–51%) and ≥52% (p = 0.952) (Table 2, Fig. 2). In the adjusted model, those who were male (OR = 1.66, p = 0.012), those with an initial shockable rhythm (OR = 2.84, p < 0.001), and those with a witnessed cardiac arrest (OR = 3.43, p = 0.003) had significantly higher odds of surviving to discharge, while those with a recurrent arrest had significantly lower odds of surviving to discharge (OR = 0.14, p < 0.001) (Table 2).

Secondary outcomes

Among those who survived to discharge (n = 338), the proportion of patients discharged with a favorable disposition decreased with increasing LVEF category (96.8% for LVEF < 30%, 95.6% for LVEF 30–40%, 92.2% for LVEF 41–51%, 88.9% for LVEF ≥52%) (Supplemental Figure 2). However, these differences were not statistically significant after adjusting for age, sex, initial shockable rhythm, witnessed cardiac arrest, out-of-hospital arrest, recurrent arrest, and temperature management (p = 0.063, p = 0.088, p = 0.587, Supplemental Table 1). In the adjusted model, those who received temperature management had significantly lower odds of being discharged with a favorable disposition than those who did not receive temperature management (OR = 0.15, p = 0.023, Supplemental Table 1).

There was numerous missing data including the date and time of the initial arrest in both cohorts, especially from the out of hospital group for the duration of CPR. Of the available data collected, the median CPR duration was 6 min (IQR 3–10).

We were also faced with the same limitation for time from cardiac arrest to first echocardiogram performed. Two hundred and thirty-six time to echocardiography were recorded. Among those, 104 were collected within 24 h, 64 were collected from 24 to 48 h, 47 were collected from 48 h to 1 week, and 23 were collected more than 1 week after ROSC.

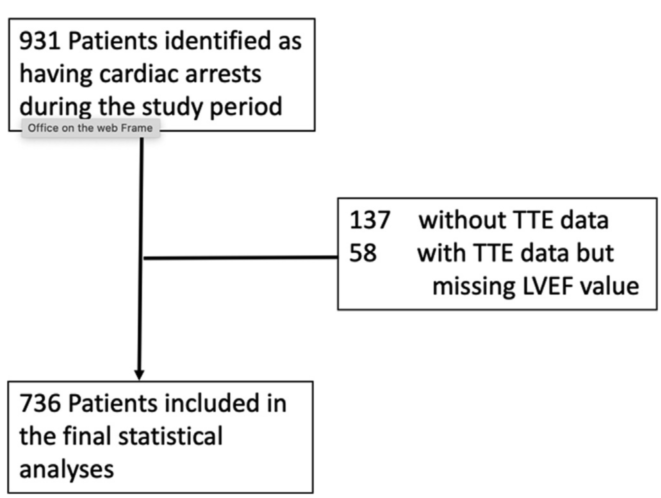

Fig. 1 – Patient flow.

Table 1 – Demographic and clinic characteristics.

Variable	Overall (N = 736)	Didn't survive (N = 398)	Survived (N = 338)	p-value
Age				0.766
Median (1Q, 3Q)	59.4 (49.5, 69.2)	59.3 (49.1, 69.5)	59.8 (49.7, 68.8)	
Gender				0.151
Female	303 (41.8%)	175 (44.2%)	128 (38.9%)	
Male	422 (58.2%)	221 (55.8%)	201 (61.1%)	
Unknown	11	2	9	
Race				0.795
Asian	2 (0.3%)	2 (0.5%)	0 (0.0%)	
Black	79 (11.0%)	42 (10.7%)	37 (11.3%)	
Spanish	5 (0.7%)	3 (0.8%)	2 (0.6%)	
White	634 (87.9%)	346 (87.8%)	288 (88.1%)	
Unreported	1 (0.1%)	1 (0.3%)	0 (0.0%)	
Unknown	15	4	11	
Tobacco Use				0.004
Current	168 (29.4%)	65 (23.3%)	103 (35.3%)	
Former	111 (19.4%)	64 (22.9%)	47 (16.1%)	
Never	292 (51.1%)	150 (53.8%)	142 (48.6%)	
Unknown	165	119	46	
BMI				0.643
Median (1Q, 3Q)	27.5 (23.5, 32.5)	27.5 (23.7, 32.3)	27.5 (23.1, 32.8)	
Unknown	79	56	23	
Arrest Location				0.002
In-hospital	614 (84.5%)	346 (88.3%)	268 (80.0%)	
Out-of-hospital	113 (15.5%)	46 (11.7%)	67 (20.0%)	
Unknown	9	6	3	
Witnessed Cardiac Arrest				0.255
Not Witnessed	56 (8.2%)	34 (9.3%)	22 (6.9%)	
Witnessed	627 (91.8%)	331 (90.7%)	296 (93.1%)	
Unknown	53	33	20	
Shockable Initial Rhythm				< 0.001
Not Present	549 (75.8%)	322 (81.3%)	227 (69.2%)	
Present	175 (24.2%)	74 (18.7%)	101 (30.8%)	
Unknown	12	2	10	
Rearrest				< 0.001
No	502 (72.5%)	210 (57.7%)	292 (89.0%)	
Yes	190 (27.5%)	154 (42.3%)	36 (11.0%)	
Unknown	44	34	10	
Temperature Management				0.007
No	561 (90.3%)	309 (93.4%)	252 (86.9%)	
Yes	60 (9.7%)	22 (6.6%)	38 (13.1%)	
Unknown	115	67	48	
LVEF				0.101
<30%	159 (21.6%)	97 (24.4%)	62 (18.3%)	
30–40%	86 (11.7%)	41 (10.3%)	45 (13.3%)	
41–51%	97 (13.2%)	46 (11.6%)	51 (15.1%)	
≥52%	394 (53.5%)	214 (53.8%)	180 (53.3%)	
Length of Stay				< 0.001
Median (1Q, 3Q)	13.0 (4.0, 27.0)	6.0 (2.0, 17.0)	21.0 (11.0, 36.0)	

Caption: Comparison between patients that survived the index hospitalization and those that did not. P-values for continuous variables are from Wilcoxon rank sum tests; p-values for categorical variables are from chi-squared tests or Fisher's exact tests. Abbreviations: 1Q, first quartile; 3Q, third quartile; BMI, body mass index; LVEF, left ventricular ejection fraction.

Among those who survived to discharge (n = 338), the proportion of patients who were readmitted within 30 days was lowest among those with LVEF < 30% (30-day readmission = 13.3%) compared to those with LVEF 30–40% (30-day readmission = 17.8%), LVEF 41–51% (30-day readmission = 30.6%), and LVEF ≥52% (30-day readmission = 25.1%) (Supplemental Figure 3). However, these differences were not statistically significant after adjusting for age, sex, initial shockable rhythm, witnessed cardiac arrest, out-of-hospital arrest, recurrent arrest, and temperature management (p = 0.355, p = 0.289, p = 0.094, Supplemental Table 2). In the adjusted model, those with an initial shockable rhythm had significantly lower odds of 30-day readmission than those without an initial shockable rhythm (OR = 0.44, p = 0.033, Supplemental Table 2).

Subgroup analyses

Among those with an initial shockable rhythm, the probability of survival to hospital discharge was lower among those with severe LV dysfunction (52.0%) than among those without severe LV dysfunc-

Table 2 – Logistic regression model for survival to discharge.

Variable	Odds ratio (95% CI)	p-value
LVEF [ref: ≥52%]		
<30%	0.52 (0.31, 0.88)	0.015*
30–40%	1.09 (0.59, 2.02)	0.783
41–51%	1.02 (0.56, 1.85)	0.952
Age	1.00 (0.99, 1.01)	0.886
Male	1.66 (1.12, 2.48)	0.012*
Shockable Rhythm	2.84 (1.79, 4.57)	<0.001*
Witnessed Cardiac Arrest	3.43 (1.53, 8.01)	0.003*
Out-of-Hospital Arrest	1.78 (0.96, 3.36)	0.071
Recurrent Arrest	0.14 (0.09, 0.24)	<0.001*
Temperature Management	1.99 (0.93, 4.41)	0.083

Caption: Abbreviations: LVEF, left ventricular ejection fraction; CI, confidence interval.
* Indicates p < 0.05.

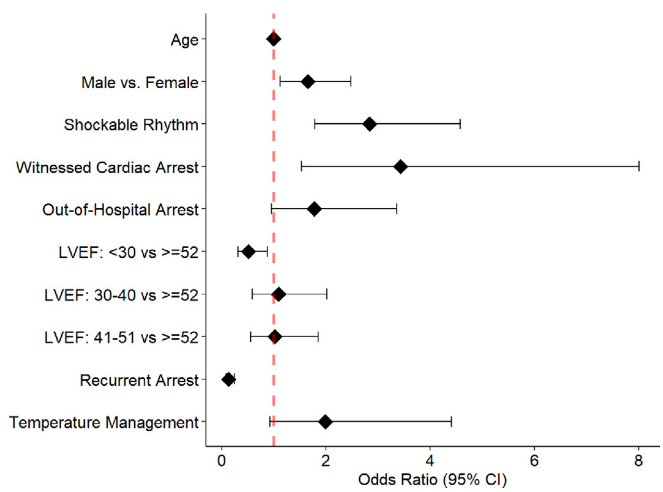

Fig. 2 – Forest Plot of Adjusted Odds Ratios from Logistic Regression Model for Survival to Discharge. Caption: Diamonds indicate odds ratio point estimates, and bars indicate 95% confidence intervals. Abbreviations: LVEF, left ventricular ejection fraction.

tion (60.0%) (Fig. 3A). Similarly, among those without an initial shockable rhythm, the probability of survival to hospital discharge was lower among those with severe LV dysfunction (31.8%) than among those without severe LV dysfunction (43.7%) (Fig. 3A). The association between severe LV dysfunction and survival to hospital discharge did not differ significantly between those with/without an initial shockable rhythm (p = 0.651, Supplemental Table 3).

Among those with an in-hospital cardiac arrest, the probability of survival to hospital discharge was lower among those with severe LV dysfunction (36.8%) than among those without severe LV dysfunction (45.4%) (Fig. 3B). Similarly, among those with an out-of-hospital cardiac arrest, the probability of survival to hospital discharge was lower among those with severe LV dysfunction (50.0%) than among those without severe LV dysfunction (63.0%) (Fig. 3B). The association between severe LV dysfunction and survival to hospital discharge did not differ significantly between those who experienced their cardiac arrest in or out of the hospital (p = 0.710, Supplemental Table 4).

Discussion

Summary of major findings

Our study is one of the largest single-center series on the outcomes of patients resuscitated after both in-hospital and out-of-hospital cardiac arrests. We report several important findings; (1) only patients with severely reduced LV systolic function (LVEF < 30%) post cardiac arrest had a reduced survival to hospital discharge; (2) this effect persisted after adjusting for age, sex, presence of initial shockable rhythm, witnessed cardiac arrest, types of cardiac arrest (in-hospital vs out-of-hospital), recurrent arrest, and whether targeted temperature management was performed; and (3) in an exploratory analysis, the trend of lower survival with severely reduced LVEF persisted, but did not reach statistical significance.

Comparison to previous studies

Our group reported predictive variables in the in-hospital arrest portion of this cohort in the past. A multivariate analysis of factors

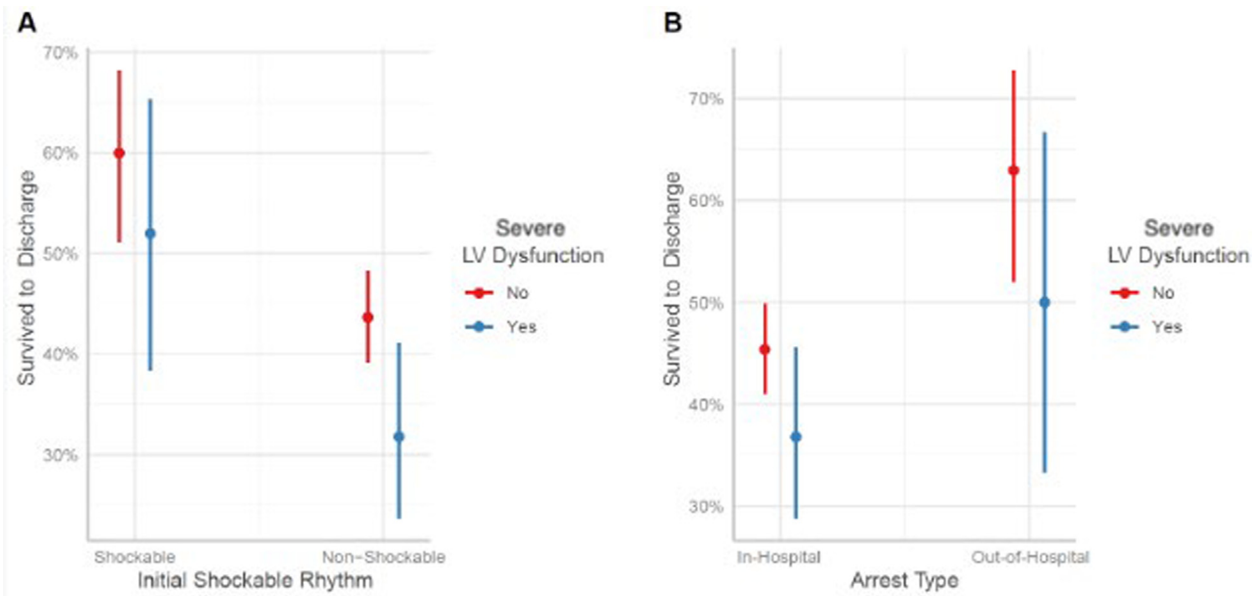

Fig. 3 – Probability of Surviving to Discharge by Severe LV Dysfunction and Initial Shockable Rhythm (A) and by Severe LV Dysfunction and Arrest Type (B). Caption: Plot shows predicted probabilities with 95% prediction intervals from a logistic regression model including severe LV dysfunction, initial shockable rhythm (A) or arrest type (B), and their interaction. Severe LV dysfunction refers to left ventricular ejection fraction < 30%. Abbreviations: LV left ventricle.

predicting in-hospital cardiac arrest demonstrated that recurrent cardiac arrest, increasing age, time to return of spontaneous circulation (ROSC), higher serum creatinine levels, and history of cancer were predictors of in-hospital mortality, with the recurrent cardiac arrest being the strongest.[7,16–23] Post cardiac arrest LVEF < 45% was also associated with worse survival to discharge after in-hospital cardiac arrest.[9] This did not, however, transfer to sustained ROSC or 24-hour survival. This was proven to be true in the case of out-of-hospital cardiac arrest as well where LVEF < 45% was significantly related to 7-day mortality.[8] However, in each of these studies, the LVEF was dichotomized, and some nuance is also lost as to whether those with mildly reduced LVEF had similar outcomes as to those with severely reduced LVEF. In this investigation, survival was reduced only in those with severe LV systolic dysfunction and allows for some clinical focus in a high-risk cohort for prognostication and goals of care discussions. This is especially important as post-arrest LV dysfunction is not unusual, occurring in over 46% of our cohort. It is still unclear whether guideline directed medical therapy for heart failure in this cohort would confer the same benefit as it does for other more chronic etiologies of heart failure.

Previous studies have generally looked at specific subgroups of cardiac arrest (i.e., in-hospital vs out-of-hospital cardiac arrest),[9] while this investigation attempts to assess the importance of LVEF across all cardiac arrest patients. In a large heterogeneous group, LVEF < 30% is an important marker of survival, and there was a trend towards lower survival in an exploratory analysis. This, however, did not reach statistical significance. Further research is needed to see if this can be confirmed.

The trend toward lower survival with an LVEF < 30% across the different important subgroups (in-hospital vs out of hospital, and shockable versus non-shockable) needs to be corroborated with additional studies. If confirmed, the consistent impact of an LVEF < 30% in different subtypes of cardiac arrest allows for less cognitive load and potentially more consistent clinical practice.

It is also important to note though that the findings in this study do not distinguish between pre-existing LV systolic dysfunction versus new dysfunction after the arrest, suggest a primary cardiac cause of the arrest or speak to the cause of mortality. There was limited data on pre-existing LV function for the majority of patients, as well as limited data on subsequent assessment of LV function to see if there was recovery of function (and potentially a transient reduction in LV function due to the arrest itself). While shockable vs non-shockable initial rhythm can help suggest a primary cardiac etiology, it is also imperfect. There was limited data available to identify the underlying etiology of the cardiac arrest. Similarly, there is limited data to see if the LV dysfunction was contributing to the cause of mortality.

Strengths

Compared to prior studies, we included a large sample size with relatively equal number of patients in the out-of-hospital and the in-hospital cardiac arrest groups. With such a large sample size, selection bias can somewhat be mitigated, although not eliminated. Given the large cohort of patients included and the limited exclusion criteria of our study, our results should be generalizable to many other centers who wish to explore the outcomes of cardiac arrest survivors or the correlation between post-arrest LVEF with outcomes in a longitudinal manner.

Limitations

First, this is a single center, retrospective, study and primarily includes Caucasian patients which may limit the generalizability to the general population. It is subjected to the inherent limitations of a retrospective study including accuracy of documented information within the electronic medical record and the tracking of follow up data. While we had no data on CPC or other objective scores to define outcomes on discharge, we used discharge from hospital as a surrogate outcome since it has been shown that these patients have decent long-term survival rates.[7,24]

Second, patients who may have sustained brief cardiac arrests during invasive procedures (invasive angiography for instance) typically have favorable outcomes as they are quickly resuscitated.[25] These patients were excluded from our analysis as they are difficult to capture (suboptimal coding or charting) and this represents a selection bias.

Third, the timing of echocardiogram in relation to cardiac arrest was not always clear. This is common in clinical practice and can often reflect more real-life experience. However, dynamic changes to the LV can be missed if there are delays in acquiring the echocardiogram.

Fourth, data regarding the cause of death, including cardiac and non-cardiac, and whether withdrawal of care was pursued in each case were not collected in this study. This may have implications in terms of reversible VS irreversible causes of death and whether the attempt at ACLS was futile. Future study is needed to answer this question.

Finally, the data collection period of this study was between the year 2012–2015 due to a readily available dataset for assessment of ventricular function. With the ongoing changes in practice standards and trends for post-cardiac arrest care, the study results may have been different if it were repeated more in the present time. Other parameters were less readily available and were not included in this study, including left/right ventricular size and right ventricular function.

Conclusion

After a cardiac arrest and accounting for several arrest related factors, an LVEF < 30% on a post-arrest echocardiogram is associated with significantly lower survival to hospital discharge compared to other LVEF categories.

CRediT authorship contribution statement

Kanjit Leungsuwan: Writing – original draft, Validation, Project administration, Investigation, Data curation. **Kory R. Heier:** Writing – review & editing, Visualization, Software, Methodology, Formal analysis. **Olivia Henderson:** Investigation, Data curation. **Karam Ayoub:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Talal Alnabelsi:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Emily Slade:** Writing – review & editing, Visualization, Software, Methodology, Formal analysis. **Vedant A. Gupta:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization.

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 A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2024.100737.

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