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Clinical paper

# Patient characteristics and survival outcomes of cardiac arrest in the cardiac catheterization laboratory: Insights from get with the Guidelines®-Resuscitation registry

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## Abstract

**Background**: Characteristics and outcomes of patients with in-hospital cardiac arrest (IHCA) in the cardiac catheterization laboratory (CCL) have not been well-described. Thus, we compared the outcomes of patients with an IHCA in the CCL versus those in the intensive care unit (ICU) and operating rooms (OR).

**Methods**: Within the American Heart Association's Get With the Guidelines®-Resuscitation registry, we identified patients ≥ 18 years old with IHCA in the CCL, ICU, or OR between 2000–2019. Using hierarchical multivariable logistic regression, we compared rates of survival to discharge for patients with IHCA in the CCL versus ICU and OR.

**Results**: Across 428 hospitals, 193,950 patients had IHCA, of whom 6865, 181,905 and 5180 were in the CCL, ICU and OR, respectively. Overall, 2614 (38.1%) patients with IHCA in the CCL survived to discharge, whereas 30,830 (16.9%) and 2096 (40.5%) survived to discharge from the ICU and OR, respectively. After adjustment, patients with IHCA in CCL were more likely to survive to discharge as compared to those with IHCA in the ICU (odds ratio, 1.37 [95%CI: 1.29–1.46], $p < 0.001$). In contrast, those who had IHCA in the CCL were less likely to survive to discharge as compared to patients with IHCA in the OR (odds ratio, 0.81 [95%CI: 0.69–0.94], $p = 0.006$).

**Conclusion**: IHCA in the CCL is not uncommon and has a lower survival rate when compared with IHCA in the OR. The reasons for this difference deserve further study given that cardiac arrest in both settings is witnessed and response time should be similar.

**Keywords**: In-hospital cardiac arrest, Cardiac catheterization laboratory, Intensive care unit, Operating room, Survival

## Introduction

Cardiac arrest in the cardiac catheterization laboratory (CCL) has substantially increased over the last decade due to the increase in complex coronary and non-coronary interventions for high-risk patients.[1–3] Previous reports from the Get with the Guidelines®—Resuscitation (GWTG-R) registry showed variation in survival outcomes based on the location of the IHCA in intensive care, telemetry or unmonitored units.[4] However, these insights were focused on patients on hospital wards and may not reflect procedural cardiac arrests such as in the CCL.[4] Although some data exists for IHCA in the operating rooms and perioperative procedural areas, these results have not been directly compared to other procedural areas such as the CCL.[5]

In addition, the characteristics and outcomes of IHCA in the CCL have not been well-described with some limited data suggesting good prognosis.[6] Although it is known that a witnessed IHCA is

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[1] The members of the American Heart Association's Get With the Guidelines®-Resuscitation Investigators are listed in Appendix A at the end of the article.

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associated with better outcomes due to prompt time to advanced cardiac life support,[7] IHCA in the CCL remains challenging due to the need to address the underlying cause while simultaneously providing advanced cardiac life support during an invasive procedure. Due to the lack of systematic contemporary data on IHCA in the CCL, we leveraged the GWTG-R registry to describe the characteristics of patients with an IHCA in the CCL and compared their survival outcomes versus those with IHCA in the intensive care unit (ICU), and in operating rooms (OR).

## Methods

### *Data source*

GWTG-R is a large, prospective, national quality-improvement registry of IHCA. Its design has been previously described.[7] In brief, trained hospital personnel identify all patients without do-not-resuscitate orders with a cardiac arrest (defined as absence of a palpable central pulse, apnea, and unresponsiveness) who undergo cardiopulmonary resuscitation. Cases are identified through multiple methods, including centralized collection of cardiac arrest flow sheets, reviews of hospital paging system logs, and routine checks of code carts and pharmacy tracer drug records.[7] Standardized Utstein-style definitions are used for all patient variables and outcomes to facilitate uniform reporting across hospitals.[8–9] Data accuracy in GWTG-R is supported by certification of data abstractors and use of standardized software with data checks for completeness and accuracy. Due to the de-identified nature of the data, this study was deemed exempt by the institutional review board.

### *Study population*

We identified patients who were 18 years of age or older enrolled in GWTG-R between 2000 and 2019 with an IHCA in the CCL, ICU or OR. We excluded 187,733 patients with IHCA in other hospital locations, 8988 IHCAs related to trauma, and 1527 IHCAs with missing data on survival to discharge. Furthermore, a total of 21,597 IHCA cases from hospitals without an IHCA event in the CCL, and 1819 IHCAs from hospitals with fewer than 25 IHCA events were excluded. The final cohort was comprised of 193,950 IHCAs from 428 hospitals in the CCL, ICU and OR (Fig. 1).

### *Statistical analysis*

The primary outcome was survival to hospital discharge. The secondary outcome was sustained return of spontaneous circulation (ROSC) for > 20 minutes. Due to the large cohort size, baseline patient characteristics between patients with IHCA in the CCL vs the ICU and CCL vs the OR were compared using standardized differences, with a standardized difference of > 0.10 difference considered clinically relevant.[10].

To compare rates of survival to discharge between IHCAs in the CCL, OR and the ICU, we constructed separate hierarchical multivariable logistic regression models and evaluated survival rates for patients with an IHCA in the CCL vs ICU and in the CCL vs OR. Hierarchical models were used, with hospital as a random effect to account for clustering of patients within hospitals. Models adjusted as fixed effects for the following patient-level factors: demographics (age, sex, race), initial cardiac arrest rhythm (asystole, pulseless electrical activity, ventricular fibrillation, pulseless ventricular tachycardia), location of cardiac arrest, illness category (medical cardiac,

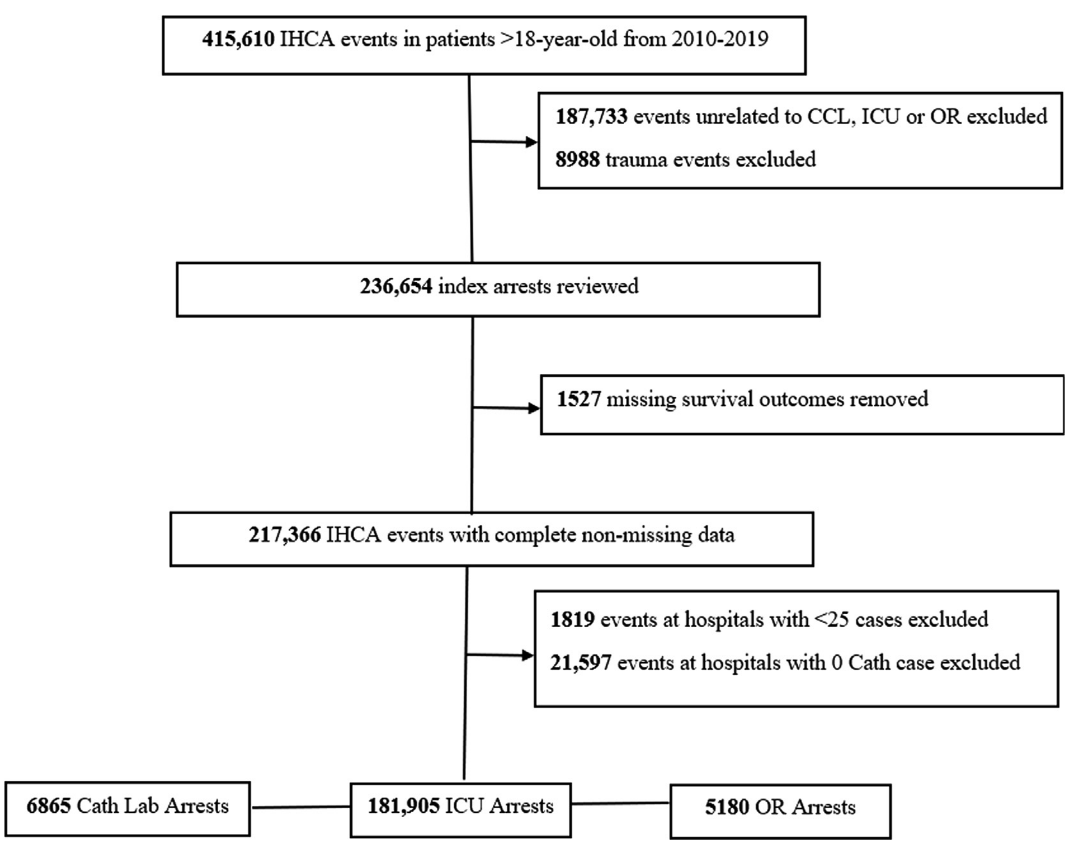


**Fig. 1 – Diagram of the study cohort. ICU indicates intensive care unit; IHCA, in-hospital cardiac arrest; OR, operating room.**

medical non-cardiac, surgical cardiac, surgical non-cardiac, other), comorbid conditions (prior heart failure or myocardial infarction, index admission heart failure or myocardial infarction, diabetes mellitus, baseline depression in central nervous system function, acute stroke, pneumonia, and metastatic or hematologic malignancy), medical conditions present within 24 hours of cardiac arrest (renal insufficiency, hepatic insufficiency, respiratory insufficiency, hypotension, septicemia, and metabolic or electrolyte abnormality), as well as interventions present within 24 hours prior to IHCA (intravenous vasopressor, hemodialysis, and mechanical ventilation). Models also adjusted for calendar year of arrest, as well as the time of day (work hours [7:00 am to 10:59 pm] vs after hours [11:00 pm to 6:59 am]), and day of the week (weekday vs weekend) of the IHCA. Similar models were constructed to compare rates of ROSC between IHCAs in the CCL vs the ICU and in the CCL vs the OR. Furthermore, we examined rates of post-ROSC survival in the cohort by repeating the models above for patients with sustained ROSC and compared rates of survival to hospital discharge for IHCAs in the CCL vs the ICU, and in the CCL vs the OR.

Finally, among those with an IHCA in the CCL, we examined for independent predictors of survival to discharge among patients who had IHCA in the CCL. We also compared outcomes among patients with an IHCA in the CCL who had probable shock (defined as having both hypotension and being on a continuous intravenous vasoactive agent at the time of their IHCA) and acute myocardial infarction. To accomplish this, we constructed separate multivariable hierarchical logistic regression models to identify predictors of survival to discharge from IHCA in the CCL, and among subgroups of patients with probable shock or acute myocardial infarction using the same model covariates as described above.

For each analysis, the null hypothesis was evaluated at a 2-sided significance level of 0.05 and calculated 95% confidence intervals (CIs) using robust standard errors. Power analyses were not performed given the large cohort size, and all analyses were conducted using R statistical software version 4.0.5 (R Project for Statistical Computing). The Institutional Review Board for Saint Luke's Mid America Heart Institute approved the study project as an exempt study as the registry contained only de-identified data.

## Results

Of 193,950 patients in the study cohort, 6865 had an IHCA in the CCL, 181,905 patients in the ICU, and 5180 in the OR. Patients with IHCA in the CCL, as compared to those in the ICU or OR, were generally older, more frequently male and of White race, more likely to have ventricular fibrillation as the initial cardiac arrest rhythm, had higher rates of prior myocardial infarction or index hospitalization for myocardial infarction, and had lower rates of most other comorbidities (Table 1). A medical-cardiac admission diagnosis was the most common cause of hospitalization among patients with an IHCA in the CCL. Patients with IHCA in the CCL vs those in the ICU or OR were also less likely to be on dialysis or on mechanical ventilation at the time of their IHCA.

Overall, 2614 (38.1%) patients with IHCA in the CCL survived to discharge, whereas 30,830 (16.9%) and 2096 (40.5%) of those with IHCA survived to discharge from the ICU and OR, respectively (Fig. 2). After adjustment for 27 patient and cardiac arrest factors, patients with IHCA in CCL were more likely to survive to discharge as compared with those with IHCA from the ICU (odds ratio, 1.37 [95% CI: 1.29–1.46], p < 0.001; Fig. 2/Supplemental Table-1). In contrast, patients with IHCA in the CCL were less likely to survive to discharge as compared with those with IHCA in the OR (odds ratio, 0.81 [95% CI: 0.69–0.94], p = 0.006; Fig. 2/Supplemental Table-2). For the secondary outcome, patients with IHCA in the CCL were less likely to achieve sustained ROSC as compared with those with IHCA in ICU (odds ratio, 0.90 [95% CI: 0.85–0.95], p < 0.001; Fig. 2/Supplemental Table-3) and in the OR (odds ratio, 0.84 [95% CI: 0.72–0.98], p = 0.027; Fig. 2/Supplemental Table-4). Finally, when examining post-ROSC survival by limiting the analytic cohort to those patients with sustained ROSC, patients with IHCAs in the CCL were more likely to survive to discharge as compared to IHCAs in the ICU (odds ratio, 1.68 [95% CI: 1.56–1.80], p < 0.001; Supplemental Table-5) and there was a nonsignificant trend in lower post-ROSC survival in patients with IHCA in the CCL vs the OR (odds ratio, 0.86 [95% CI: 0.71–1.03], p = 0.098; Supplemental Table-6).

Among patients who had IHCA in the CCL, 1395 patients had probable shock of whom 280 (20.1%) survived to discharge, while for those who had acute myocardial infraction (4111 patients), 1,426 (34.7%) survived to discharge. Predictors of survival to discharge among patients with IHCA in the CCL are shown in Table 2. Older age, non-white race, an initial non-shockable rhythm, and IHCA during nighttime hours and on weekends were associated with a lower likelihood of survival to discharge after an IHCA in the CCL. Similarly, patients with prior myocardial infarction, an index myocardial infarction, hypotension, metabolic or electrolyte abnormalities, respiratory insufficiency, and requirement for mechanical ventilation or continuous intravenous vasopressors were less likely to survive to discharge after an IHCA in the CCL. Furthermore, independent predictors of survival to discharge among subgroups of patients with IHCA in the CCL who had probable shock or acute myocardial infarction did not significantly differ from the overall group of patients with CCL IHCA (Supplemental Table-7, and 8, respectively).

## Discussion

In the GWTG-R national registry of IHCA, we examined the characteristics and outcomes of patients with an IHCA in the CCL. We found that patients with IHCA in the CCL were more likely to survive to discharge when compared to those with an IHCA in the ICU. In contrast, they were less likely to survival to discharge when compared to patients with an IHCA in the OR. Furthermore, patients who had IHCA in the CCL were less likely to achieve sustained ROSC when compared to those who had IHCA in either the ICU or OR. Among those with sustained ROSC, patients with IHCAs in the CCL had a higher likelihood of survival to discharge when compared to those with IHCA in the ICU, and the relationship for post-ROSC survival for IHCAs in the CCL vs the OR, though borderline nonsignificant, was similar to the main analysis (0.86 vs 0.81, respectively). Among patients with IHCA in the CCL, older age, non-shockable rhythm, IHCA during weekend or afterhours, having myocardial infarction during this index admission or previous hospitalization and treatment with mechanical ventilation or continuous intravenous vasopressors at the time of the cardiac arrest were associated with a lower likelihood with survival to discharge.

Although IHCAs occurring in the CCL and the OR would be witnessed and have received immediate medical response, we found that patients with an IHCA in the CCL had a lower likelihood of

**Table 1 – Patient and Arrest Characteristics of IHCA Events by CCL vs ICU and CCL vs OR.**

| | CCL<br>N = 6865 | vs ICU<br>N = 181905 | *SMD*[*] | vs OR<br>N = 5180 | *SMD*[*] |
|---|---|---|---|---|---|
| Demographics | | | | | |
| **Age, year** | 66.4 (13.5) | 63.9 (15.3) | 0.168 | 63.3 (16.3) | 0.204 |
| **Female** | 2590 (37.7) | 76,604 (42.1) | 0.090 | 2286 (44.1) | 0.131 |
| **Race** | | | 0.343 | | 0.169 |
| White | 5459 (79.5) | 119,854 (65.9) | | 3816 (73.7) | 0.204 |
| Black | 781 (11.4) | 43,195 (23.7) | | 893 (17.2) | |
| Asian | 131 (1.9) | 3556 (2.0) | | 99 (1.9) | |
| Other/Unknown | 494 (7.2) | 15,300 (8.4) | | 372 (7.2) | |
| Co-existing conditions | | | | | |
| **Acute stroke** | 93 (1.4) | 7424 (4.1) | 0.168 | 122 (2.4) | 0.074 |
| **Acute CNS non-stroke event** | 370 (5.4) | 15,421 (8.5) | 0.122 | 245 (4.7) | 0.030 |
| **Baseline depression in CNS function** | 316 (4.6) | 17,375 (9.6) | 0.194 | 345 (6.7) | 0.089 |
| **Congestive heart failure (this admission)** | 986 (14.4) | 33,640 (18.5) | 0.112 | 526 (10.2) | 0.129 |
| **Congestive heart failure (prior admission)** | 1189 (17.3) | 40,978 (22.5) | 0.131 | 1033 (19.9) | 0.067 |
| **Myocardial ischemia/infarction (this admission)** | 4111 (59.9) | 34,649 (19.0) | 0.920 | 446 (8.6) | 1.284 |
| **Myocardial ischemia/infarction (prior admission)** | 1740 (25.3) | 27,984 (15.4) | 0.249 | 787 (15.2) | 0.255 |
| **Pneumonia** | 213 (3.1) | 30,736 (16.9) | 0.472 | 229 (4.4) | 0.069 |
| **Respiratory insufficiency** | 2273 (33.1) | 105,310 (57.9) | 0.514 | 2164 (41.8) | 0.180 |
| **Renal insufficiency** | 1255 (18.3) | 77,973 (42.9) | 0.554 | 1521 (29.4) | 0.262 |
| **Hepatic insufficiency** | 181 (2.6) | 19,926 (11.0) | 0.335 | 335 (6.5) | 0.185 |
| **Diabetes mellitus** | 2077 (30.3) | 61,554 (33.8) | 0.077 | 1664 (32.1) | 0.040 |
| **Metabolic/electrolyte abnormality** | 950 (13.8) | 51,207 (28.2) | 0.357 | 950 (18.3) | 0.123 |
| **Metastatic or hematologic malignancy** | 235 (3.4) | 20,767 (11.4) | 0.309 | 548 (10.6) | 0.283 |
| **Hypotension/hypoperfusion** | 2250 (32.8) | 72,986 (40.1) | 0.153 | 1987 (38.4) | 0.117 |
| **Sepsis** | 157 (2.3) | 38,199 (21.0) | 0.610 | 523 (10.1) | 0.328 |
| Arrest characteristics | | | | | |
| **Initial rhythm** | | | 0.487 | | 0.409 |
| Asystole | 1337 (19.5) | 45,954 (25.3) | | 1704 (32.9) | |
| PEA | 2951 (43.0) | 101,915 (56.0) | | 2271 (43.8) | |
| Pulseless VT | 680 (9.9) | 16,515 (9.1) | | 487 (9.4) | |
| VF | 1897 (27.6) | 17,521 (9.6) | | 718 (13.9) | |
| **Length of hospital stay, day** | 2.0 [0.0, 7.0] | 5.0 [1.0, 14.0] | 0.347 | 5.0 [1.0, 13.0] | 0.316 |
| **Admitting diagnosis** | | | 0.128 | | 0.285 |
| Medical-Cardiac | 5813 (84.7) | 69,661 (38.3) | | 332 (6.4) | |
| Medical-Noncardiac | 214 (3.1) | 77,625 (42.7) | | 554 (10.7) | |
| Surgical-Cardiac | 745 (10.9) | 16,427 (9.0) | | 945 (18.2) | |
| Surgical-Noncardiac | 86 (1.3) | 17,983 (9.9) | | 3259 (62.9) | |
| Other | 7 (0.1) | 209 (0.1) | | 90 (1.7) | |
| **After hours arrest** | 1001 (14.6) | 60,050 (33.0) | 0.443 | 500 (9.7) | 0.151 |
| **Weekend or holiday arrest** | 1610 (23.5) | 60,722 (33.4) | 0.221 | 911 (17.6) | 0.146 |
| **Assisted or mechanical vent already in place** | 2768 (40.3) | 126,189 (69.4) | 0.610 | 4242 (81.9) | 0.943 |
| **Vasoactive agent already in place** | 2662 (38.8) | 90,353 (49.7) | 0.221 | 1739 (33.6) | 0.108 |
| **Dialysis/extracorporeal filtration (ongoing)** | 38 (0.6) | 9851 (5.4) | 0.289 | 72 (1.4) | 0.085 |

Values are mean (SD), median [25th – 75th interquartile range] or n (%).

CCL, cardiac catheterization laboratory; ICU, intensive care unit; IHCA, in-hospital cardiac arrest; OR, operating room; CNS, central nervous system.

[*] The standardized mean difference (SMD) compares the difference in means or proportions in units of the pooled standard deviation; a standardized difference greater than 0.10 considered clinically relevant.

achieving sustained ROSC or survival to discharge than those with an IHCA in the OR. Despite adjustment for measurable differences in patient or cardiac arrest characteristics between both patient groups, this difference in survival may be related to other unmeasured factors like acuity of presentation between both groups (i.e. acute coronary syndrome presentation in the CCL vs more stable patients in the OR) and factors triggering the cardiac arrest in each group (e.g., cardiac arrest in the OR may be due to a reversible cause such as hypovolemia, electrolyte abnormality, drug reaction, or procedure complication in a prior stable patient). Similarly, the higher survival rate for IHCA in the CCL versus in the ICU could reflect unmeasured confounding regarding illness severity of patients as rates of ROSC were lower in the CCL versus that in the ICU.[11] We did not have hemodynamic information on patients with IHCA in the CCL or the OR, and it is possible that unmeasured factors such as higher rates of cardiogenic shock could have accounted for lower survival rates in the CCL. Indeed, the fact that only 2.3% of patients with IHCA in the CCL had documented sepsis at the time of IHCA while 38.8% of CCL patients were on continuous intravenous vasoactive agents at the time of IHCA supports this (see Table 1). Furthermore, patients with an IHCA in the CCL were more likely to have an initial shockable rhythm when compared to patients with

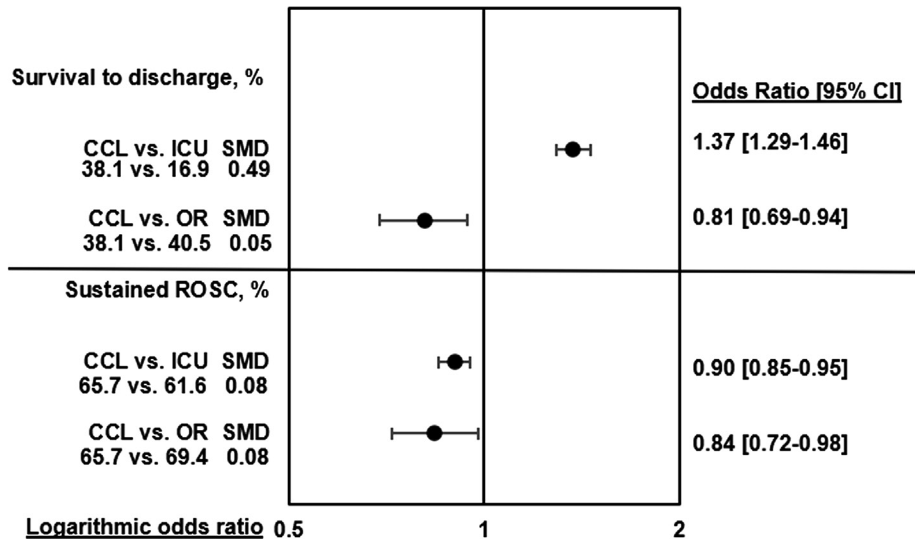


**Fig. 2 – Likelihood of survival to discharge and sustained ROSC among patients with IHCAs in the CCL vs ICU and in the CCL vs OR. ICU, intensive care unit; IHCA, in-hospital cardiac arrest; OR, operating room; ROSC, return of spontaneous circulation; SMD, standardized mean difference. The list of all variables included in each multivariable hierarchical regression model is reported in the supplementary tables.**

**Table 2 – Multivariable hierarchical model showing predictors of survival to discharge among patients with IHCA in the CCL.**

| b | Died | Survived | OR (95% CI) |
|---|---|---|---|
| Age, year mean (standard deviation) | 68.1 (13.3) | 63.6 (13.4) | 0.97 (0.97–0.98) |
| Female gender | 1685 (39.6) | 905 (34.6) | 0.95 (0.85–1.08) |
| White race | 3297 (77.7) | 2163 (82.9) | 1.24 (1.06–1.45) |
| Acute stroke | 69 (1.6) | 24 (0.9) | 0.68 (0.40–1.16) |
| Acute CNS non-stroke event | 297 (7.0) | 73 (2.8) | 0.64 (0.47–0.87) |
| Baseline depression in CNS function | 242 (5.7) | 74 (2.8) | 0.79 (0.57–1.09) |
| Congestive heart failure (this admission) | 667 (15.7) | 319 (12.2) | 1.04 (0.87–1.25) |
| Congestive heart failure (prior admission) | 789 (18.6) | 400 (15.3) | 0.88 (0.74–1.05) |
| Myocardial ischemia/infarction (this admission) | 2684 (63.1) | 1427 (54.6) | 0.59 (0.52–0.67) |
| Myocardial ischemia/infarction (prior admission) | 1115 (26.2) | 625 (23.9) | 0.82 (0.71–0.95) |
| Pneumonia | 163 (3.8) | 50 (1.9) | 0.81 (0.56–1.18) |
| Respiratory insufficiency | 1711 (40.2) | 562 (21.5) | 0.86 (0.74–0.99) |
| Renal insufficiency | 913 (21.5) | 343 (13.1) | 0.85 (0.72–1.01) |
| Hepatic insufficiency | 135 (3.2) | 46 (1.8) | 0.89 (0.59–1.33) |
| Diabetes mellitus | 1338 (31.5) | 739 (28.3) | 1.05 (0.92–1.20) |
| Metabolic/electrolyte abnormality | 732 (17.2) | 218 (8.3) | 0.75 (0.62–0.92) |
| Hypotension/hypoperfusion | 1689 (39.7) | 561 (21.5) | 0.67 (0.58–0.78) |
| Sepsis | 121 (2.8) | 36 (1.4) | 0.77 (0.50–1.18) |
| Initial rhythm | | | - |
| - Pulseless electrical activity | 2241 (52.7) | 710 (27.2) | 0.66 (0.56–0.77) |
| - Pulseless ventricular tachycardia | 361 (8.5) | 319 (12.2) | 1.66 (1.34–2.06) |
| - Ventricular fibrillation | 744 (17.5) | 1154 (44.1) | 2.69 (2.27–3.18) |
| Admitting diagnosis | | | - |
| - Medical-Noncardiac | 151 (3.6) | 63 (2.4) | 0.67 (0.47–0.95) |
| - Surgical-Cardiac | 455 (10.7) | 290 (11.1) | 1.02 (0.84–1.25) |
| - Surgical-Noncardiac | 55 (1.3) | 31 (1.2) | 0.89 (0.53–1.50) |
| - Other | 6 (0.1) | 1 (0.0) | 0.10 (0.01–1.08) |
| After hours arrest | 688 (16.2) | 313 (12.0) | 0.84 (0.70–1.00) |
| Weekend or holiday arrest | 1096 (25.8) | 514 (19.7) | 0.85 (0.73–0.98) |
| Assisted or mechanical vent already in place | 2182 (51.3) | 587 (22.5) | 0.39 (0.34–0.45) |
| Vasoactive agent already in place | 2031 (47.8) | 632 (24.2) | 0.55 (0.49–0.63) |
| Dialysis/extracorporeal filtration (ongoing) | 27 (0.6) | 11 (0.4) | 0.83 (0.37–1.82) |

CCL, cardiac catheterization laboratory; CI, confidence interval; CNS, central nervous system;
IHCA, in-hospital cardiac arrest; OR, odds ration; Asystole is the reference for initial rhythm variable, and medical-cardiac is the reference for admitting diagnosis.

an IHCA in the ICU, which results in higher unadjusted survival rates to discharge. Because an initial shockable rhythm of overall survival, adjusted rates of survival to discharge for patients with IHCA in the CCL compared to those in the OR were ultimately lower. This may be because of unmeasured factors that predispose patients with IHCA in the CCL to have lower survival rates than patients in the OR, after accounting for initial rhythm including issues of cardiogenic shock. Finally, the known difficulty of performing high quality cardiopulmonary resuscitation with manual chest compression while fixing the underlying cause of cardiac arrest in the CCL can also contribute to the lower survival in the CCL vs OR.

The findings from this study extend the available evidence about different rates of survival among patients with IHCA based on the location of IHCA in the hospital and add a different perspective about a unique group of patients with IHCA in the CCL. Previous reports from GWTG-R found a survival to discharge rate of 19.3% in a monitored ward setting, 10.6% in an unmonitored ward setting, 14% in ICU, and 31.7% in perioperative settings.[4–5] Those different insights from GWTG-R examining odds of survival to discharge after IHCA based on the location of IHCA demonstrated that patients with witnessed CA (in the CCL or OR) had a relatively higher survival to discharge than IHCA in other locations like the ICU, or monitored/unmonitored wards.

Previous studies that explored the characteristics of IHCA in the CCL showed a prevalence of initial shockable rhythm rates of only 14.0% and 16.6%.[12–13] However, these were small studies. In our cohort from a national registry, we found that 37.5% of patients with IHCA in the CCL had an initial shockable rhythm. The difference in analytic cohorts can be the reason for this variation in initial cardiac rhythm at presentation. The overall survival to discharge rates from those studies were ~25%.[12–13] In contrast, our study had higher rates of survival to discharge at 38.1%, owing to the fact that a larger proportion of patients with IHCA in the CCL had shockable rhythms.

### *Clinical implications*

While our findings are helpful in showing that IHCA in CCL is not uncommon, our model to predict survival in patients with an IHCA in the CCL defined some similar predictors as in the overall IHCA setting. There were differences, though. For instance, a history of myocardial infarction or an index myocardial infarction for IHCA in the CCL were negative predictors, whereas they are usually associated with a neutral or positive association for survival for patients with IHCA on hospital wards. Nonetheless, these predictors may help define patients with higher risk for decompensation to IHCA while undergoing coronary or non-coronary interventions in the CCL. Furthermore, whether using mechanical cardiopulmonary resuscitation devices in the CCL may have an effect on survival outcomes may deserve further investigation.

### *Limitations*

Despite that GWTG-R is the largest nationwide multicenter registry describing IHCA in the United States, it only represents ~15% of all U.S. hospitals; therefore, our findings may not be generalizable to non-participating hospitals.[4] We were unable to calculate the incidence rate of IHCA in the CCL or account for the severity of the underlying comorbidities (hepatic, renal, and renal insufficiency, severity of shock or acute cerebrovascular event), ascertain presence of cardiogenic shock, the type of myocardial infarction (ST vs non-ST elevation myocardial infarction), ejection fraction, the type of intervention in the CCL (coronary, valvular, pericardial or right heart catheterization), details about procedural-related complications which may have led to IHCA (acute coronary occlusion, pericardial tamponade, coronary or ventricular perforation, or dissection), and the type of procedure during which IHCA occurred in the OR, as these variables are not collected in GWTG-R. There is the possibility that some brief IHCA events in the CCL (e.g., ventricular fibrillation requiring one defibrillation shock) may not be captured in the GWTG-R and therefore our analyses of IHCA in the CCL reflect sustained IHCA events.

### *Conclusion*

In a large national registry, patients with an IHCA in the CCL had a 38% chance of survival to discharge. This survival likelihood was lower than IHCA occurring in the OR but higher than those occurring in the ICU. The lower rate of IHCA survival in the CCL as compared with IHCA survival in the OR deserves further study given that cardiac arrest in both settings is witnessed and response time should be similar.

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## Author Disclosures

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## CRediT authorship contribution statement

**Ahmed Elkaryoni:** Conceptualization, Methodology, Validation, Investigation, Writing – original draft, Visualization, Project administration. **Andy T. Tran:** Conceptualization, Methodology, Software, Formal analysis, Resources, Writing – original draft. **Marwan Saad:** Writing – review & editing, Visualization. **Amir Darki:** Writing – review & editing, Visualization. **John J. Lopez:** Writing – review & editing, Visualization. **J Dawn Abbott:** Writing – review & editing, Visualization. **Paul S. Chan:** Conceptualization, Methodology, Validation, Investigation, Visualization, Project administration, Writing – review & editing, Supervision, Project administration.

## Appendix A

a) “The Get With The Guidelines® programs are provided by the American Heart Association.”

b) “Hospitals participating in the registry submit clinical information regarding the medical history, hospital care, and outcomes of consecutive patients hospitalized for cardiac arrest using an online, interactive case report form and Patient Management Tool™ (IQVIA, Parsippany, New Jersey)."

c) "IQVIA (Parsippany, New Jersey) serves as the data collection (through their Patient Management Tool – PMTTM) and coordination center for the American Heart Association/American Stroke Association Get With The Guidelines® programs. The University of Pennsylvania serves as the data analytic center and has an agreement to prepare the data for research purposes."

d) AHA Adult Research Task Force members: Anne Grossestreuer PhD; Ari Moskowitz MD; Dana Edelson MD MS; Joseph Ornato MD; Mary Ann Peberdy MD; Matthew Churpek MD MPH PhD; Monique Anderson Starks MD MHS; Paul Chan MD MSc; Saket Girotra MBBS SM; Sarah Perman MD MSCE; Zachary Goldberger MD MS.

## Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2022.08.002.

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