

## ORIGINAL RESEARCH

# Short- and Long-Term Outcomes of Hematologic Malignancy Patients After Cardiopulmonary Resuscitation: Experience of a Large Oncology Center

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Authors' disclosures of conflicts of interest are found at the end of this article.

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## Abstract

**Purpose:** The objective of this study is to describe characteristics and short- and long-term outcomes of patients with hematologic malignancies who received cardiopulmonary resuscitation (CPR). **Methods:** A retrospective review was conducted of all Code Blues at a large comprehensive cancer center. Demographic, clinical, and outcome variables were analyzed for patients with a hematologic malignancy who underwent CPR. **Results:** Of 258 patients, 60.1% had leukemia. Outcomes included return of spontaneous circulation (70.2%), hospital survival (12%), and 90-day, 6-month, and 1-year survival rates of 9.8%, 8.2%, and 5.9%, respectively. Factors associated with hospital mortality included establishing a do not resuscitate order after CPR ( $p < .0001$ ), location of CPR ( $p = .0004$ ), cause of arrest ( $p = .0019$ ), requiring vasopressors ( $p = .0130$ ), mechanical ventilation ( $p = .0423$ ), and acute renal failure post CPR ( $p = .0006$ ). Although no difference in hospital survival between leukemia and non-leukemia patients was found, more non-leukemia patients were alive at 90 days ( $p = .0099$ ), 6 months ( $p = .0023$ ), and 1 year ( $p = .0119$ ). **Conclusions:** Factors including organ dysfunction, location of CPR, and cause of arrest are associated with hospital mortality post CPR. However, immediate survival post CPR does not seem to be affected by a diagnosis of leukemia. These data should assist health care providers with discussions regarding advance care planning and goals of care after cardiac arrest.

Cardiopulmonary resuscitation (CPR) can be a life-saving intervention in the right patient population. Up to 209,000 people are treated for in-hospital cardiac arrest (IHCA) each year, with a survival rate to hospital discharge of 24.8% (Benjamin et al., 2019). Although outcomes post IHCA have improved since the early 2000s, most likely due to earlier initiation of CPR and better-quality CPR (Andersen et al., 2019), evaluating variables that impact survival continues to be important to assist with end-of-life or advance care planning discussions. Over time, multiple studies have demonstrated low survival rates post cardiac arrest in cancer patients when compared to the general population (Ballew et al., 1994; Bedell et al., 1983; Ebell & Preston, 1993; Ewer et al., 2001; Merja et al., 2015; Schwenzer et al., 1993; Taffet et al., 1988). Conflicting data exist regarding the type of malignancy and the impact on outcomes post CPR, with older data suggesting that patients with hematologic malignancies have worse outcomes (Reisfield et al., 2006; Sheldon, 2010; Zafar et al., 2017). However, more recent data suggest that the type of malignancy does not have an impact on survival post CPR (Finan et al., 2017).

In our current environment with rising medical costs, offering appropriate and non-futile care is of great importance. This should include resuscitation measures in high-risk populations such as patients with hematologic malignancies. However, as outcomes of patients with hematologic cancer improve (Cronin et al., 2018), having recent and pertinent data to support medical decisions regarding CPR is important. A better understanding of factors that affect short- and long-term survival of patients with hematologic malignancy who undergo CPR can inform and guide providers, patients, and family members when addressing goals of care. The objective of this study is to describe short- and long-term outcomes of hematologic malignancy patients after cardiac arrest, and evaluate factors that may predict mortality post arrest.

## METHODS

The University of Texas MD Anderson Cancer Center is the largest freestanding comprehensive cancer center in the world treating only cancer

patients and with an average of 28,000 hospital admissions per year. Cardiopulmonary resuscitation services and emergency medical responses within the institution are referred to as “Code Blues.” Events triggering a Code Blue include unresponsiveness, apnea, absence of palpable pulse, physical distress, and/or requests for help due to difficulty of breathing. A Code Blue team consisting of physicians, pharmacists, and critical care nurses trained to evaluate, treat, and triage these emergencies responds to all Code Blue calls at the institution. Each team activation is logged, and interventions during the event are documented.

Code Blue activations between January 2011 and December 2015 were retrospectively reviewed for this study. Only records documenting a loss of pulse and need for CPR in patients with underlying hematologic malignancies were included in this study. Within the leukemia group, patients with chronic and acute leukemias were included, as well as patients with high-risk myelodysplastic syndrome due to their high risk for leukemic transformation. In patients with multiple cardiac arrest events, only the initial event was included in the analysis. Patients with solid tumors, without cancer, younger than 18 years old, or who had no CPR during the Code Blue call were not included in the study.

All data were collected in REDCap (Harris et al., 2009). Patient characteristics included age, gender, cancer diagnosis, disease status, chemotherapy history, presence of neutropenia, and Charlson Comorbidity Index (CCI; Charlson et al., 1987). Cardiopulmonary resuscitation-specific data included hospital location at time of the arrest, duration of CPR, initial rhythm, and whether return of spontaneous circulation (ROSC) was achieved. Progress notes were reviewed to determine the probable cause of arrest. If ROSC was achieved, data on need for intensive care unit (ICU) admission, mechanical ventilation, and vasopressors, as well as the development of acute renal failure (ARF) were collected. A do not resuscitate (DNR) order placed post ROSC was also documented. Outcomes collected included ROSC and survival at hospital discharge, 90 days, 6 months, and 1 year. Intensive care unit and hospital length of stay (LOS) were also evaluated.

### Statistical Analysis

A subgroup analysis was conducted on all patients within the data set labeled as having hematologic cancer. Summary statistics, including mean, standard deviation, median, and range for continuous variables, such as age and duration of CPR in minutes, frequency counts and percentages for categorical variables such as gender, hematologic type, appropriate CPR, and mortality, were reported. Fisher's exact test or chi-squared test was used to evaluate the association between two categorical variables. Wilcoxon rank-sum test was used to evaluate the difference in continuous variables between patient groups. Multivariate logistic regression model was used to assess the effects of important covariates on mortality at hospital discharge. Statistical software SAS 9.4 (SAS, Cary, NC) and R (version 3.4.0) were used for all the analyses.

## RESULTS

### General Characteristics of Hematologic Patients Post Cardiac Arrest

A total of 512 patients had documented CPR during the 5-year time period. Of those, 258 patients (50.4%) had hematologic malignancies. The majority of hematologic malignancy patients were male (57.4%), had a CCI  $\geq 4$  (69.7%), and was  $55.7 \pm 17.03$  years old (Table 1). Sixty percent of patients had leukemia, including those with a diagnosis of acute myeloid leukemia (28.7%), acute lymphoid leukemia (13.2%), chronic leukemias (11.6%), and myelodysplastic syndrome (10.5%). Non-leukemia diagnoses included non-Hodgkin lymphoma (19%), multiple myeloma (10.5%), and Hodgkin lymphoma (2.7%).

The majority of patients (86.8%) had active disease at the time of the arrest; 41.5% of patients had received chemotherapy within 10 days of CPR, and 41.5% had severe neutropenia. Cardiac arrest occurred on average within  $18.36 \pm 21.19$  days of hospital admission. Cardiopulmonary resuscitation most commonly occurred in the ICU (53.5%) or on inpatient floors (38.4%). A cause for the arrest was identified in 69.8% of patients. A primary cardiac event was found to be the cause of arrest in 22.1%, multiorgan failure in 20.5%, a respiratory event in 15.5%, and 11.6% due to other causes. An initial rhythm at the time of arrest was documented in 90.7% of cases. Non-shockable rhythms

of asystole and pulseless electrical activity (PEA) were the most common initial rhythm (82.9%), with PEA comprising the majority (70.4%). Shockable rhythms of ventricular tachycardia and ventricular fibrillation only occurred in 20 patients (7.8%). The median duration of CPR was 10 minutes (range: 1–60 minutes).

### Short- and Long-Term Outcomes Post Cardiac Arrest of Hematologic Patients

Return of spontaneous circulation was achieved in 70.2% of the 258 hematologic patients who underwent CPR (Table 2). Post CPR, 86% of patients required mechanical ventilation, 83.3% vasopressors, and 60.5% developed ARF (Table 1). A DNR was established post CPR in 49.6% of all patients (70.2% of patients that had ROSC). Thirty-one patients (12%) survived hospital discharge. Two patients were lost to follow-up at 90 days and 6 months, and 3 patients at 1 year. Long-term survival included 25 (9.8%) patients at 90 days, 21 (8.2%) at 6 months, and 15 (5.9%) at 1 year (Table 2).

Survival at hospital discharge was not associated with age, gender, CCI, disease remission, stem cell transplant status, recent chemotherapy, or neutropenic status at time of CPR. Development of ARF (64.3% vs. 32.3%;  $p = .0006$ ), requiring mechanical ventilation (87.7% vs. 74.2%;  $p = .0423$ ) and requiring vasopressors (85.5% vs. 67.7%;  $p = .0130$ ) were associated with hospital mortality. Survival rates at hospital discharge were significantly different among patients who received CPR in the ICU, in the emergency department, on the medical floors, and at other hospital sites ( $p = .0004$ ). A shockable rhythm at the time of arrest was associated with survival. Additionally, of those patients in whom the cause of the arrest was known, cardiac and respiratory events were more likely to occur in those who survived, while multiorgan failure was more likely in those who died ( $p = 0.0019$ ). Hospital mortality was associated with a longer duration of CPR (10 [1–60] vs. 6 [1–24] minutes;  $p = .0103$ ) and longer hospital stay prior to the arrest (11 [1–112] vs. 6 [1–99] days;  $p = .0472$ ). Establishing a DNR post CPR was significantly associated with hospital mortality (55.1% vs. 9.7%;  $p < .0001$ ). When compared to patients who did not survive hospital discharge, those who were alive at hospital discharge had longer ICU and hospi-

**Table 1. General Characteristics of Hematologic Patients Post Cardiac Arrest and Survival at Hospital Discharge**

Variable	All patients (n = 258)	Hospital death (n = 227; 88%)	Hospital survival (n = 31; 12%)	p value
Gender (female)	110 (42.6%)	96 (42.3%)	14 (45.2%)	.7618
Age (years) <sup>a</sup>	55.70 ± 17.03	55.77 ± 16.37	55.23 ± 21.59	.7139
Hematologic diagnosis				
Leukemia	155 (60.1%)	141 (62.1%)	14 (45.2%)	.0706
Non-leukemia	103 (39.9%)	86 (37.9%)	17 (54.8%)	
Active disease (not in remission) <sup>a</sup>	224 (86.8%)	198 (87.2%)	26 (83.9%)	.5755
Recent chemotherapy ( $< 10$ days from CPR)	107 (41.5%)	92 (40.5%)	15 (48.4%)	.4048
Severe neutropenia <sup>a</sup> (ANC $< 500$ )	107 (41.5%)	96 (42.3%)	11 (35.5%)	.4706
Stem cell transplant (yes) <sup>a</sup>	89 (34.5%)	79 (34.8%)	10 (32.3%)	.7799
Co-morbidity index $\geq 4^a$	180 (69.7%)	158 (69.6%)	22 (71%)	.8767
DNR after CPR	128 (49.6%)	125 (55.1%)	3 (9.7%)	<b><math>&lt; .0001</math></b>
Mechanical ventilation	222 (86%)	199 (87.7%)	23 (74.2%)	<b>.0423</b>
Vasopressors	215 (83.3%)	194 (85.5%)	21 (67.7%)	<b>.013</b>
Acute renal failure	156 (60.5%)	146 (64.3%)	10 (32.3%)	<b>.0006</b>
ICU length of stay (days) <sup>b</sup>	3 (1-78)	3 (1-69)	9 (2-78)	<b><math>&lt; .0001</math></b>
Hospital length of stay (days) <sup>b</sup>	15 (1-158)	13 (1-134)	31 (3-158)	<b>.0002</b>
Location of CPR				
ICU	138 (53.5%)	129 (56.8%)	9 (29.1%)	<b>.0004</b>
Inpatient floor	99 (38.4%)	82 (36.1%)	17 (54.8%)	
Emergency Center	15 (5.8%)	14 (6.1%)	1 (3.2%)	
Other	6 (2.4%)	2 (0.9%)	4 (12.9%)	
Cause of the arrest				
Cardiac event	57 (22.2%)	45 (19.8%)	12 (38.7%)	<b>.0019</b>
Multi-organ failure	53 (20.5%)	52 (22.9%)	1 (3.2%)	
Respiratory event	40 (15.5%)	31 (13.7%)	9 (29%)	
Other	30 (11.6%)	28 (12.3%)	2 (6.5%)	
Initial rhythm				
Asystole/PEA	214 (82.9%)	195 (85.9%)	19 (61.3%)	<b>.0397</b>
VT/VF	20 (7.8%)	15 (6.6%)	5 (16.1%)	
Duration of CPR (minutes) <sup>b</sup>	10 (1-60)	10 (1-60)	6 (1-24)	<b>.0103</b>
Days between hospital admission to CPR <sup>b</sup>	10 (1-112)	11 (1-112)	6 (1-99)	<b>.0472</b>

Note. Bold indicates statistical significance. ANC = absolute neutrophil count; CPR = cardiopulmonary resuscitation; DNR = do not resuscitate; ICU = intensive care unit; PEA = pulseless electrical activity; VT = ventricular tachycardia; VF = ventricular fibrillation.

<sup>a</sup>At time of arrest.

<sup>b</sup>Median (min-max).

**Table 2. Short- and Long-Term Outcomes of Leukemia and Non-Leukemia Patients Post Cardiac Arrest**

Outcomes	All patients (n = 258)	Leukemia (n = 155)	Non-leukemia (n = 103)	p value
ROSC	181 (70.2%)	101 (65.2%)	80 (77.7%)	<b>.0315</b>
Hospital survival	31 (12%)	14 (9%)	17 (16.5%)	.0706
90-day survival	25 (9.8%)	9 (5.8%)	16 (15.5%)	<b>.0099</b>
6-month survival	21 (8.2%)	6 (3.9%)	15 (14.6%)	<b>.0023</b>
1-year survival	15 (5.9%)	4 (2.6%)	11 (10.8%)	<b>.0119</b>
Received cancer therapy post arrest	28 (10.9%)	15 (9.7%)	13 (12.6%)	.4676

Note. Bold indicates statistical significance. ROSC = return of spontaneous circulation.

tal LOS. On multivariate analysis adjusted to the presence of mechanical ventilation and rhythm at time of CPR, the odds of mortality at hospital discharge for the patients with ARF was 3.248 times higher than those without ARF (95% confidence interval [CI] = 1.256–8.402;  $p = .0151$ ).

Cause of arrest, initial rhythm, location of CPR, development of ARF, and use of vasopressors were significantly associated with mortality at 90 days, 6 months, and 1 year (Table 3). Longer duration of CPR and longer hospital stay prior to the arrest were also significantly associated with mortality at 90 days, 6 months, and 1 year. Mechanical ventilation was significantly associated with survival at 6 months and 1 year, but not at 90 days.

### Impact of the Type of Hematologic Malignancy on CPR Outcomes

To further evaluate the effects of the type of hematologic malignancy on survival post CPR, the patient population was grouped into those with a leukemia and non-leukemia diagnosis. There were 155 (60.1%) patients with a diagnosis of leukemia and 103 patients (39.9%) with a non-leukemia diagnosis. No significant differences in age, gender, remission status, recent chemotherapy, or CCI were observed between patients with leukemia and those without leukemia (Table 4).

Patients with leukemia were more likely to be neutropenic (47.7% vs. 32%;  $p = .0122$ ), but less likely to have received a stem cell transplant (27.7% vs. 44.7%;  $p = .0051$ ). Location of CPR was not statistically different between patients with leukemia and patients without leukemia ( $p = .1975$ ). While the leading cause of arrest was multiorgan failure in the leukemia patients and cardiac events in the

non-leukemia group, the difference in cause of arrest between both groups did not reach statistical significance. The rhythm at the time of arrest, duration of CPR, and time from hospital admission to the arrest were not different between the two groups ( $p > .05$ ). Additionally, no differences were found between the two groups regarding the need for mechanical ventilation or vasopressors, or the development of ARF.

Non-leukemia patients were more likely to achieve ROSC (77.7% vs. 65.2%;  $p = .0315$ ), and while there was a trend towards increased survival at hospital discharge in the non-leukemia group, the difference did not reach statistical significance (16.5% vs. 9%;  $p = .0706$ ; Table 2). Additionally, there was no difference observed in the number of patients being made DNR post CPR (53.4% vs. 47.1%;  $p = .3215$ ), nor in the number of patients who died due to withdrawal of care (46.5% vs. 46.5%;  $p = .4867$ ). Of those who survived hospital discharge, fewer patients with leukemia were discharged home than in the non-leukemia group (57.1% vs. 76.5%;  $p = .0319$ ). Survival at 90 days (5.8% vs. 15.5%;  $p = .0099$ ), 6 months (3.9% vs. 14.6%;  $p = .0023$ ), and 1 year (2.6% vs. 10.8%;  $p = .0119$ ) were significantly lower in leukemia patients (Table 2). Despite these differences in survival, a similar percentage of patients in both groups received cancer therapy post CPR (9.7% vs. 12.6%;  $p = .4676$ ).

### DISCUSSION

Previous publications reporting post CPR outcomes in cancer patients are small studies, with heterogeneous groups as they combine patients with both solid and hematologic cancers and in-

**Table 3. Factors Associated With Long-Term Outcomes in Hematologic Patients**

	90 days <sup>a</sup>			6 months <sup>a</sup>			1 year <sup>b</sup>		
	Dead (n = 231)	Alive (n = 25)	p value	Dead (n = 234)	Alive (n = 21)	p value	Dead (n = 240)	Alive (n = 15)	p value
Cause of the arrest (multiorgan failure)	52 (22.5%)	1 (4%)	<b>.0024</b>	53 (22.6%)	0	<b>.0001</b>	53 (22.6%)	0	<b>.0019</b>
Location of CPR (ICU)	131 (56.7%)	6 (24%)	<b>.0018</b>	133 (56.6%)	4 (16%)	<b>.0002</b>	135 (56.3%)	2 (13.3%)	<b>.0001</b>
Initial rhythm (asystole/PEA)	199 (86.2%)	13 (52%)	<b>.0118</b>	202 (85.9%)	10 (47.6%)	<b>.0049</b>	206 (85.8%)	6 (40%)	<b>.0061</b>
Mechanical ventilation	202 (87.4%)	19 (76%)	.1136	206 (87.7%)	15 (71.4%)	<b>.0389</b>	210 (87.5%)	10 (66.7%)	<b>.0394</b>
Vasopressors	197 (85.3%)	17 (68%)	<b>.0267</b>	201 (85.5%)	10 (47.6%)	<b>.0049</b>	205 (85.4%)	9 (60%)	<b>.0093</b>
Acute renal failure	148 (64.1%)	7 (28%)	<b>.0005</b>	150 (63.8%)	5 (23.8%)	<b>.0007</b>	151 (62.9%)	3 (20%)	<b>.0017</b>
Duration of CPR (minutes) <sup>c</sup>	10 (1-60)	7 (1-21)	<b>.0155</b>	10 (1-60)	7 (1-20)	<b>.0402</b>	10 (1-60)	6 (1-15)	<b>.0258</b>
Days between hospital admission to CPR <sup>c</sup>	11 (1-112)	4 (1-45)	<b>.0187</b>	1 (11-112)	3 (1-39)	<b>.004</b>	11 (1-112)	3 (1-39)	<b>.0183</b>

Note. Bold indicates statistical significance. CPR = cardiopulmonary resuscitation; PEA = pulseless electrical activity.

<sup>a</sup>2 lost to follow-up

<sup>b</sup>3 lost to follow-up

<sup>c</sup>Median (min-max)

clude both inpatient and out-of-hospital arrests. This study is the first to look at only hospitalized hematologic patients and to evaluate both short- and long-term outcomes after CPR. This study found higher rates of ROSC, hospital discharge, and long-term survival when compared to prior literature. Variables such as location of the arrest (e.g., ICU) and underlying multiorgan failure, but not a diagnosis of leukemia, were associated with increased mortality. The findings of the study could be used to support medical decisions and discussions regarding CPR in the inpatient setting.

In this study, 70.2% of hematologic patients achieved ROSC, which is higher than previously reported rates of 2% to 25% (Reisfield et al., 2006; Vitelli et al., 1991). Data published by The University of Texas MD Anderson Cancer Center looking at survival post CPR 2 decades ago demonstrated an ROSC rate as low as 37%, with the highest mortality occurring in the leukemia patient population (Wallace et al., 2002). Besides having a higher ROSC rate, the data from this study showed a higher survival to hospital discharge (12%) compared to other reports of 0 to 9% (Khasawneh et

al., 2013; Reisfield et al., 2006; Vitelli et al., 1991; Wallace et al., 2002). Although quality of CPR was not evaluated, outcomes have clearly improved and such findings could be associated to institutional efforts over time including a rapid response team, decreasing time to CPR, and education to improve quality of CPR.

Similar to other published data, mortality was higher in patients with a non-shockable rhythm (Ballew et al., 1994; Champigneulle et al., 2015; Doig et al., 2000; Meaney et al., 2010; Peberdy et al., 2003). A shockable initial rhythm occurred in 7.8% of study participants, which is similar to the 4.9% to 17% range found in the literature (Bruckel et al., 2017; Wallace et al., 2002). The data are also consistent with other reports suggesting that a shorter duration of CPR is a predictor of hospital survival (Khasawneh et al., 2013). Another consistent finding was the association of cause of arrest and hospital mortality (Champigneulle et al., 2015; Sculier & Markiewicz, 1993; Vitelli et al., 1991). Ewer and colleagues (2001) offer an explanation when they evaluated the difference in outcomes of CPR when a cardiac arrest was ex-

**Table 4. Characteristics of Hematologic Patients Post Cardiac Arrest: Leukemia and Non-Leukemia**

	<b>Leukemia (n = 155; 60.1%)</b>	<b>Non-Leukemia (n = 103; 39.9%)</b>	<b>p value</b>
Gender (female)	71 (45.8%)	39 (37.9%)	.2065
Age (years) <sup>a</sup>	54.45 ± 18.2	57.58 ± 15	.3668
Stem cell transplant (yes) <sup>a</sup>	43 (27.7%)	46 (44.7%)	<b>.0242</b>
Active disease (not in remission) <sup>a</sup>	135 (87.1%)	89 (86.4%)	.8727
Recent chemotherapy (< 10 days from CPR)	67 (43.2%)	40 (38.8%)	.4833
Severe neutropenia <sup>a</sup> (ANC < 500)	74 (47.7%)	33 (32%)	<b>.0051</b>
Co-morbidity index ≥ 4 <sup>a</sup>	105 (67.7%)	75 (72.8%)	.3848
Mechanical ventilation	135 (87.1%)	87 (84.5%)	.5503
Vasopressors	132 (85.2%)	83 (80.6%)	.3338
Acute renal failure	99 (63.9%)	57 (55.3%)	.1699
ICU length of stay (days) <sup>b</sup>	3 (1-78)	3 (1-29)	.4977
Hospital length of stay (days) <sup>b</sup>	14 (1-158)	16 (1-87)	.5906
Location of CPR			
ICU	91 (58.7%)	47 (45.6%)	.1975
Inpatient floor	52 (33.5%)	47 (45.6%)	
Emergency center	9 (5.8%)	6 (5.8%)	
Other	3 (1.9%)	3 (2.9%)	
Cause of the arrest			
Cardiac event	30 (19.4%)	27 (26.2%)	.2605
Multiorgan failure	36 (23.2%)	17 (16.5%)	
Respiratory event	28 (18.1%)	12 (11.7%)	
Other	19 (12.3%)	11 (10.7%)	
Initial rhythm			
Asystole/PEA	132 (85.2%)	82 (79.6%)	.0586
VT/VF	8 (5.2%)	12 (11.7%)	
Duration of CPR (minutes) <sup>b</sup>	11 (1-56)	8 (1-60)	.0529
Days between hospital admission to CPR <sup>b</sup>	10 (1-112)	9 (1-87)	.2239

Note. Bold indicates statistical significance. CPR = cardiopulmonary resuscitation; DNR = do not resuscitate; ICU = intensive care unit; PEA = pulseless electrical activity; VT = ventricular tachycardia; VF = ventricular fibrillation.

<sup>a</sup>At time of arrest

<sup>b</sup>Median (min-max)

pected vs. not expected. Cancer patients in multi-organ failure and with no DNR status who arrest will undergo CPR and are not expected to survive. However, those cancer patients who have an unexpected sudden event are more likely to have had a cardiac or respiratory cause of arrest and have a higher likelihood of survival. Similar to a meta-analysis of 42 studies on CPR outcomes in cancer patients (Reisfield et al., 2006), it was found that

location of CPR was also associated with hospital mortality. This could be related to the cause of arrest. Most patients in the ICU are more likely to have CPR due to multiorgan failure and not due to a primary cardiac or respiratory event. The impact of multiorgan failure on short- and long-term survival was similar to other published data in hematologic patients. Patients who developed ARF or required mechanical ventilation or vasopressor

therapy have higher hospital mortality and low long-term survival (Al-Zubaidi et al., 2018; Azoulay et al., 2013; Cornish et al., 2016; de Vries et al., 2019; Grgić Medić et al., 2015; Soares et al., 2010).

When evaluating long-term outcomes, this study showed a 90-day, 6-month, and 1-year survival of 9.8%, 8.9%, and 5.9%, respectively. Champigneulle and colleagues (2015) reported a 6-month survival rate of 14% in hematologic patients post CPR; however, the sample size was small ( $n = 52$ ) and did not include CPR occurring in the ICU. Moreover, the study did not examine the impact of the type of hematologic malignancy on long-term survival. Varon and colleagues (1998) reported a 3.6% survival rate for 35 hematologic patients post CPR at both 6 months and 1 year. The higher survival rates in this study may be explained by overall improved outcomes for cancer patients in general (Cronin et al., 2018; Jemal et al., 2017). Cancer therapies have evolved with the use of targeted therapies and immunotherapies, and while they continue to have significant toxicities, in many cases, these are reversible and improve short- and long-term survival (Locke et al., 2019; Marin-Acevedao et al., 2019; Maude et al., 2018). Moreover, outcomes for critically ill patients with hematologic malignancies have improved, with a recent multicenter study demonstrating a 37.6% 1-year survival rate (Cornish et al., 2016). Therefore, as overall outcomes in the hematologic population continue to improve, in a select patient population, supportive care in the ICU post arrest could have an impact on overall survival once ROSC is achieved.

Data suggesting the impact of a leukemia diagnosis in outcomes post CPR vary (Reisfield et al., 2006; Wallace et al., 2002). It should be noted that earlier studies were performed at a time when outcomes of acutely ill leukemia patients were still dire. In this study, although leukemia patients were less likely to achieve ROSC, there was no difference in hospital survival. These results are interesting, especially considering that leukemia patients were more likely to arrest in the ICU and have multiorgan failure as the cause of arrest. The similar hospital survival rates could be due to the similarities in initial rhythm, time from hospital admission to arrest, and duration of CPR, all of which are significant factors in overall CPR

survival (Ballew et al., 1994; Champigneulle et al., 2015; Doig et al., 2000; Khasawneh et al., 2013; Meaney et al., 2010; Peberdy et al., 2003).

Moreover, factors associated with increased mortality in oncologic patients such as the development of ARF and the need for mechanical ventilation and vasopressors were similar in both leukemia and non-leukemia patients (Al-Zubaidi et al., 2018; Azoulay et al., 2013; Cornish et al., 2016; de Vries et al., 2019; Grgić Medić et al., 2015; Khasawneh et al., 2013; Soares et al., 2010). Long-term outcomes were better in non-leukemia patients (90 days, 6 month, and 1 year), but no risk factors predictive of mortality prior to the arrest were identifiable. It begs the question if the malignancy itself has an effect on long-term survival, rather than the cardiac arrest event. However, if this were considered a possibility, no difference was found in remission state, recent chemotherapy, DNR status, or cancer treatment received post CPR, all of which could indirectly determine the state and treatability of the disease. It was observed that a lower percentage of leukemia patients were discharged home, which may reflect on a poor functional status, a factor that has been associated with lower survival (Vitelli et al., 1991). Moreover, recent data suggest that leukemia patients are known to have lower long-term survival when compared to other hematologic malignancies (de Vries et al., 2019), findings which may further explain the results. In future work, evaluating more specific markers of disease state may be warranted to better identify the role of specific underlying malignancies in long-term survival post CPR.

### Limitations

This study has several limitations. Although it is the first to evaluate post-arrest outcomes in patients with hematologic malignancies, this was a single-center retrospective study. Moreover, the study was conducted at a comprehensive cancer center where the aggressive approach to treatment and the willingness to support full code status in these patients may influence the study results. As with other studies evaluating post-arrest outcomes, patients who have a DNR status at the time of arrest were not included and thus may influence survival outcomes. Despite these limitations, the results of the study demonstrate



that performing CPR in patients with hematologic malignancies should not be considered futile. However, identifying the risk factors for poor short- and long-term outcomes, such as admission to the ICU and multiorgan failure, should further aid health-care providers in discussing long-term quality of life and expectations of further cancer care with patients and families.

## CONCLUSIONS

This is the first study to evaluate long-term outcomes in post CPR patients with hematologic malignancies and the impact of a leukemia diagnosis on outcomes. The higher rates of ROSC and hospital survival demonstrated in this study may be reflective of the overall improvement in outcomes of hematologic malignancies. Factors including organ dysfunction, location of CPR, and cause of arrest are associated with hospital mortality post CPR. However, immediate survival post CPR does not seem to be affected by a diagnosis of leukemia. These data can be used to assist health-care providers in their ongoing discussions of goals of care with patients and families. Additional post CPR studies specific to patients with hematologic malignancies are warranted to validate the study findings. ●

## Disclosure

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