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Clinical paper

Characteristics and outcomes of maternal cardiac arrest: A descriptive analysis of Get with the guidelines data☆

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ABSTRACT

Background: Maternal mortality has risen in the United States in the twenty-first century, yet large cohort data of maternal cardiac arrest (MCA) are limited.
Objective: We sought to describe contemporary characteristics and outcomes of in-hospital MCA.
Methods: We queried the American Heart Association's Get with the Guidelines Resuscitation voluntary registry from 2000 to 2016 to identify cases of maternal cardiac arrest. All index cardiac arrests occurring in women aged 18–50 with a patient illness category designated as obstetric or location of arrest occurring in a delivery suite were included. Institutional review deemed that this research was exempt from ethical approval.
Results: A total of 462 index events met criteria for MCA, with a mean age of 31 ± 7 years and a racial distribution of: 49.4% White, 35.3% Black and 15.3% Other/Unknown. While 32% had no pre-existing conditions or physiologic disorders, respiratory insufficiency (36.1%) and hypotension/hypoperfusion (33.3%) were the most common antecedent conditions. In most cases, the first documented pulseless rhythm was non-shockable; pulseless electrical activity (50.8%) or asystole (25.6%). Only 11.7% presented with a shockable rhythm; ventricular fibrillation (6.5%) or pulseless ventricular tachycardia (5.2%) while the initial pulseless rhythm was unknown in 11.9% of cases. Return of spontaneous circulation occurred in 73.6% but 68 (14.7%) had more than one arrest. The rate of survival to discharge was 40.7% overall; 37.3% with non-shockable rhythms, 33% with shockable rhythms and 64.3% with unknown presenting rhythms.
Conclusions: Maternal survival at hospital discharge in this cohort was less than 50%, lower than rates reported in other epidemiological datasets. More research is required in maternal resuscitation science and translational medicine to continue to improve outcomes and understand maternal mortality.

Introduction

Maternal mortality in the United States has increased more than 50% between 1990 and 2015; current estimates suggest a ratio that exceeds one maternal death for every 4000 live births [1]. Explanations for this national crisis include: 1) social, economic and demographic disparities; 2) gaps in clinical care and team performance; and 3) increased maternal co-morbidities. Maternal cardiac arrest (MCA)

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represents a final common pathway for a variety of maternal pathophysiologic insults including: hemorrhage, cardiovascular abnormalities, embolic events, sepsis and hypertensive disorders of pregnancy.

Despite the importance of MCA in characterizing maternal morbidity and mortality, large cohort studies detailing MCA remain limited. Einav et al. [2] reported a series in 2012 of 94 cases of MCA encompassing 1980–2010 with an overall maternal survival rate of 54.3%. Subsequently, utilizing data from the National Inpatient Sample from 1998 to 2011, Mhyre et al. [3] reported that MCA complicated 8.3/100,000 hospitalization admissions for delivery (99% CI, 7.7 to 9.3 per 100,000) with a maternal survival to discharge rate (N = 4843) of 58.9%. Most recently, a series of 66 women with MCA identified from the United Kingdom Obstetric Surveillance System (UK OSS) revealed a 58% maternal survival rate at discharge [4]. Analysis of the Canadian Perinatal Surveillance system data also reported in 2017 by Balki et al. [5] revealed that the incidence of cardiac arrest during pregnancy was 1: 12,500 deliveries, with a higher survival to discharge rate of 71.3% (204/286). We sought to further describe contemporary characteristics and outcomes of in-hospital MCA in the United States.

Methods

The American Heart Association's Get with the Guidelines-Resuscitation® (GWTG-R) is a voluntary national quality improvement program for in-hospital cardiac arrest including all adult, pediatric and obstetrical patients who undergo resuscitation for cardiopulmonary arrest in a participating hospital facility. The associated registry includes detailed data relevant to cardiopulmonary resuscitation. Individual sites are not reported to maintain confidentiality of the quality improvement process and avoid potential HIPAA violation. We queried the database to identify cases of MCA from 2000 to 2016. We included all index cardiac arrests occurring in women aged 18–50 with a patient illness categorized at the time of data abstraction as "obstetric" or an arrest location of "delivery suite". Fig. 1 depicts the identification process that was utilized to identify women sustaining one or more in-hospital MCA events from the entire GWTG dataset of cardiac arrests. Variables captured for each patient included demographic data, clinical resuscitation parameters and outcomes. The primary outcome was survival to hospital discharge. Secondary outcomes included: return of spontaneous circulation (ROSC) for at least 20 min and survival at 24 h. Survival outcomes were examined separately by initial pulseless rhythm. All patient and facility data were collected as part of a quality assurance program that is not specific to pregnancy; it contains no data on pregnancy-related diagnoses, pregnancy outcome or linkage to fetal or neonatal outcomes. The data repository is powered by Outcomes, an IQVIA Company in Parsippany, NJ. Institutional review deemed this research exempt from ethical approval.

Statistical analysis was performed using Statistical Package for the Social Sciences (IBM/SPSS; 19.1). Descriptive statistics were utilized to report both the demographic features and the outcomes of the MCA cohort. These included frequency distributions for categorical data, and mean with standard deviation and range for age, which was the only continuous variable. Proportions were calculated using the denominator of MCA cases (women) with available data.

Results

A total of 462 women met criteria for MCA. Table 1 presents the information provided at the time of reporting regarding prearrest data including: maternal age, race and pre-existing conditions of the women experiencing MCA. Respiratory insufficiency and hypotension/hypoperfusion were common antecedents to MCA. While 32% had no pre-existing conditions or physiologic disorders, 36.1% had respiratory insufficiency, 33.3% had hypotension/hypoperfusion, 12.6% had diabetes, 9.1% had renal insufficiency, 8.4% acute CNS non-stroke events and 7.4% had cardiac disease.

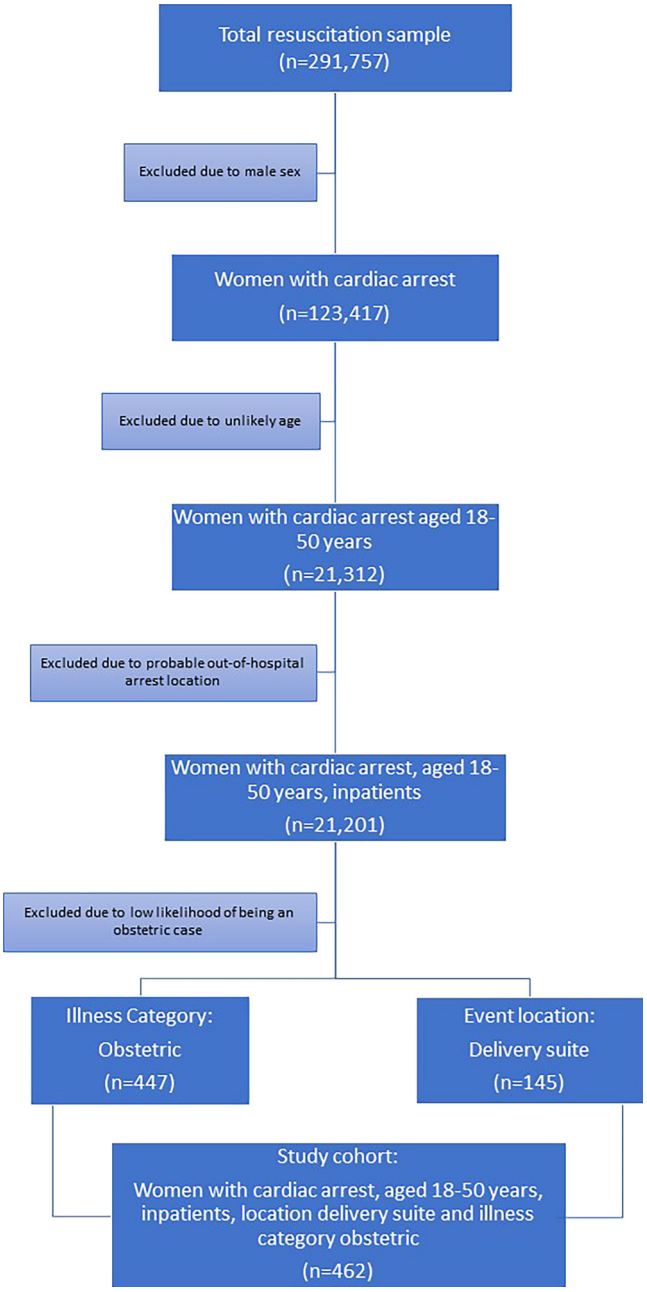

Fig. 1. Identification of Maternal Cardiac Arrest Cohort.

Characteristics of the arrests were also analyzed. The index event was witnessed in 93.7% and a hospital-wide resuscitation response was activated in 77.0% of events. Table 2 depicts the locations of maternal cardiac arrest with most occurring in the delivery suite. In most cases, the first documented pulseless rhythm was non-shockable: pulseless electrical activity (50.8%) or asystole (25.6%). Only 11.7% presented with a shockable rhythm: ventricular fibrillation (6.5%) or pulseless ventricular tachycardia (5.2%). The initial pulseless rhythm was unknown in 11.9% of MCA cases. See Table 3.

Treatment and management characteristics of the MCAs were also analyzed. An AED was applied in 21.6% of cases. The observed rate of ventilatory support was high (99.4%) with endotracheal intubation utilized in (416/462) (90.0%) of MCA cases. Our data did not allow us to identify which patients were intubated prearrest. Epinephrine was administered in 86.8% of the cases. The medications utilized for resuscitation in this cohort are reported in Table 3.

Outcomes for this cohort of women sustaining MCA were also

Table 1
Prearrest Characteristics.

		Mean ± SD (range)
Age admission (years)		31 ± 7 (18-50)
		n (% of 462)
Race	White	228 (49.4)
	Black	163 (35.3)
	Other/Unknown	70 (15.3)
Pre-existing Conditions	None	148 (32)
	Respiratory Insufficiency	167 (36.1)
	Hypotension/ Hypoperfusion	154 (33.3)
	Diabetes	58 (12.6)
	Renal Insufficiency	42 (9.1)
	Acute CNS Non- Stroke Event	39 (8.4)
	Cardiac Disease	34 (7.4)
Total Hospitals		793
Bed size	< 250	225
	250–500	235
	> 500	192
	Not specified	192
Ownership	Non-profit	536
	Private	127
	Government/Military	113
	Not specified	27
Geographic Region	North Mid Atlantic	47 (10.2)
	South Atlantic	120 (26.0)
	North Central	112 (24.2)
	South Central	91 (19.7)
	Mountain/Pacific	92 (19.9)
Time of Arrest	Night	98 (30.9)
	Weekend or holiday	114 (28.9)

Table 2
Location of Maternal Cardiac Arrest.

Location	Frequency (N)	Percent
Delivery Suite	145	31.4%
Adult Intensive Care Unit	96	20.8%
Operating Room	62	13.4%
General In- Patient Area	45	9.7%
All Other Intensive Care Units	43	9.3%
Emergency Department	13	2.8%
Adult Coronary Care Unit	12	2.6%
Post-Anesthesia Recovery Room	7	1.5%
General Inpatient Area including Telemetry	6	1.3%
Diagnostic Study Area including CAT Scan	3	0.6%
Diagnostic Intervention Area	1	0.2%
Cardiac Catheterization Lab	1	0.2%
Other	26	5.6%

analyzed. Return of spontaneous circulation occurred in 340 women (73.6%) but 68 (14.7%) had more than one arrest. Overall, 188 women (40.7%) survived to hospital discharge. Survival at discharge appeared to be more likely when a hospital wide response was activated (46.3% versus 22.6%). The rates of survival to hospital discharge, according to initial pulseless rhythm, were: 37.3% with non-shockable rhythms, 33% with shockable rhythms and 64.3% with unknown presenting rhythms. See Table 4.

Discussion

In this cohort of 462 cases of MCA, ROSC occurred in 73.6% while survival until hospital discharge was 40.7%. This difference underscores the importance of post arrest care as an area that requires further emphasis in resuscitation research. Although this survival rate is lower than those reported recently in other epidemiologic studies [4,5], it is still more than double that generally observed inhospital cardiac arrests [6]. Although this GWTG data set lacks obstetrical parameters and linkage with fetal/neonatal outcomes, several observations derived

Table 3
Arrest Characteristics.

First pulseless rhythms	Number (%)
Pulseless electrical activity	226 (50.8)
Asystole	114 (25.6)
Ventricular fibrillation	29 (6.5)
Pulseless ventricular tachycardia	23 (5.2)
Unknown rhythm	53 (11.9)
Ventilation modalities	**Number (%)**
Endotracheal tube	416 (90)
Laryngeal mask airway (LMA)	5 (1.1)
Tracheostomy tube	6 (1.3)
Pharmacological interventions	**Number (%)**
Epinephrine	401 (86.8)
Vasopressin	64 (13.9)
Dobutamine	8 (1.7)
Dopamine	94 (20.3)
Norepinephrine	127 (27.5)
Amiodarone	61 (13.2)
Adenosine	4 (1)
Sodium Bicarbonate	246 (53.2)

Table 4
Survival outcomes.

Population	Outcome	n	%
Whole study cohort	ROSC	340/462	73.6
	Survival to 24 h	240/394	60.9
	Survival to discharge	188/462	40.7
Non-shockable rhythm[a]	Survival to discharge	127/340	37.3
Shockable rhythm[a]	Survival to discharge	17/52	33.0
Unknown presenting rhythms[a]	Survival to discharge	34/53	64.3

ROSC Return of spontaneous circulation.
[a] 17 cases were missing from first pulseless rhythm calculation.

from the analysis of these women with maternal cardiac arrest are noteworthy.

First, respiratory insufficiency and hypotension/hypoperfusion were each recorded as pre-existing conditions in over one-third of the women. The high rate of respiratory insufficiency reinforces the current ACLS guidelines for maternal resuscitation that recommend concurrent ventilation and oxygenation along with chest compressions and manual left lateral uterine displacement if uterine size is greater than or equal to twenty weeks gestation [7]. Resuscitation during pregnancy requires modifications to accommodate the physiological changes of pregnancy including increased oxygen demand and aortocaval compression secondary to an enlarging uterine size. In this cohort of women, the observed rate of ventilatory support was high (99.4%) with endotracheal intubation utilized in 90.0% of MCA cases. Although oxygenation is the supreme goal, securing the airway via endotracheal intubation is preferred to prevent maternal aspiration if a clinician with advanced airway management skills is present [8].

Hypotension/hypoperfusion is a non-specific variable that may denote hemorrhagic, septic, cardiac or other form of shock. The recognition of shock should mandate immediate escalation of care to avert impending cardiac arrest. Cases of MCA in this cohort reveal a predominance (76.4%) of non-shockable first documented pulseless rhythms: pulseless electrical activity (50.8%) and asystole (25.6%). Although “etiology” of MCA was not captured in this dataset, these cardiac rhythms coincide with reversible causes of cardiac arrest such as hypovolemia (hemorrhage), hypoxemia, acidosis, hypo/hyperkalemia, hypothermia, toxins (magnesium sulfate, opioids), thrombosis (pulmonary or coronary), tamponade and tension pneumothorax discussed in the first Scientific statement of Maternal Cardiac arrest from

the American Heart Association (AHA) [7]. Early activation of a massive transfusion protocol has emerged since the new millennium as a salient component in the management algorithms of obstetrical hemorrhage [9]. Additionally, the reversibility of these etiologies may also explain the similar outcome survival rate observed in this cohort among patients with shockable versus non-shockable rhythms. While this observation may be artifactual due to the small number of patients with a shockable rhythm, it may underscore some of the resuscitation nuances unique to the obstetrical population that require further investigation.

While most cases of MCA were witnessed (93.7%), a hospital-wide response for resuscitation was only activated for 77% of the women sustaining MCA. Events that occur in the operating room or emergency ward may be managed by the team that is caring for the patient without triggering a hospital-wide response. Our data did not enable us to determine the rationale for those cases that did not trigger emergency activation. Our data does demonstrate that MCA can occur anywhere in the hospital including areas where patient emergency care may be challenging to provide underscoring the importance of institutional preparedness. The AHA [7] recommends that each institution should activate emergency care for MCA using a phrase that summons a multidisciplinary resuscitation team such as “maternal code blue” to ensure that all the necessary team members are alerted and respond to this arrest signal. Data from our cohort appear to support this recommendation.

In this cohort, an AED was only applied in 21.6% of cases. Inexperience with rhythm analysis or knowledge deficits regarding treatment algorithms for cardiac arrest may render the resuscitation process ineffective. Shockable rhythms are unlikely to revert to perfusing rhythms without defibrillation and redundant delivery of electrical currents to the myocardium may exacerbate heart stunning. In some populations, use of an AED may mitigate difficulties in rhythm analysis, although this is not a substitute for thorough training. Additionally, rhythms may change throughout the resuscitation process underscoring the importance to verify rhythm at two- minute intervals [10].

The severity of MCA supersedes any concerns regarding medication exposure used during the resuscitation process. Epinephrine is the vasopressor of choice during resuscitation of MCA, as recommended by AHA [7]. In this cohort, 86.8% of women received epinephrine. In addition, a substantial portion (53.2%) of women in this cohort received sodium bicarbonate, despite recent recommendations against the routine use of this medication [11]. Notably, the guidelines on the use of sodium bicarbonate were altered in 2010. The elevated administration rate of sodium bicarbonate in these patients may reflect that over half of the 17-year data collection period occurred prior to 2010. When used late in resuscitation to correct severe acidemia, sodium bicarbonate may actually exacerbate intracellular acidosis. Furthermore, prolonged no-flow times with severe metabolic acidosis are probably not the reason bicarbonate was administered in these MCAs as most were witnessed, probably by hospital staff members. On the other hand, sodium bicarbonate is indicated as a treatment for certain toxic ingestions. In the case of maternal CPR, concerns about any pharmacologic effect on uteroplacental perfusion and fetal acidemia [12] are secondary to high quality maternal resuscitation, particularly when delivery has been accomplished as part of the resuscitation.

This study has several strengths including the first to report outcomes for maternal cardiac arrest from the GWTG-R dataset, which is recorded as part of a large national but voluntary quality assurance program. The sample size of this MCA cohort is robust. However, our study has limitations. Some of the variables were underpopulated, which may bias data interpretation. This current dataset is not directed towards maternal resuscitation and, although the location of arrest and clinical category are recorded, the data set is missing critical variables to understand the epidemiology of maternal CPR, including mode of delivery, the timing of delivery relative to the arrest, perinatal outcomes and the presence of common antecedent conditions for maternal arrest (e.g., hemorrhage, amniotic fluid embolism, preeclampsia). Additionally, some centers may fail to report cases of MCA leading to ascertainment bias.

Conclusions

Maternal survival to hospital discharge was 41%, lower than rates of survival reported in other data sets focusing on maternal CPR. More research is required in maternal resuscitation science and translational medicine to produce data with sufficient granularity to improve MCA outcomes and understand maternal mortality. These data support the need for a mandatory national database for MCA that will provide the framework to ultimately increase survival and quality of life of our mothers.

Conflict of interest

Two of the authors report the following conflicts of interest:

Carolyn M Zelop, MD, discloses receiving royalties from Uptodate on the topic of maternal cardiac arrest.

Dana P Edelson, MD discloses that she is the Co-Chair of the AHA GWTG-Resuscitation Adult Research Task.

The remainders of the authors do not have any relevant disclosures.

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