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Use of Early Head CT following Out-of-Hospital Cardiopulmonary Arrest

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Abstract

Aim—Neurological emergencies can lead to cardiac arrest, and post-arrest patients can develop life-threatening neurological abnormalities. This study aims to estimate and characterize the use of early head CT, and its potential impact on post-resuscitation management.

Methods—This retrospective study analyzed 213 adults suffered an out-of-hospital cardiac arrest (OHCA) and survived for at least 24 hours. Demographics were collected and arrest-related variables were documented. Timing of HCT was recorded and if abnormalities were found on HCT within 24 hours of resuscitation, any resulting changes in management were recorded. Outcome was measured by cerebral performance category at discharge.

Results—Only 54% of patients who survived OHCA underwent HCT in the first 24 hours after resuscitation. Patients who underwent HCT were healthier and had better pre-arrest functional status and shorter duration of their arrest. Acute abnormalities were found on 38% of HCT and 34% of these abnormal scans resulted in management changes.

Conclusions—Early HCT is not consistently performed after outside hospital cardiac arrest and may be heavily influenced by a patient's premorbid status and arrest-related variables. Early Head CT can demonstrate acute abnormalities that can result in significant changes in patient management.

Introduction

The American Heart Association estimates there were 326,200 number of out-of-hospital cardiac arrests (OHCA) in 2015 with a 10.6% survival rate.¹ Computed tomography of the head (HCT) is not recommended as part of routine post-resuscitation care.² However, 2.3–16% of unselected OHCA cases are caused by neurological emergencies.^{3–5} Furthermore, other clinically significant abnormalities can be found which result in changes in clinical management up to 39% of the time.^{6,7} In this study we aim to characterize the use of early HCT in a large academic center and its impact on post-resuscitation management and prognosis.

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Conflicts of Interest

The authors report no conflicts of interest relevant to the data presented in this paper.

Methods

In this retrospective chart review approved by the Columbia University institutional review board, we identified 241 consecutive adult patients who presented to the New York-Presbyterian Hospital – Columbia Emergency Room (ER) from October 2007 to February 2015 with cardiopulmonary arrest and achieved return of spontaneous circulation (ROSC). Only the 213 patients who survived for at least 24 hours were included in this study to minimize bias from patients who were very unstable or in whom care was withdrawn early. Our hospital is not a trauma center; however, patients in whom head or cervical spine trauma was possible after collapse from OHCA, are routinely seen in our ER and were included. The following variables from the Utstein reporting guidelines⁸ were collected: age, sex, race, initial cardiac rhythm, whether arrest was witnessed or bystander cardiopulmonary resuscitation (CPR) administered, time to ROSC, whether therapeutic hypothermia (TH) was used. Additional data collected included whether early HCT (within the first 48 hours) was done, mean arterial pressure (MAP) in the first 24 hours, initial pH and lactate, survival to hospital discharge, placement of a do-not-resuscitate (DNR) order, withdrawal of life-sustaining therapies, and cerebral performance category (CPC)⁹ prior to cardiopulmonary arrest and at discharge.

If early HCT was obtained, the documented reason was recorded and subsequently categorized. Acute findings on the HCT according to the final attending radiologist report, as well as changes in management resulting from those findings, were recorded including: transfer of patient to the neurocritical care unit (NICU), administration of hyperosmolar therapy, reversal of coagulopathy, neurosurgery consultation, administration of antiepileptic drugs, repeat CT imaging, avoidance of TH, placement of a DNR order, or withdrawal of life-sustaining therapies.

Categorical variables were compared using Fisher's exact and Pearson chi-square tests. As distributions were non-normal, medians were compared using Mann-Whitney U test. A p value <0.05 was considered significant. SPSS (version 23, Chicago, IL) was used for all statistical analyses.

Results

Of 213 patients who survived OHCA, 115 (54%) underwent HCT in the first 24 hours (78% of which were done within the first 6 hours after ROSC) and 12 (6%) underwent HCT between 24 to 48 hours (Figure 1). As shown in Table 1, patients with HCT in the first 24 hours were more likely to be previously healthy with better pre-arrest functional status, and to have had a witnessed arrest and shorter time to ROSC. They had better outcomes on discharge. Early HCT was done because of a concern for trauma or pre-arrest neurological complaints in 31 (27%), because of change in neurological exam in four (3%), by the request of the neurology consultant in three (3%), after cardiac catheterization did not reveal a cause for the arrest in two (2%), and because of severe thrombocytopenia on admission in one patient (1%). In 75 cases (66%) there was no documented reason for HCT. In the first 24 hours, 43 HCTs showed abnormalities (37% of all scans) (Table 2). Findings on 15 HCTs (35% of abnormal scans) resulted in changes in management: ten patients were triaged to go

to the NICU, seven received hyperosmolar therapy, one underwent reversal of a coagulopathy, eight received neurosurgical consults, one went to the operating room for neurosurgery, seven received prophylactic antiepileptic therapy, and eight underwent repeat HCT. HCT findings were directly responsible for stopping TH on two patients, placing DNR orders on two patients, and withdrawal of care in one patient.

Within the second 24 hours, eight HCTs showed abnormalities (67% of HCTs done within that timeframe) (Table 2) and five HCTs resulted in changes in management. Four were requested by neurology consultation due to exam changes. Two patients with global cerebral oedema received hypertonic solutions. Two patients had DNR orders placed, one had care withdrawn and in one patient finding a subarachnoid haemorrhage resulted in halting of further genetic workup for presumed primary cardiac cause of the arrest.

Only one of twenty patients in whom HCT changed management survived; HCT showed global cerebral oedema at 48 hours post-arrest and cooling was resumed. He survived in a persistent vegetative state.

Discussion

In this retrospective study we show that 38% of early HCTs done show abnormalities, and that many of these abnormalities lead to changes in management, consistent with prior studies.^{6,7} Those patients in our cohort who had early HCTs had shorter ROSC and were previously healthy with better pre-arrest functional status.

Even within a large academic center, only 54% of patients who survived cardiac arrest had HCT done in the first 24 hours. HCT is not part of our institution's protocol for post-OHCA care, and is not recommended as routine post-resuscitation care,² despite primary neurological processes being the aetiology of cardiac arrest in 15–20%.⁴ Notably, no patient who was identified as having a subarachnoid, intraparenchymal, or intraventricular haemorrhage survived hospitalization, though this observation may be confounded by high rates of withdrawal of care.

This study has many limitations. Our study spans almost eight years, during which time policies in our hospital changed regarding use of TH and therefore affecting the involvement of neurologists in post-resuscitation care. Our study population was highly selected because of the initial decision by the treating physician to obtain HCT and by our decision to exclude patients who did not survive for 24 hours. Additionally, the retrospective nature of the study made it difficult to assess the reasoning behind ordering a majority of HCTs. This makes it difficult to determine the inherent bias involved in decision-making regarding whether to perform a HCT. We did not find significant differences in presence of shock at admission, initial lactate, or initial pH, suggesting that instability of the patient was not a major factor. However, we found that patients with good cerebral function pre-arrest were more likely to get HCTs which may indicate an earlier consideration for non-cardiac causes of an arrest in an otherwise healthy patient. Additionally, patients with shorter time to ROSC and witnessed arrest were more likely to get HCTs, which, in conjunction with better premorbid cerebral

function, may reflect a more aggressive approach by physicians early on in the course of post-resuscitation care for patients perceived as having the potential for better outcome.

Conclusions

Early HCT often demonstrated acute abnormalities in our cohort and resulted in significant changes in patient management, but decision-making regarding when to get HCT may be heavily influenced by a patient's premorbid status. A prospective trial in which every post-arrest patient has a HCT is necessary to accurately evaluate the utility of obtaining HCT on treatment and functional outcome.

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Figure 1. Imaging of patients after resuscitation

Flow chart demonstrating numbers of patients in whom head CT was obtained, numbers of acute abnormalities, and occasions when management was changed.

Abbreviations: OHCA: out-of-hospital cardiac arrest; ROSC: return of spontaneous circulation; HCT: head computed tomography

Table 1

Characteristics of patients with and without head CT in first 24 hours

Baseline Characteristics	Early head CT (within 24hrs of ROSC) n=115	No early head CT n=98	p value, if significant
Age, median (IQR)	64 (54, 77)	73 (59, 79)	NS
Female (%)	58 (50%)	57 (58%)	NS
Race			NS
White – Non-Hispanic	36 (31%)	25 (26%)	
Black – Non-Hispanic	35 (31%)	30 (30%)	
Hispanic	42 (36%)	40 (41%)	
Asian	0 (0%)	2 (2%)	
Unknown	2 (2%)	1 (1%)	
Previously healthy	18 (16%)	5 (5%)	0.02
CPC pre-arrest			0.01
1	71 (62%)	40 (41%)	
2	17 (15%)	26 (27%)	
3	26 (22%)	30 (31%)	
4	1 (1%)	2 (2%)	
Witnessed arrest	87 (76%)	61 (62%)	0.04
Bystander CPR	54 (47%)	44 (45%)	NS
Initial arrest rhythm			NS
VF or VT	26 (23%)	16 (16%)	
PEA	49 (43%)	44 (45%)	
Asystole	37 (32%)	37 (38%)	
Unknown	3 (2%)	1 (1%)	
Time to ROSC (min), median (IQR)	20 (15, 30)	27 (17, 40)	0.01
Initial lactate, median (IQR)	5.8 (3.0, 10.3)	7.0 (2.5, 10.9)	NS
Initial pH, median (IQR)	7.2 (7.1, 7.3)	7.2 (7.1, 7.3)	NS
Therapeutic hypothermia completed	97 (84%)	78 (80%)	NS
Shock at admission	37 (32%)	31 (32%)	NS
Care capped	47 (41%)	53 (55%)	NS
Life support withdrawn	39 (33%)	44 (45%)	NS
CPC at discharge			0.005
1	11 (10%)	1 (1%)	

Baseline Characteristics	Early head CT (within 24hrs of ROSC) n=115	No early head CT n=98	p value, if significant
2	10 (9%)	4 (4%)	
3	8 (7%)	5 (5%)	
4	14 (12%)	6 (6%)	
5	72 (63%)	82 (84%)	

Abbreviations: IQR: interquartile range; NS: Not Significant

Table 2

Abnormalities seen on early head CT

CT abnormality	Within first 24 hours (n=115)	Within 24–48 hours (n=12)	Total within first 48 hours (n=127)	Poor outcome among survivors (%)	Overall mortality rate [% of total deaths after withdrawal of care]
Diffuse loss of gray-white differentiation	14 (12.2%)	0	14 (11.0%)	14%	86% [33%]
Global cerebral oedema *	7 (6.1%)	5 (41.7%)	12 (9.4%)	8%	92% [36%]
Hypodensities in the basal ganglia	8 (7.0%)	4 (33.3%)	12 (9.4%)	17%	83% [50%]
Focal or mild loss of gray-white differentiation	7 (6.1%)	3 (25.0%)	10 (7.9%)	0%	70% [14%]
Hypodensities in the thalami	6 (5.2%)	3 (25.0%)	9 (7.0%)	11%	89% [50%]
Ischemic stroke	7 (6.1%)	1 (8.3%)	8 (6.3%)	12%	88% [71%]
Subarachnoid haemorrhage *	4 (3.4%)	1 (8.3%)	5 (3.9%)	0%	100% [20%]
Intraparenchymal haemorrhage *	4 (3.5%)	0	4 (3.1%)	0%	100% [50%]
Intraventricular haemorrhage *	3 (2.6%)	1 (8.3%)	4 (3.1%)	0%	100% [50%]
Early cerebral oedema	3 (2.6%)	0	3 (2.4%)	0%	67% [50%]
Subdural haemorrhage *	2 (1.7%)	0	2 (1.6%)	0%	100% [50%]
Hypodensities in the cerebellum	1 (0.9%)	1 (8.3%)	2 (1.6%)	50%	50% [100%]
Questionable blood	2 (1.7%)	0	2 (1.6%)	50%	50% [0%]
Questionable dense vessel	2 (1.7%)	0	2 (1.6%)	0%	50% [0%]
Contusion	1 (0.9%)	0	1 (0.8%)	0%	100% [0%]
Midline shift *	1 (0.9%)	0	1 (0.8%)	0%	100% [0%]
Mass with vasogenic oedema *	1 (0.9%)	0	1 (0.8%)	0%	100% [0%]

Imaging findings followed by * denote findings that prompted a change in management.

Poor outcome among survivors is defined as Cerebral Performance Category of 3–4.