RESEARCH ARTICLE

Correlation of prognosis and cost-effectiveness of computed tomography for out-of-hospital cardiac arrest patients with return of spontaneous circulation in the Emergency Department

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Abstract

Objective: To assess the prevalence of computed tomography application in out-of-hospital cardiac arrest cases during emergency department processes, its contribution to changes in patient management, and effects on hospital discharge, and its cost-effectiveness.

Method: The retrospective study was conducted at the Izmir Bakircay University Cigli Training and Research Hospital, Izmir, Turkey, and comprised data of adult out-of-hospital cardiac arrest patients who were brought to the emergency department and survived for at least 24 hours between June 21, 2016, and December 31, 2018. Demographic variables and computed tomography results were collected and analysed. Abnormalities found in computed tomography results that could have changed patient management, discharge results, and the cost of the computed tomography were recorded.

Results: Of the 109 patients, 65(59.6%) were men with a mean age of 62.1±14.2 years (range: 28-95 years), and the mean age of the 44(40.3%) female patients was 69.2±15.8 years (range: 18-96 years). Overall, 74(67.9%) patients underwent computed tomography in the emergency department after resuscitation. Acute abnormalities were found in 4(3.6%) scans, and 3(2.7%) abnormal scans resulted in management changes.

Conclusion: Computed tomography of out-of-hospital cardiac arrest patients in the emergency department should not be a matter of routine, and the scan, if necessary, should be done post-admission.

Keywords: Out-of-hospital cardiac arrest, Return of spontaneous circulation, Computed tomography, Emergency medicine. (JPMA 72: 1507; 2022)

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Introduction

Cardiac arrest, whether stemming from cardiac origins or not, is caused by sudden loss of cardiac function. Cardiopulmonary resuscitation (CPR) often may not avoid death if performed ineffectively or insufficiently.[1] Cardiac-originated cardiac arrests are responsible for two-thirds of out-of-hospital deaths and one-third of in-hospital deaths. This is supported by the delays in return of spontaneous circulation (ROSC) outside of the hospital.[2] Out-of-hospital cardiac arrest (OHCA) constitutes about 10% of the total mortality rate in the developing countries.[3] Despite the improvements, the survival rate after OHCA is reported to be 6.4% on average, ranging from 0.2% to 23%.[1,3,4] While the most common cause of non-traumatic cardiac arrest is coronary artery disease (CAD), hypoxia, hypovolaemia, metabolic disorders, hypothermia, thromboembolism, pericardial tamponade, toxic causes, and tension pneumothorax may also cause cardiac arrest.[3]

New patient care recommendations after cardiac arrest offer a useful, evidence-based approach to the management of this patient group.[5] The indications and timing of computed tomography (CT) were specified in a guideline in 2015. It is recommended that coronary angiography be performed in advance if there is a potential presence of cardiac aetiology, and in the absence of lesions, a CT scan of the brain and thorax should be carried out.[6] Kurkciyan et al. identified subarachnoid haemorrhage (SAH) in only 4% of 765 patients,[3] and it was argued that this rate did not justify routine CT scanning in all such patients.[3,7] CT scanning was reported to be appropriate when supported only by clinical findings.[7,8] With the advancements of technological developments, the use of imaging methods in post-arrest cases increases daily due to easier access to CT and physicians' concerns regarding case-skipping.[8-10]

The current study was planned to assess the prevalence of CT use during ED processes after OHCA, its contribution to changes in patient management decisions, its effects on hospital discharge, and its cost-effectiveness.

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Materials and Methods

The retrospective study was conducted at the Izmir Bakircay University Cigli Training and Research Hospital, Izmir, Turkey, and comprised data of adult OHCA patients who were brought to the ED between June 21, 2016, and December 31, 2018. Data was retrieved after approval from the ethics review board of the University of Health Sciences, Izmir Bozyaka Education and Research Hospital. Those included were adult patients of either gender who had been brought to ED after OHCA, underwent CPR, and survived for at least 24 hours post-ROSC. The study hospital became functional on June 12, 2016, and all patients within 2.5 years meeting the study criteria were included. In order to avoid any bias, only patients who survived for at least 24 hours were included.[7] Patient files were scanned via the hospital data processing system. Electronic records were reviewed to filter out patients who had a whole-body CT as their first clinical evaluation post-CPR. Patients with unstable or premature interruption of care, trauma patients, or with other CT indications were excluded.

The variables recorded included age, gender, pre-arrest heart rhythm, presence of witnessed arrest, time of ROSC, initial potential of hydrogen (pH), lactate (mmol/L), blood glucose levels (mg/dL), and the presence of acute blood loss, which was determined by comparison of haemoglobin (Hb) (gr/dL), haematocrit (%), mean corpuscular volüme (MCV) (µm3) and previous Hb values, if available. Some data could not be obtained correctly as the duration of CPR performed by the Emergency Medical Services, which is the national ambulance network accessed via 112, was not registered in the hospital's data processing system. As such, only the time spent within the hospital was recorded for ROSC duration.

During the ED process, results of CT brain, thorax and abdomen obtained post-CPR during the acute stage were categorised as no findings, acute findings and chronic findings, and CT costs were recorded. Changes in treatment management resulting from acute CT findings, duration of hospital stay (hours), and patient outcome (discharge, referral, death) were determined.

IBM SPSS (Version 1.0.0.1347) was used for all statistical analyses. Patient demographics were reported as mean ± standard deviation (SD) for continuous variables and frequencies and percentages for categorical variables. Continuous variables were displayed as mean ± SD and were analysed using student t test, while categorical variables were analysed using the chi-square test or Fisher's exact test, as appropriate. $P<0.05$ was considered statistically significant.

Results

Of the 3203 patients who underwent CPR in ED, 109(3.4%) were included (Figure); 65(59.6%) men with a mean age of 62.1±14.2 years (range: 28-95 years), and 44(40.3%) women with a mean age of 69.2±15.8 years (range: 18-96 years).

There were only seven patients (6.4%) who were as without any witnesses among the 109 study patients. Dyspnoea and asystole were the most frequent symptoms after ROSC (Table-1).

Median ROSC duration was 10 minute (range: 2-55 minutes) and the mean value was 14.81±10.36 minutes, median length of hospital stay was 260.76 hours (range: 24-1950 hours), median pH was 7.13 (range: 6.07-7.59), and median lactate level was 9.21 (range: 0.60-25). There was no significant relationship of CT results with lactate

Table-1: Relationships between arrest rhythms that were identifiable and the initial treatments performed after return of spontaneous circulation (ROSC).

Cardiac arrest rhythm		Coronary angiography	Medical	*Other	Total
§ VF-Pulseless VT	N	17	13	2	32
	%	47.2	19.1	40.0	29.4
Asystole	N	6	30	2	38
	%	16.7	44.1	40.0	34.9
Pulseless electrical activity	N	0	13	0	13
	%	0.0	19.1	0.0	11.9
ST elevation	N	12	2	1	15
	%	33.3	2.9	20.0	13.8
Unclear	N	1	10	0	11
	%	2.8	14.7	0.0	10.1
Total	N	36	68	5	109
	%	100.0	100.0	100.0	100.0
Patient's complaints					
β LOC	N	11	16	4	31
	%	33.3	24.6	100.0	30.4
Chest pain	N	12	9	0	21
	%	36.4	13.8	0.0	20.6
Dyspnoea	N	5	32	0	37
	%	15.2	49.2	0.0	36.3
Fainting	N	5	8	0	13
	%	15.2	12.3	0.0	12.7
Total	N	33	65	4*	102
	%	100.0	100.0	100.0	100.0
CT					
CT performed	N	11	59	4	74
	%	14.9	79.7	5.4	100.0
No CT performed	N	25	9	1**	35
	%	71.4	25.7	2.9	100.0

§VF-Pulseless VT: Ventricular fibrillation-Pulseless ventricular tachycardia.
βLOC: Loss of consciousness.
• Others: 1 case of haemodialysis, 1 case of pacemaker, 3 cases of surgery.
** Patient with pacemaker.

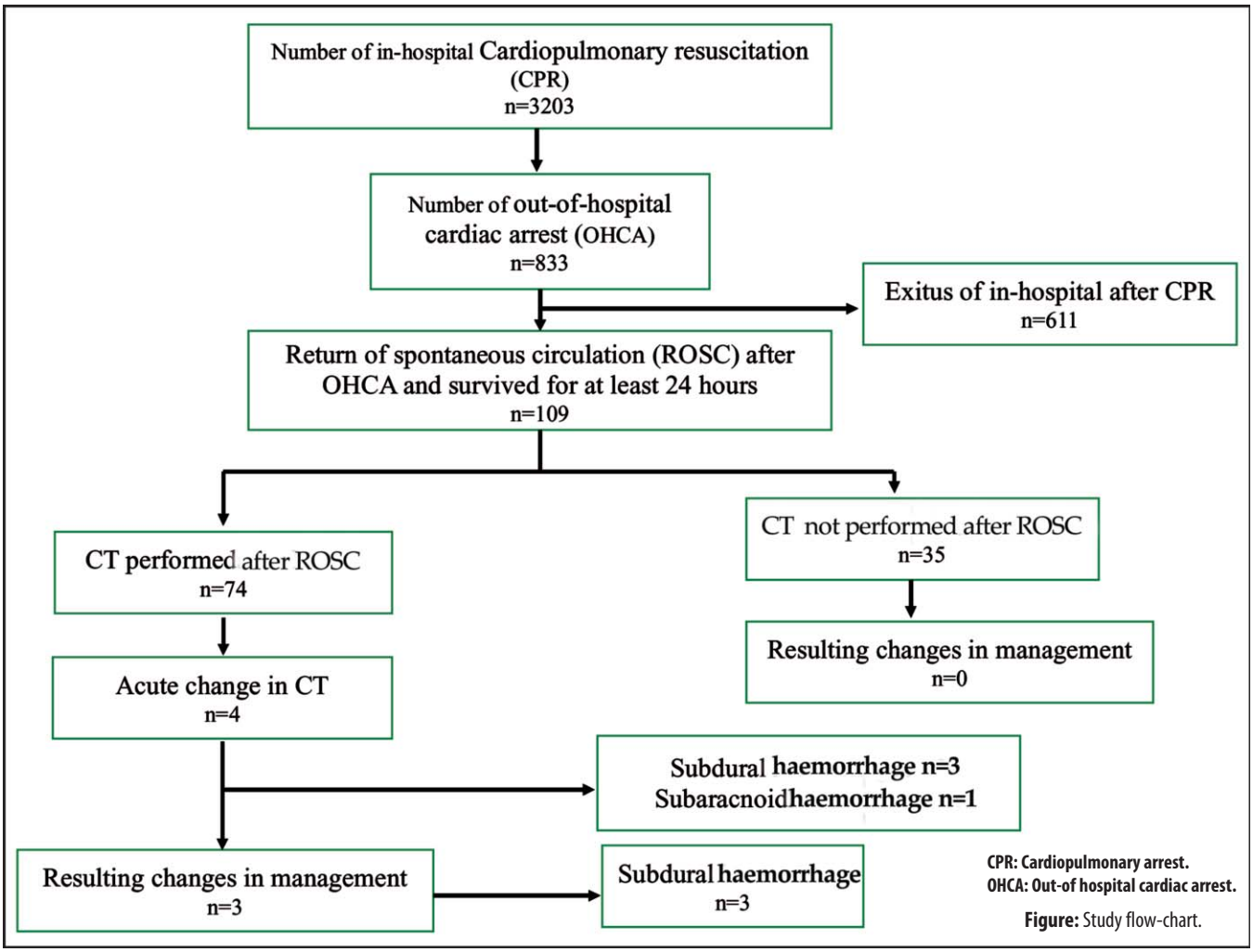

Figure: Study flow-chart.

(p=0.998) and pH levels (p=0.733). No acute blood loss was detected in any of the patients. Of the 109 patients, 74(67.9%) had CT scans done within the ED, while 35(32.1%) were not subjected to CT. In terms of CT type, it was cranial in 9(8.3%) cases, cranial and thorax 22(20.2%), thorax 4(3.7%), cranial and thoracoabdominal 12(11%), cranial and thorax angiography 6(5.5%), cranial and thoracoabdominal angiography 18(16.5%) and other types 3(2.8%). It was also found that the numbers of CT scans increased gradually over the years 17(23%) in 2016, 26(35.1%) in 2017, and 31(41.9%) in 2018. Among the CT patients, 11(10%) also had coronary angiography, while 25(23%) of those who did not have CT underwent coronary angiography. Among the patients who did not have a CT scan 1(0.9%) had a pacemaker installed. Thorax or thorax angiography was performed in 9(8.2%) patients who underwent CT but did not undergo coronary angiography. Aortic dilatation which did not require intervention was detected in 1(0.9%) case.

CT results showed acute change in 4(3.6%) patients. Of them, 3(2.7%) patients underwent surgical treatment with subdural haemorrhage and 1(0.9%) underwent medical treatment with the diagnosis of subarachnoid haemorrhage. All the patients who underwent surgery died during hospitalisation (Table-2).

None of the patients who did not receive a CT scan had a delay in treatment or change in treatment due to the absence of CT in ED during their stay. No significant difference was found between patients who had CT while in ED or those who did not (p=0.550). Of the patients without CT, 20(18.3%) died; 1(0.9%) had pneumonia, 3(3.7%) had chronic obstructive pulmonary disease (COPD), 10(9.2%) had CAD, and 6(5.5%) died due to other medical reasons. Among the rest, 1(0.9%) patient was referred to another hospital, and 14(12.8%) were discharged with CAD diagnosis. Among those who underwent CT, it led to a change in treatment management for 3 (2.7%) patients. The average cost of CT scans performed on patients was found to be 24.6 dollars (0-82.1 dollars). This price was calculated based on the

Table-2: Characteristics of patients who had changes in their treatment management as a result of computed tomography (CT) performed in the emergency department.

	Patients		
Gender	Male	Male	Male
Age	79	86	63
Arrest rhythm	Asystole	Asystole	Asystole
Fitness	Present	Present	Present
Complaint	LOC*	LOC	LOC
CT type	Different combinations	Cranial-thorax	Different combinations
pH / Lactate	7.06 / 9.00	7.59 / 1.90	7.34 / 3.70
ROSC time** (minutes)	5	10	10
Length of stay in hospital (hours)	81	410	100
Outcome	Exitus	Exitus	Exitus

*LOC: Loss of consciousness.
** ROSC: Return of spontaneous circulation.

2016-2018 exchange rate at the time of the study. These calculations are government-supported payments of patients with insurance. Since the hospital where the study was conducted is a state hospital, only the state-supported price was taken as a basis.

Discussion

Cardiac arrest has become an important public health problem and it is estimated that it causes approximately 15-20% of all deaths.[10] The most common cause of OHCA is CAD. Despite some important improvements in post-CPR care in OHCA cases, overall survival (OS) rates remain low at about 10%.[10] The majority of patients in the current study were male, and most of them required more time to obtain ROSC than women (15 minutes versus 10 minutes). Other studies have shown similar results.[10] As the availability of focussed CT increases, it is widely used in patients with ROSC after non-traumatic cardiac arrest in order to investigate suspected causes of arrest. In a study performed by Reynolds et al., 115 of 213 post-CPR patients who had OHCA and who survived at least 24 hours had cranial CT within 24 hours, and it was determined that 20 patients had pathologies. The CT findings led to a change in treatment management in only 15 patients, and surgery was performed in one case. Considering this limited clinical significance of change in treatment management, the study suggested that routine CT scans are not necessary if there is not a precursor pre-arrest.[7] In a single-centre retrospective study in Germany, researchers evaluated the efficacy of whole-body CT in 100 patients with non-traumatic cardiac arrest after ROSC. They identified that most of the cases were associated with CPR-related injuries (93%).[10] Although the study yielded many findings with whole-body CT, very few of them had acute clinical effects. As Westafer remarked, even though the authors recommended whole-body CT scanning at the end of that study, their findings did not support these views.[11] In the end, some of the findings obtained were already expected results, like brain oedema, or were also available on X-ray, like pneumothorax and ileus. Some findings consisted of post-CPR injuries.[8] In our study, similar to the findings in the study of Viniol et al., acute changes were not recorded.[10] The current study recorded the findings among CT results that could lead to death and could change the treatment management. Only three cases (subdural haemorrhage) with clinical effects and treatment changes were identified in the current study. We believe that the small number of cases contributed to this result. Despite the presence of injury and pathology at the end of the study, it is not clear how acute CT scan post-ROSC would change the clinical management or patient outcomes.[11] Although it has been shown that whole-body tomography gives faster results in detecting life-threatening pathologies in trauma patients when compared with plain X-ray, ultrasound, and focussed CT, it must be remembered that non-traumatic patients have different causative factors than trauma patients and the underlying cause in the majority of cases is cardiac pathologies.[10] The American Heart Association (AHA) and European Resuscitation Council (ERC) guidelines recommend focussed CT (often brain CT) scans in OHCA cases, but only after invasive coronary angiographic evaluation, if there is a suspicion of high risk.[12,13] The ERC does not routinely recommend whole-body tomography in non-traumatic post-CPR patients.[13] CT can be planned before or after coronary angiography according to the condition that caused the patient's cardiac arrest and the conditions indicating respiratory or neurological aetiology in the data obtained from the patient.[13] However, whole-body CT scan is now increasingly performed for post-CPR patients.[8-10] In the current study, although not all patients underwent whole-body CT, a considerable number of CT scans were performed (114 CT scans for 74 patients). In the literature, although these were reviews for trauma patients, in four of the nine studies evaluated, treatment changes were described in 2-27% of the patients with whole-body CT.[14]

The treatment continuity of ROSC patients in the intensive care unit (ICU) as quickly as possible and scanning of the patient with focussed or whole-body CT scans are seen as more significant since most CT scans performed in ED do not change the treatment approach. Emergency services are dynamic areas. The attempt to identify pathologies in these areas, most of which are iatrogenic or do not cause significant changes in clinical and management terms, would cause inequality in manpower distribution in ED and for other new patients.

It would be more meaningful to shift the advanced examinations and treatments to ICUs where the patients will be placed. However, further studies involving more patients are needed in this regard.

To determine the cost of CT scans, the margin was based on the reimbursement made by the state to the public-sector hospital, from the general health insurance system. Private hospitals and CT costs of patients without health insurance were not taken into consideration. Therefore, the cost appears to be relatively low. In literature, CT seems to be a more cost-effective method for multi-trauma patients when compared to other bedside evaluations, like peritoneal lavage, abdomen ultrasonography urography, and, if indicated, CT and/or aortography or transoesophageal echocardiography.[15] However, since there is no randomised study regarding non-traumatic ROSC patients, it is not possible to evaluate the cost. In literature, post-CPR CT, especially cranial scans, are not intended to reveal pathologies that may lead to a possible change in the treatment management of patients in the acute stage.[4,5,16] In one study, although it was associated with neurological outcome, early brain CT scan was supported since it may be useful for possible intracerebral haemorrhage or for the exclusion of ischemic pathologies.[2]

Similar to the current findings, a study conducted from 2007 to 2015 comprised OHCA patients who survived for at least 24 hours after ROSC and reported that, according to the brain CT results obtained within the first 24 hours, 20(9.3%) of 213 patients had pathological changes that led to a change in treatment; 7 ischaemic stroke patients, 13 neurosurgical consults, and 1 neurosurgery patient. Only one patient underwent surgery and, as a result, only 1 patient survived in a permanent vegetative state.[7] The authors indicated that even though brain CT abnormalities were observed in the early stage, there was still a need for prospective studies with across-the-board brain CT in order to demonstrate the usefulness of early brain CT. Naples et al. determined an abnormality in cranial CT in 79% of post-CPR ROSC patients.[17] These changes included acute changes, such as brain oedema, 11 new infarcts, 11 intracerebral haemorrhages, and 5 masses, as well as chronic changes, such as atrophy and prior infarct. However, no patient survived in the end.[17] In the current study, even though not all patients received CT, pathology leading to treatment changes was encountered in 2.7% cases. However, although abnormalities were observed in CT examinations, early CT examination did not definitely improve patient care. The limited clinical significance of CT results and consequent management changes do not create compelling evidence to expand the use of CT scans. It is said that brain CT should be performed for patients who are sufficiently stable for scanning, for patients with pre-arrest symptoms, and for patients with arrest as a result of neurological examination.[7] The main objective of the current study was to clarify that in an unstable process, routine CT scans may not provide benefits for most of the patients in ED. The literature also supports the current findings in this regard.[7,12]

The current study has limitations that must be considered when interpreting the results. The most important constraint was the small and single-centre sample. Besides, the sample size was not calculated. More accurate results can be obtained in studies with larger and multi-centre samples. Also, in view of the basic focus of the study, only acute findings and those that caused treatment changes were discussed. Changes, such as brain oedema, atrophic conditions, lung parenchymal changes and old fractures were not included. Another constraint was the fact that not all patients received CT, and the CT images were not re-examined.

Conclusion

Decisions made as a result of having both brain and other CT scans during ED processes did not provide enough evidence in favour of CT scans during ED stay.

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Conflict of Interest: None.

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