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Assessment of Acute Cardiac Function via Post-Resuscitation Triple-Rule-Out Computed Tomography

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Abstract

Background: In patients with return of spontaneous circulation (ROSC) after resuscitation, the current gold standard for assessing acute cardiac function is cardiac echocardiography. However, its use may be limited in acute critically ill patients by delays, interobserver discrepancies or the varying priorities of radiographic examinations. We now report that standardised acute cardiac function in these patients can be assessed with triple rule out thoracic (TRO) computed tomography.

Methods and Patients: We retrospectively analysed cardiac function in all patients with ROSC after resuscitation and who underwent acute computed tomography between 01/2013 and 01/2015 with a new post processing software client after TRO- computed tomography angiography (n=15). The syngo-CT-cardiac-function-client (syngo.via VA 20, Siemens, Erlangen, Germany) was used to measure ejection fraction, myocardial mass, stroke volume, end systolic and end-diastolic volumes, as well as coronary morphology. Multivariate regression modelling and ROC analysis were used to control the independent associations between these parameters.

Results: ROC curve analysis showed that right cardiac end systolic volume and left cardiac end systolic volume were associated with ROSC (AUC: 0.74 and AUC: 0.74, respectively). In these patients, we defined thresholds for right cardiac end systolic volume of 119 ml and for left cardiac end systolic volume of 48 ml.

Conclusions: In combination with TRO computed tomography, the syngo-CT-cardiac-function-client provides a valuable, standardised tool to assess acute cardiac function in patients with ROSC after resuscitation.

Key words:

Cardiac function; CT; ROSC

Introduction

Thrombembolic events due to coronary heart disease are one of the major causes of mortality [1,2]. Because of suspected coronary heart disease, dyspnoea or chest pain are commonly considered to require urgent emergency care [3]. The diagnostic route is initially supplemented with non-invasive cardiac imaging, despite the lack of evidence for outcome benefits and the low diagnostic yield [4].

Modern coronary computed tomography angiography (CCTA) is the first approach to a relatively new diagnostic modality, for evaluating patients with chest pain and the presence or absence of coronary heart disease [5-10]. Registry data have shown that this method can select patients for cardiac catheterisation and coronary revascularisation [11,12]. In low risk patients with chest pain admitted to an emergency department, randomised trials have demonstrated that CCTA is more time efficient and less expensive than standard triage protocols, which usually involve stress testing with electrocardiography (ECG), echocardiography, or direct cardiac catheterisation [13-16].

Echocardiography is currently one of the major standard non-invasive diagnostic tools for cardiac abnormalities in acute settings. However, echocardiography depends on the examiner and his experience, especially in acute settings. This is currently a controversial issue [17-19].

Patients with return of spontaneous circulation (ROSC) after resuscitation receive computed thoracic tomography to differentiate cardiac from pulmonary abnormalities. Echocardiography is therefore limited by the time available or the setting. Acute standardised non-invasive cardiac computed tomography cannot yet be used routinely to measure parameters such as ejection fraction, end systolic or end diastolic left and right cardiac volumes. The new syngo-CT-cardiac-function-client measures cardiac functional parameters aside from pulmonary, thoracic, vascular or coronary abnormalities (therefore referred as triple rule out or TRO) but has not been tested yet.

We now report the first measurements of cardiac parameters with this client in patients with different cardiac and pulmonary abnormalities, using this thoracic triple rule out computed tomography.

Materials, Methods and Patients

Between the 1 January 2013 and 1 January 2014, 135 patients underwent acute thoracic computed tomography for the exclusion or diagnosis of pulmonary embolism, thoracic aneurysm or other thoracic abnormalities or traumas at the ER of the Inselspital, University Hospital Bern. The patients in this group with return of spontaneous circulation after resuscitation (n=15) were included into our study cohort and retrospectively analyzed. Data were analyzed anonymously. For ethical and legal reasons and in accordance with the guidelines provided by the ethical committee of Bern, data are available upon request from the authors. The study protocol was approved by the Ethics Committee of the Canton of Bern, Switzerland.

Methodology

All patient were scanned with the same retrospectively ECG-triggered CT-protocol using a 128-slice CT-scanner (Somatom Edge, Siemens, Erlangen Germany) after iv administration of 100 mL of non-ionic contrast media (400mg/mL) and 20 mL of saline. Cardiac function was assessed automatically with the syngo-CT-cardiac-function-client (syngo.via VA 20, Siemens, Erlangen, Germany) (To get an impression of interface of the syngo-CT-cardiac-function-client see the screenshot of the analysis; table 1). The client segmented right and left ventricles and calculated the following parameters: ejection fraction (EF), myocardial mass (MM), stroke volume (SV) and ends systolic (ESV), and end diastolic volumes (EDV).

Standard Values		Indexed Values		
Blood Vol. Mode		**LV**	**RV**	**Normal Values**
Ejection Fraction	(%)	35	20	47-74
Myocardial Mass ED	(g)	128.69	-	30-70
Stroke Volume	(ml)	42.15	45.96	52-138
ED Volume	(ml)	119.94	226.6	88-227
ES Volume	(ml)	77.79	180.64	23-103
myocardial Mass ED	(ml)	100.94	197.68	

Table 1: Analysis of cardiac parameters in acute triple rule out computed tomography.

Statistical analysis

Data are presented as medians and standard deviation (SD). Cox regression analysis was used to explore the association of the various predictors with the presence of electrolyte disorders and with hospitalization. Predefined covariates were added to the logistic regression models. Cox regression was used to test associations of the diuretics with the survival time adjusted for predefined covariates. The Hosmer-Lemeshow test was used to assess goodness of model fit.

A two-sided p value of <0.05 was considered statistically significant for all analyses. The statistical analysis was performed using SPSS (SPSS for Windows V.17.0, Chicago, IL, USA).

Results

Baseline characteristics are shown in table 2. Our study included 11 male and 4 female patients.

Parameter	Median (± SD)
Age (years)	71 ± 21
eGFR (MDRD) (ml/min/1,73m2)	51 ± 24
CRP (mg/dl)	7.5 ± 49
Troponin T	0.056 ± 0.30
CK (mg/ml)	161 ± 235
LDH (mg/dl)	770 ± 627
Heart rate (beats/min)	80 ± 22
Left cardiac ejection fraction (%)	59 ± 18
Left cardiac mass (g)	177 ± 45
Left cardiac stroke volume (ml)	60 ± 44
Left cardiac end diastolic volume (ml)	132 ± 73
Left cardiac end systolic volume (ml)	72 ± 48
Left cardiac output (l/min)	6 ± 3
Right cardiac ejection fraction (%)	36 ± 12
Right cardiac stroke volume (ml)	61 ± 47
Right cardiac end diastolic volume (ml)	231 ± 73
Right cardiac end systolic volume (ml)	148 ± 48
Right cardiac output (l/min)	6 ± 3

Table 2: Baseline characteristics of patients after resuscitation and return of spontaneous circulation (n=15). Medians ± standard deviation.

To detect independent associations between resuscitation and cardiac parameters as assessed with TRO computer tomography, we applied a multivariate Cox regression model (Table 3). We found no associations between independent variables associated with cardiac resuscitation (Table 3).

Parameter	OR (95% CI)	p-value
Troponin T	n.a.	n.a.
Left cardiac ejection fraction	0.96 (0.87; 1.05)	0.38
Left cardiac mass	0.99 (0.98; 1.02)	0.87
Left cardiac stroke volume	0.98 (0.96; 1.01)	0.16
Left cardiac end diastolic volume	1.00 (0.98; 1.03)	0.70
Left cardiac end systolic volume	1.01 (0.97; 1.06)	0.51
Left cardiac output	0.51 (0.95; 0.61)	0.83
Right cardiac ejection fraction	0.97 (0.83; 1.14)	0.74
Right cardiac stroke volume	1.02 (0.98; 1.05)	0.35
Right cardiac end diastolic volume	1.00 (0.99; 1.02)	0.73
Right cardiac end systolic volume	1.02 (0.98; 1.04)	0.26

Right cardiac output	1.02 (0.71; 1.45)	0.93
p<0.05*; data presented as odds ratios (OR) with 95% confidence intervals (95% CI).		

Table 3: Multivariate Cox regression analysis for associations of acute computer tomography cardiac parameters in patients after resuscitation and return of spontaneous circulation.

Discussion

To our knowledge, our study is the first to demonstrate that it is feasible to use cardiac and coronary computed tomography angiography to assess functional cardiac parameters such as ejection fraction, mass and different volumes in patients after resuscitation and ROSC.

Computed tomography scans in patients after resuscitations are now commonly performed to exclude either pulmonary embolism or after trauma [20]. Bedside echocardiography for patients with acute coronary syndrome, pulmonary embolism or aortic dissection is used in the emergency room to assess the correct diagnosis, as well as to identify other complications and to help institute appropriate management strategies swiftly [21-23]. All patients in our cohort are currently given a computed tomography scan, either routinely or as an alternative to invasive imaging [20,21]. Our study therefore demonstrates the potential to accelerate diagnosis and with low interobserver variability.

Many prior studies have shown that there is interobserver variability between cardiologists interpreting left ventricular systolic and diastolic function [17-19,22-24]. Furthermore, echocardiography examinations in an emergency department are not of consistent quality [17-19]. In addition, physicians with different training tend to assume that individuals with their training provide higher quality echocardiographic examinations [17-19,22-24]. The problem of echocardiography is therefore rather based on its interobserver variability than on the different subjects physicians are trained in. Our method therefore provides highly standardized measurements, minimizes interobserver variability to almost zero and is practically simple in acutely symptomatic patients. In addition to clinical assessment alone, this CT protocol may add further objective information about functional cardiac parameters.

The possibly negative effects of contrast application and the feasibility of this CT protocol regarding resources available in the ER setting as well as financial aspects are still unclear at this point. This should be assessed in future research.

Limitations

Our study has some limitations, as it included only patients who were appropriate candidates for cardiac and coronary computed tomography angiography. Moreover, we included only patients who initially had a clinical requirement for non-invasive imaging. The decisions to perform cardiac catheterization, echocardiography or other imaging were made for clinical reasons, without including our method as a first step. Factors other than initial imaging played a role in treatment decisions. The sensitivity and specify findings were set in accordance with numerous other studies. However, since our sample size yet is rather small, larger studies would be necessary to confirm our findings further. The feasibility of the implementation of this CT scanning protocol in different routine ER settings should be assessed in further research.

Conclusion

In summary, our study demonstrates that the combination of cardiac and coronary computed tomography angiography with the assessment of functional cardiac parameters provides an easy and rapid method with low interobserver variability, and leads to a rapid diagnostic process- especially in patients with ROSC after resuscitation.

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