Non-gated cardiac CT angiography for detection of cardio-aortic sources of embolism in the acute phase of ischaemic stroke

LETTER

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INTRODUCTION

Up to one-third of ischaemic strokes are caused by cardioembolism, which can result from atrial fibrillation (AF) or structural abnormalities.[1] Establishing cardioembolic stroke aetiology is essential for secondary prevention, but cardiac thrombi may dissolve <2 hours after intravenous thrombolytic therapy (IVT).[2] CT angiography (CTA) from aortic arch to intracranial vessels is necessary for patient selection for endovascular treatment (EVT) in most centres. We investigated the diagnostic yield and image quality of extending the non-ECG-gated CTA to include the heart for detection of structural cardio-aortic sources of embolism in the acute phase of ischaemic stroke, defined as within the time window for reperfusion therapy (IVT/EVT).

METHODS

We performed a single-centre, retrospective analysis of consecutive patients with acute ischaemic stroke with suspected large vessel occlusion (LVO) eligible for EVT who presented to the emergency department of Maastricht University Medical Center between March 2016 and April 2017. Patients underwent a non-contrast CT of the brain. Subsequently, patients with suspected LVO eligible for EVT underwent CT perfusion of the brain, and non-ECG-gated CTA from the heart to the intracranial arteries in the acute phase, as part of standard care. Patients <4.5 hours of onset of stroke without contraindications received IVT, directly after non-contrast CT and before CTA. Patients <6 hours of stroke onset with a National Institutes of Health Stroke Scale score ≥2 and/or disabling neurological deficit were eligible for EVT if LVO was identified on CTA. Study inclusion criteria were age ≥18 years, diagnosis of acute ischaemic stroke and availability of CTA images from heart to brain. Diagnosis was established by a neurologist, based on clinical evaluation, imaging data and exclusion of other diagnoses.

Patients were scanned non-ECG-gated in caudo-to-cranial direction using a dual-source CT scanner (DSCT) in dual-energy mode: third-generation DSCT Siemens Somatom Force or second-generation DSCT Siemens Somatom Definition Flash. Details of the imaging protocol (including radiation) are provided in online supplementary table I. The CTA contrast media protocols prior to and after incorporation of the heart were identical.

For the purpose of this study, cardiac CTA images were assessed retrospectively by two experienced cardiac radiologists, blinded to clinical data and intracranial images, on a consensus basis.

Image quality was assessed based on extent of motion artefacts and contrast opacification, and graded on a 5-point Likert scale (0=very poor, 1=poor, 2=moderate, 3=good and 4=excellent). Motion artefacts were defined as blurring of the vessel contours and graded on a 3-point scale (0=few, 1=some, 2=many). Mean attenuation in Hounsfield units (HU) was measured at the aortic root, left atrium and left ventricle. Sufficient contrast opacification was defined as ≥250 HU.[3] Potential high-risk sources of embolism were systematically scored.[1]

Data were summarised using descriptive statistics. Two-sided independent T-test was used for comparison of continuous data, χ^2 test or Fisher's exact test for comparison of proportions, whichever was appropriate.

RESULTS

We included 82 patients. For patient selection, clinical characteristics and image quality, see online supplementary figure I, tables II-III. Image quality was good to moderate in 50/82 (61%) patients, with few motion artefacts in 38/82 (46%). Sufficient contrast opacification in all three regions of interest was reached in 19/82 (23%) patients. The diagnostic yield of non-ECG-gated cardiac CTA in the acute phase of ischaemic stroke for detection of high-risk sources of embolism is presented in table 1. Thirteen high-risk sources were detected in 12/82 (15%) patients (online supplementary figure IIA-L). All high-risk sources were found in patients who were scanned on the third-generation DSCT (12/59 (20%) vs 0/23 (0%) on the second-generation DSCT, p=0.017). Echocardiography was performed in 9/82 (11%) patients.

DISCUSSION

Despite suboptimal image quality, high-risk cardio-aortic sources of embolism were retrospectively detected by experienced cardiac radiologists in 15% of patients who underwent non-ECG-gated CTA of the heart-brain axis in the acute phase of ischaemic stroke. This is the largest study to demonstrate the feasibility

Table 1 Diagnostic yield of non-ECG-gated cardiac CT angiography in patients with acute ischaemic stroke for detection of structural cardio-aortic sources of embolism

	n/N (%)*
Patients with a high-risk source	12/82 (15)
High-risk sources	
Left atrial appendage thrombus†	3/65 (5)
Left atrial thrombus	0/66 (0)
Left ventricular thrombus	0/60 (0)
Prosthetic valve abnormalities	2/74 (3)
Signs of endocarditis	0/30 (0)
Enlarged left ventricle	3/75 (4)
Atrial myxoma	0/65 (0)
Papillary fibroelastoma	0/57 (0)
>4 mm ulcerated, non-calcified aortic arch atherosclerotic plaques	5/78 (6)
Stanford Classification type A acute aortic dissection	0/78 (0)

Structural sources that were considered high-risk were intracardiac thrombi (left atrial appendage/atrium/ventricle), prosthetic valve abnormalities (eg, pannus or thrombus material on valve in patients with mechanical/bioprosthetic valves), signs of infective or non-bacterial thrombotic endocarditis (eg, valvular vegetations), enlarged left ventricle (defined as left ventricle >55 mm[6] and left ventricle diameter/body surface area >36 mm/m^2 for men and >37 mm/m^2 for women[7]), cardiac tumours such as atrial myxoma and papillary fibroelastoma, large (>4 mm) ulcerated, non-calcified (soft or mixed composition) aortic arch atherosclerotic plaques and Stanford Classification type A acute aortic dissection. Intracardiac thrombus was defined as a filling defect that appeared as an oval/round shape, typically with a mean attenuation level <60 Hounsfield units. Slow-flow, or circulatory stasis, was defined as a filling defect that appeared as a triangular shape in the left atrial appendage with homogenous attenuation.

*Categorical variables are given as n/N, where n is the number of patients in which the variable was present and N is the total number of patients in which image quality was sufficient to assess that particular variable.

†3/3 (100%) patients with left atrial appendage thrombi had atrial fibrillation vs 18/79 (23%) patients without left atrial appendage thrombi (p=0.015).

of heart-brain axis CTA in an acute ischaemic stroke setting.

The diagnostic yield in our patients, who were selected based on suspicion of acute LVO, may be higher than in a general ischaemic stroke population. To our knowledge, only two small studies have examined the diagnostic yield of extending non-ECG-gated CTA to include the heart in the acute phase of ischaemic stroke.[4 5] In one study 3/20 (15%) patients had a high-risk source of embolism in the heart/aortic arch, which is in line with our study.[4] In the other study, 5 cardioembolic sources were found in 21 patients (24%) with acute ischaemic stroke/transient ischaemic attack with AF or embolic stroke of undetermined source.[5]

Notably, there was a significant difference in image quality, motion artefacts and diagnostic yield between third-generation and second-generation DSCT in favour of the former. More advanced reconstruction filters and technological improvements including faster CTA acquisition times associated with third-generation DSCT may have contributed to better image quality and higher diagnostic yield. Still, we cannot exclude that differences in diagnostic yield may be due to chance, or patient characteristics, as we did not perform multivariable logistic analyses with adjustments for risk-profiles.

Our study has several limitations, most inherent to the retrospective design. First, dual-source scanners were used in dual-energy mode, resulting in longer CTA acquisition times and more motion artefacts on cardiac CTA images. Second, we cannot conclude if findings impacted patient management at the time. Third, a minority of patients underwent echocardiography, consequently it was not possible to compare diagnostic yield between cardiac CTA and echocardiography. Fourth, no interobserver agreement measurement was performed. Fifth, extending the CTA protocol to include the heart resulted in a slightly higher radiation dose (median +1.74 mSv), with a median total radiation dose for the heart-brain axis CTA of 3.38 mSv.

In conclusion, despite multiple limitations including suboptimal image quality, high-risk structural cardio-aortic sources of embolism as a potential cause of stroke were retrospectively found in a substantial proportion of patients who underwent heart-brain axis CTA in the acute phase of ischaemic stroke. This novel approach is promising, but requires further study. ECG-gating, cardiac contrast injection protocols and patient positioning for cardiac CTA may increase image quality and diagnostic yield. Future prospective studies should also compare the diagnostic yield of acute phase cardiac CTA with echocardiography and monitor the impact of cardiac CTA findings on patient management.

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