

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

Citation for published version (APA):

Guglielmi, V., Planken, R. N., Muhl, C., Niesen, S., Staals, J., Coutinho, J. M., & Postma, A. A. (2020). Non-gated cardiac CT angiography for detection of cardio-aortic sources of embolism in the acute phase of ischaemic stroke. *Journal of Neurology Neurosurgery and Psychiatry*, 91(4), 442-443. <https://doi.org/10.1136/jnnp-2019-321923>

Document status and date:

Published: 01/04/2020

DOI:

[10.1136/jnnp-2019-321923](https://doi.org/10.1136/jnnp-2019-321923)

Document Version:

Publisher's PDF, also known as Version of record

Document license:

Taverne

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.umlib.nl/taverne-license

Take down policy

If you believe that this document breaches copyright please contact us at:

repository@maastrichtuniversity.nl

providing details and we will investigate your claim.

LETTER

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

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 mm⁶ and left ventricle diameter/body surface area >36 mm² for men and >37 mm² for women⁷), 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.

Valeria Guglielmi ,¹ Robrecht Nils Planken,² Casper Mihal,^{3,4} Sandra Niesen,³ Julie Staals,^{4,5} Jonathan M Coutinho,¹ Alida A Postma^{3,6}

¹Neurology, Amsterdam UMC, University of Amsterdam, Amsterdam, The Netherlands

²Radiology and Nuclear Medicine, Amsterdam UMC, University of Amsterdam, Amsterdam, The Netherlands

³Radiology and Nuclear Medicine, Maastricht University Medical Center, Maastricht, The Netherlands

⁴Cardiovascular Research Institute Maastricht, Maastricht University Medical Center, Maastricht, The Netherlands

⁵Neurology, Maastricht University Medical Center, Maastricht, The Netherlands

⁶School for Mental Health & Neuroscience, Maastricht University Medical Center, Maastricht, The Netherlands

Correspondence to Dr Alida A Postma, Department of Radiology and Nuclear Medicine, P. Debye laan 25, 6229 HX, Maastricht, The Netherlands; l.jacobi@mumc.nl

Contributors Study design: VG, RNP, CM, JMC, AAP. Study supervision: AAP. Statistical analysis: VG. Imaging protocol data: SN. Initial draft: VG. Revision of the draft for important intellectual content: all authors. Interpretation of results: all authors.

Funding VG received research grants from the Royal Netherlands Academy of Arts and Sciences (Van Leersum Grant), Foundation De Drie Lichten, Remmert Adriaan Laan Fund and AMC Young Talent Fund.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The institutional review board of Maastricht University Medical Center approved this study.

Provenance and peer review Not commissioned; externally peer reviewed.

© Author(s) (or their employer(s)) 2020. No commercial re-use. See rights and permissions. Published by BMJ.

► Additional material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/jnnp-2019-321923>).



To cite Guglielmi V, Planken RN, Mihal C, *et al.* *J Neurol Neurosurg Psychiatry* 2020;**91**:442–443.

Received 23 August 2019

Revised 10 December 2019

Accepted 24 December 2019

Published Online First 23 January 2020

J Neurol Neurosurg Psychiatry 2020;**91**:442–443.

doi:10.1136/jnnp-2019-321923

ORCID iD

Valeria Guglielmi <http://orcid.org/0000-0002-5531-4766>

REFERENCES

- Adams HP, Bendixen BH, Kappelle LJ, *et al.* Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of ORG 10172 in acute stroke treatment. *Stroke* 1993;24:35–41.
- Ferrari E, Benhamou M, Berthier F, *et al.* Mobile thrombi of the right heart in pulmonary embolism: delayed disappearance after thrombolytic treatment. *Chest* 2005;127:1051–3.
- Scholtz J-E, Ghoshhajra B. Advances in cardiac CT contrast injection and acquisition protocols. *Cardiovasc Diagn Ther* 2017;7:439–51.
- Yeo LLL, Holmin S, Andersson T, *et al.* Nongated cardiac computed tomographic angiograms for detection of embolic sources in acute ischemic stroke. *Stroke* 2017;48:1256–61.
- Popkrov S, Schlegel U, Weber W, *et al.* Cardiac imaging within emergency CT angiography for acute stroke can detect atrial clots. *Front Neurol* 2019;10:349.
- Huckleberry J, Haltom S, Issac T, *et al.* Accuracy of non-ECG-gated computed tomography angiography of the chest in assessment of left-sided cardiac chamber enlargement. *J Thorac Imaging* 2012;27:354–8.
- Lang RM, Badano LP, Mor-Avi V, *et al.* Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of echocardiography and the European association of cardiovascular imaging. *Eur Heart J Cardiovasc Imaging* 2015;16:233–71.