Updates from Industry Satellite Symposium, 16th May 2024, in Basel, Switzerland: 10th European Stroke Organisation Conference (ESOC)

JONATHAN COUTINHO[1], FREDRIK STÅHL[2], JOHAN WASSÉLIUS[3]

[1]Amsterdam University Medical Centers UMC, Netherlands.

[2]Karolinska Institutet and Department of Neuroradiology, Karolinska University Hospital, Sweden.

[3]Skåne University Hospital & Lund University, Sweden.

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Meeting summary

These presentations were sponsored by Siemens Healthineers as part of the 10th European Stroke Organisation Conference (ESOC), in Basel, Switzerland. At the Industry Satellite Symposium on Thursday, 16th May 2024 titled "State of the art imaging helps preventing strokes" Dr Jonathan Coutinho presented 'Mind the Heart - Hyperacute Cardiac CT in Stroke Patients'; Dr Fredrik Ståhl presented on the topic of 'Photon-Counting CT of the Heart - Possible Advantages in Acute Stroke Patients," and Dr Johan Wassélius presented 'Clinical Advantages of NAEOTOM Alpha® and ARTIS icono for Neurovascular Disease.'

KEYWORDS: ACUTE ISCHEMIC STROKE, ARTIS ICONO, CARDIAC IMAGING, COMPUTED TOMOGRAPHY (CT), COMPUTED TOMOGRAPHY ANGIOGRAPHY (CTA), CRYPTOGENIC STROKE, EMBOLIC STROKE OF UNDETERMINED SOURCE (ESUS), IMAGING, NAEOTOM ALPHA®, NEUROVASCULAR DISEASE, PHOTON-COUNTING CT (PCCT), TRANSESOPHAGEAL ECHOCARDIOGRAPHY (TTE), TRANSTHORACIC ECHOCARDIOGRAM (TTE).

Corresponding author: Dr Johan Wassélius – johan.wasselius@gmail.com

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Introduction

Acute ischemic stroke (AIS) is the most common form of stroke and is caused by thrombotic or embolic occlusion of a cerebral artery with sudden loss of blood supply to an area of the brain. The standard treatment is the removal of the occlusion with medication (IV-lysis), mechanically (for large vessel occlusions), or both. Time is of the essence with any treatment for AIS – time to diagnosis, time to treatment, and reducing the risk of long-term complications.

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Fast, accurate, and non-invasive imaging is vital to not only reduce the time to diagnosis and treatment but also to detect the location of thrombi, arteriovenous malformations (AVMs), and aneurysms in patients (at risk of) suffering from a stroke. Accurate imaging allows clinicians to make suitable treatment decisions, determine prognosis, and plan for surgical or endovascular intervention. Improvements in technology have meant it is now possible to gather higher-resolution images of vascular structures, which can in turn improve treatments and outcomes in patients.

Dr Coutinho discussed the importance of cardiac imaging in AIS patients to identify those who have a cardiac thrombus or structural abnormality and presented his work from the "Mind the Heart" trial.

Dr Ståhl provided numerous case studies highlighting the benefits of the advanced imaging technique photon-counting CT (PCCT), particularly of the heart. Dr Wassélius discussed the use of two Siemens Healthineers imaging systems, NAEOTOM Alpha® (Photon Counting CT/CTA) and ARTIS icono (Cone-Beam CT/CTA) to improve diagnostic work in his clinic. These advanced imaging techniques can all be readily incorporated into hospital workflows without significantly impacting on time to diagnosis or treatment helping clinicians to make better treatment decisions and in turn improving patient outcomes.

Mind the Heart - Hyperacute Cardiac CT in Stroke Patients

Jonathan Coutinho, MD, PhD

Previous research discovered approximately 30% of AIS have origins in the heart, either a thrombus or a structural abnormality,[1a-c] with a further 25% of strokes classed as Embolic Stroke of Undetermined Source (ESUS). [2] There is a likelihood that many ESUS will also be cardiac in origin. In most cases, some cardiac work-up will be completed in the period after stroke onset, with 70% of ESUS patients having a Trans-thoracic echocardiogram (TTE) within one week. However, only 17% will get a more sensitive Transesophageal echocardiography (TEE) meaning many patients may not have an underlying cardiac cause of stroke discovered.[3] While TTE is accessible, it is insensitive particularly when imaging the left atrium, left atrial appendage or aorta meaning some diagnoses can be missed. TEE can provide more comprehensive cardiac imaging, but requires a specialist operator, thereby limiting accessibility. The time-consuming and semi-invasive nature of TEE, together with difficulties in imaging the left ventricle and heart apex, means the availability and routine use of TEE post AIS is often limited.[4a-b] Failure to diagnose cardiac thrombi rapidly and correctly could have serious impacts on treatment outcomes. The benefit of early diagnosis and treatment of cardiac thrombi in post-AIS has been demonstrated in previous research showing where right-sided cardiac thrombi were detected and treated (i.e., alteplase) early in patients with pulmonary embolism, and complete removal of the thrombus within 24 hours was observed.[5]

Consequently, neurologists should consider the heart in post-AIS care. Standard AIS workup includes CT-angiography images from the brain to the aortic arch, but the question remains whether imaging of the heart should become standard in AIS patients. Does the technique used and the additional time to perform this imaging impact patient outcomes?

Dr Coutinho went on to discuss a study which investigates this issue in depth, Mind the Heart,[6] where he explores the key research question, "Does cardiac CT, performed in the acute phase of ischemic stroke, have a higher diagnostic yield for high-risk cardio-aortic sources of embolism than TTE?"

Study Design

The study was designed as a single-centre, single-arm, prospective, observational cohort study on AIS-only adult patients (TIA excluded). Following power calculations and assumptions of losses of some included patients unable or unsuitable to undergo TTE (n=102), a total of 452 patients were included in the trial. Outcomes focused on increased diagnostic yields of cardio-aortic sources of embolisms. Patients experienced the standard Amsterdam UMC stroke pathway including CT scans (non-contrast, CT-perfusion and CT-angiography) and ECG and were generally followed by treatment with alteplase and mechanical thrombectomy if eligible. All patients (n=452) underwent an ECG-gated cardiac CT, where the CT scan is triggered based on the ECG signal allowing clinicians to eliminate cardiac motion during the acquisition. The scan included imaging of the aortic arch, carotid, and intracranial arteries which are systematically assessed by a clinician.

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Key Results

Despite some concerns that additional steps may delay patient access to treatment, it was found the inclusion of prospective ECG-gated cardiac CTA added only around six minutes to the time-to-treatment, so not a substantial delay. Intravenous thrombolysis could also be started prior to cardiac CT to avoid delays. A total of 350 patients underwent cardiac CT and TTE.[7]

Of the 350 patients who received both cardio-aortic CTA and TTE scan, CTA detected significantly (McNemar mid-p<0.001) more high-risk sources of emboli (n=40, 11.7%) compared to TTE (n=17, 4.9%). Of these patients, the majority were found to have an embolism of cardiac origin (n=26), with most being cardiac thrombi. As anticipated, TTE failed to detect many of these, particularly left atrial and left atrial appendage thrombi, a known diagnostic blind spot in TTE. It was noted that while some of these patients had a previous diagnosis of atrial fibrillation (AF), others were only diagnosed with AF post-stroke and about one third had no AF detected during the observation period.

When compared to routine practice the benefits of cardio-aortic CTA become even more pronounced, particularly when approximately 25% of patients will not undergo TTE for various reasons. Use of ECG-Gated CTA resulted in diagnosis of a high-risk emboli (n=55, 12.2%) compared with using TTE alone (n=17, 3.8%).

While long term outcome measured using the modified Rankin Scale (mRS) at two years was not the primary outcome of this study, it was noted that having a high-risk embolism (i.e., a thrombus originating from the heart) was associated with a much higher risk of poor outcome. More than half of the high-risk patients died within two years, with statistical significance (adjusted common odds ratio: 2.04, 95% CI 1.12–3.71).

Finally, while the study was not powered to look at the risk of stroke recurrence in patients with cardiac thrombi, these findings indicate that more research may further highlight the importance of early diagnosis of cardiac thrombi in AIS patients.

Photon-Counting CT of the Heart

Fredrik Ståhl, MD, PhD

The Karolinska University Hospital introduced photon-counting CT (PCCT) in their stroke patient protocol in October 2023. In this presentation, Dr Ståhl details some of the approx. 16,000 PCCT scans that have been performed since installing PCCT scanners at Karolinska. The hospital now has a dedicated neuroradiological PCCT scanner and a growing number of neurological patients being assessed with PCCT (over 4000 neuro scans since September 2023).

As standard for all suspected stroke patients, non-contrast CTs are acquired and reconstructed in thin slices along with virtual non-contrast and iodine map reconstructions enabled by the photon counting technology. The next step is a multi-phase non-ECG gated CTA extended to the diaphragm, allowing for full imaging of the heart, neck and brain. This is an automatic protocol at the facility and takes around three seconds to complete. As the final step in scanning, a CT-perfusion will be performed, and all images are automatically reconstructed with a penumbra calculation. In total, the scan and reconstruction time is around six minutes twenty seconds.

Retrospective data analysis

Currently, a retrospective data analysis of 320 suspected consecutive stroke patients is underway at the Karolinska University Hospital. Of these, 80% included heart imaging depicting the atria, ventricles, left atrial appendage, interatrial septum, contrast filling, heart valves and coronary arteries with the majority of images deemed of sufficient quality.

In this retrospective data analysis, PCCT made it possible to find cardiac thrombi (in the left atrial appendage, left atrium and left ventricle), signs of endocarditis, patent foramen ovale, aortic sources of emboli, and pulmonary emboli.

Dr Ståhl continued with a presentation of some examples of PCCT images from his hospital. One example was a 75-year-old female with an M2 occlusion, and even with some streaking artifacts (photon starvation) due to obesity, it was possible to observe irregular growths (vegetation) in aortic valve replacements, which was confirmed with transoesophageal echocardiography (TEE).

Of note, using PCCT to scan from the brain to the diaphragm took less than 1.4 seconds and produced images comparable to those from an ECG-gated cardiac-CT. In addition, it is now possible with PCCT, to view the interatrial septum using non-gated CT. This technique allowed for a full view of the patent foramen ovale (PFO) in exceptional detail. Figure

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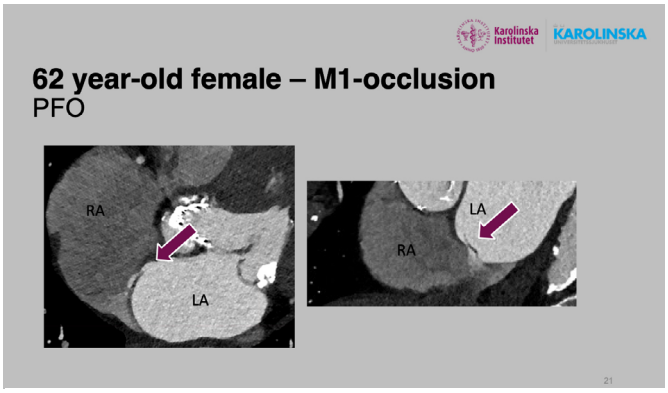

Figure 1. PCCT image of the heart at two different angles. The purple arrow highlights the PFO in the interatrial septum. RA, Right Atrium; LA, Left Atrium.

1 highlights the detail possible with PCCT, with the arrow highlighting the PFO from PCCT scans at two different angles.

Dr Ståhl explained how imaging of the heart using PCCT has now become so well resolved that it is possible to view structures of the heart that had previously been very challenging with non-gated cardiac-CTA. One key example are anatomic variants of the interatrial septum. While contrast-filled channels between the septum primum and septum secundum could be associated with a PFO, they do not reliably confirm the presence of a PFO. More work is required to understand which observations are clinically significant.

Clinical Advantages of NAEOTOM Alpha® and ARTIS icono for Neurovascular Disease

Johan Wassélius, MD, PhD

NAEOTOM Alpha®

Dr Wassélius began with several examples of how he uses NAEOTOM Alpha®, a photon-counting CT-based imaging system, in his clinic. For him, the key benefit is the improved image quality with fewer artefacts seen, with important details less likely to be lost in the images.

In the first example shown, a patient with a brain arteriovenous malformation (AVM) where the nidus can be seen in detail, detangling the mysterious "nidus" by depicting all the individual arteriovenous shunts that make up the nidus, also depicting venous ectasias/aneurysms and feeder aneurysms.

It was notable that using NAEOTOM Alpha® made it possible to view very small arteries at the level of the skull base, illustrated by viewing the ophthalmic artery all the way to the eye, something previously very difficult to image using CTA. In addition, NAEOTOM Alpha® enabled smaller vessels to be observed clearly including intranidal aneurysms with Dr Wassélius highlighting that "there is nowhere for vascular pathology to hide" with these imaging techniques. The imaging is far superior to that normally obtained from CTA allowing for a host of smaller vessels to be observed in a quick and non-invasive manner. Another example was presented of a patient with a Basilar artery perforator aneurysm (BAPA). This very rare form of aneurysm has traditionally been very difficult to diagnose using CTA. However, Dr Wasséilius has recently found that photon counting CT and cone-beam CTA (CBCTA) can readily identify BAPAs.

Conversely, NAEOTOM Alpha® can rule out a diagnosis too. An example of a patient presenting in the days following a thunderclap headache, which can be indicative of a subarachnoid haemorrhage, was discussed. Typically, this presentation can be problematic to diagnose using non-contrast CTA and the alternative diagnostic tool, a lumbar puncture, is invasive for patients and not reliable if the event occurred 10 days ago. Photon counting CT was able to identify that, in this patient, a young woman, the vascular structure suspected to be an arterial pseudoaneurysm on the initial regular CTA was a vein. This discovery ruled out vascular pathology and the need for additional invasive diagnostic angiography.

A key benefit of photon counting CT is the detailed imagery allows clinicians to make treatment decisions for the patient even before the patient has entered the surgical suite. Dr Wassélius explained how he has used these images to inform his decision-making around surgical intervention to treat aneurysms, choosing between endovascular or surgical options, including preoperative planning to select the ideal devices minimising the uncertainties and streamlining the procedures. The level of detail in the image provided by NAEOTOM Alpha® gives his team a better understanding of the vasculature so they can fully plan any interventional procedure.

ARTIS icono Biplane System

For the second part of his presentation Dr Wassélius discussed the benefits of the ARTIS icono imaging system,

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a new interventional imaging platform from Siemens Healthineers. The improved cone-beam CTA (CBCTA)[8] offers more detailed visualisations of aneurysms allowing clinicians to make diagnostic and treatment decisions. Additionally, it allows for non-invasive monitoring of patients.

In the first presented case study, the advanced CBCT capability of ARTIS icono allowed for the neck of an aneurysm to be fully visualised along with the P1 segments of the posterior cerebral artery (PCA). Following treatment of this patient with the Woven EndoBridge system device (WEB device), ARTIS icono was used to image the WEB in place to allow for continued non-invasive follow-up.

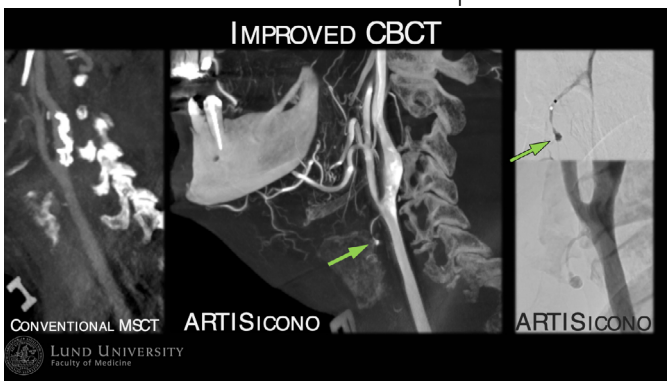

Figure 2. A conventional MSCT compared with enhanced imaging using ARTIS icono to reveal an aneurysm (highlighted with a green arrow).

Dr Wassélius went on to present a fascinating case study of a patient with head and neck cancer with severe bleeding. Use of improved CBCTA (Figure 2) led to the diagnosis of an aneurysm deep in the neck, located on the superior thyroid artery which would not have been observed using CTA. This diagnosis led to rapid and straightforward treatment of the patient.

The use of different contrast injection methods in CBCTA can also impact the image quality and the case studies presented showed that intravenous contrast (IVC) can provide excellent images comparable with those from intra-arterial contrast (IAC). The use of IVC in patients, particularly during follow-up procedures, is preferred to IAC due to the increased risk associated with arterial puncture. Dr Wassélius has now incorporated IVC-CBCTA into the protocols at Skåne University Hospital for the follow-up of patients with a flow diverter.

He went on to discuss the benefits of the 3D Roadmap technique. This is where a subtracted CTA (which will be taken of all patients during the hospital's stroke workflow) can be sent to the angio system prior to the patient entering the angiosuite and is then uploaded to the procedure on the ARTIS icono platform. The images are processed with software to automatically remove the bone structures. These subtracted CTA images allow for better viewing of the vessels. Additionally, the software on the ARTIS icono allows for annotation by clinicians to highlight areas of interest. Once the patient is in the angiosuite, one frontal and one lateral fluoroscopy image can be captured in less than a minute and used for the registration of the original CTA dataset.

During mechanical thrombectomy, the overlayed CTA allows clinicians to gain insight into the exact location of the thrombus, and suitably plan access routes for the procedure. The fusion CTA can also be used to assist clinicians in the correct placement of the stent-retriever during thrombectomy. This is particularly useful where long occlusions are present which can make vasculature visualisation difficult. Fusion CTA can be used to guide the clinicians to the correct position, place the stent retriever and complete the procedure.

Finally, some of the more advanced features of CBCTA were discussed including improvements in non-contrast CBCT imaging. These improvements may allow clinicians to estimate the final infarct size in stroke patients before the patient leaves the angiosuite, allowing clinician teams to plan for care requirements long-term following mechanical thrombectomy. Other advanced features include SMART metal artefacts reduction image processing which can be particularly useful if treating patients with coils, along with the 4D CBCT imaging capability which allows clinicians to fully visualise and understand blood flow in the brain.

Conclusion

Advanced imaging techniques can improve patient outcomes. The "Mind the Heart" trial demonstrated that ECG-gated cardiac CT had a significantly higher diagnostic yield than TTE for the detection of high-risk sources of embolisms and can be readily incorporated into the acute imaging workflow of patients with AIS.

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The impact of the inclusion of ECG-gated cardiac CT on door-to-needle time was minimal and the diagnosis of high-risk cardiac thrombi in AIS patients could significantly improve outcomes through reducing the risk of death and stroke recurrence. Cardiac-CT can be considered as an alternative to TTE when screening for cardioembolisms.

Photon-counting CT (PCCT), a relatively new technique may enable the assessment of heart structures and pathologies including thrombi without the need of ECG-gating the scan. Additionally, PCCT can allow clinicians to diagnose vegetations (signs of endocarditis), aortic sources of embolisms, patent foramen ovale (both from direct and indirect signs) and, because imaging is extended to the diaphragm, pulmonary embolisms.

Furthermore, a scan extending from the diaphragm to the brain can be performed in less than 1.4 seconds, adding virtually no delay in time-to-treatment while providing detail often similar to that seen in an ECG-gated cardiac-CT.

As the resolution of images improves, there may be a risk of incidental observations with no clinical significance, complicating diagnosis. More work is required to identify and understand these observations to recognise when they may have clinical significance.

The use of photon-counting CTA and cone-beam CTA were found to be advantageous in the diagnosis of all patients with neurovascular disease. These techniques can enhance the treatment and follow up of patients through high resolution, non-invasive imaging and can be incorporated into hospital workflows. Clinicians may need to work closely with radiology teams to understand the logistics of streamlining the process to include these advanced imaging techniques.

References

1. a) Kamel H, Healey JS. Cardioembolic Stroke. Circulation Research. 2017;120(3):514-526.

Freeman WD, Aguilar MI. Stroke Prevention in Atrial Fibrillation and Other Major Cardiac Sources of Embolism. Neurol. Clin. 2008;26(4):1129-1160; b) Fuster V, Rydén LE, Cannom DS, et al. ACC/AHA/ESC 2006 Guidelines for the Management of Patients with Atrial Fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Revise the 2001 Guidelines for the Management of Patients With Atrial Fibrillation): developed in collaboration with the European Heart Rhythm Association and the Heart Rhythm Society. Circulation. 2006;114(7):e257-e354.; c) 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(1):35-41.

2. Hart RG, Diener HC, Coutts SB, et al. Embolic strokes of undetermined source: the case for a new clinical construct. Lancet Neurol. 2014;13(4):429-438.

3. Giruparajah M, Bosch J, Vanassche T, et al. Global survey of the diagnostic evaluation and management of cryptogenic ischemic stroke. Int J Stroke. 2015;10(7):1031-1036.

4. a) McMahon NE, Bangee M, Benedetto V, et al. Etiologic Workup in Cases of Cryptogenic Stroke: A Systematic Review of International Clinical Practice Guidelines. Stroke. 2020;51(5):1419-1427; b) Saric M, Armour AC, Arnaout MS, et al. Guidelines for the Use of Echocardiography in the Evaluation of a Cardiac Source of Embolism. J Am Soc Echocardiogr. 2016;29(1):1-42.

5. Ferrari E, Benhamou M, Berthier F, Baudouy M. Mobile Thrombi of the Right Heart in Pulmonary Embolism. Chest. 2005;127(3):1051-1053.

6 Guglielmi V, Rinkel LA, et al. Mind the Heart: Electrocardiography-gated cardiac computed tomography-angiography in acute ischaemic stroke-rationale and study design. Eur Stroke J. 2020;5(4):441-448.

7. Rinkel LA, Guglielmi V, et al. Diagnostic Yield of ECG-Gated Cardiac CT in theAcute Phase of Ischemic Stroke vs Transthoracic Echocardiography. Neurology. 2022;99(14):e1456-e1464.

8. Siemens Healthineers. Siemens Healthineers introduces Artis icono biplane with detectors specially designed for cardiovascular care. Accessed 05 June 2024. https://www.siemens-healthineers.com/press/releases/artis-icono-biplane

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