showcase

The AI-STROKE project: From dry EEG data to a robust prehospital stroke triage method

SLS-SM-0315rev01- DRN-SLS-10174

Meet the researchers

The AI-STROKE project brings together a multi-disciplinary research team from the Neurology, Biomedical Engineering and Physics; as well as the Radiology and Nuclear Medicine Departments of Amsterdam UMC (University Medical Centers). The project idea came about after the team recognized the need for a prehospital stroke triage method that routes each stroke patient directly to the right treatment. The project is being led by Jonathan Coutinho, MD PhD, who is a stroke neurologist at Amsterdam UMC and Wouter Potters, PhD, technical physician at Amsterdam UMC. They are joined in this endeavor by Henk Marquering, PhD, who is also Professor of Translational Artificial Intelligence in Amsterdam UMC. At the core of the project are the two PhD candidates, Maritta van Stigt, MSc and Eva Groenendijk, MSc. Both Maritta and Eva are technical physicians at Amsterdam UMC and drive the project forward in cooperation with ambulance stations and personnel across the Netherlands.

The AI-STROKE project also built the foundation of the newly established company TrianecT, which intends to valorise the project technology and bring it to the market. Wouter leads TrianecT with Jonathan and Henk as co-founders. Dr. Frank Zanow (CEO, Neuromotion Ventures) also joins them as a co-founder in TrianecT. The mission statement of TrianecT is to get stroke patients to the right hospital for the right treatment without delays.

Figure 1: Team AI-STROKE (from left to right):
Wouter Potters, Jonathan Coutinho, Maritta van Stigt, Eva Groenendijk, Henk Marquering.

Project motivation and objectives

Acute ischemic stroke (AIS) affects 9 million people per year worldwide and large vessel occlusion (LVO) stroke patients make up about a quarter to a third of that number [1]. LVO stroke patients are potentially eligible for endovascular thrombectomy (EVT) which is a procedure that needs to be initiated urgently to increase the chance of good patient outcomes [2].

Intravenous thrombolysis (IVT) has been the standard treatment for acute ischemic stroke and in 2015, a combination of trials established the efficacy of EVT for patients with large vessel occlusion stroke of the anterior circulation (LVO-a) [3]. EVT has since then been adopted as the standard therapy for this patient group. EVT can only be performed in comprehensive stroke centers (CSCs), however all suspected stroke patients are transported to the nearest hospital, often a primary stroke center (PSC) (Figure 2). Once a CT scan confirms that the patient has an LVO-a stroke, they are transported again to the CSC for endovascular treatment. This leads to a 1-hour delay which worsens the outcome of those patients. The AI-STROKE project and researchers therefore propose to triage suspected stroke patients in a prehospital setting, so they can be directly brought to a CSC without losing any time [4,6,7].

In the AI-STROKE project, the team uses electroencephalography (EEG) and artificial intelligence algorithm to reliably predict LVO-a stroke. Dry EEG fullfils all the criteria for successful prehospital triage tool: high diagnostic accuracy; fast application and interpretation; user-friendliness; compactness; and low costs [4].

Project partners:

Ambulance Amsterdam
zorg met hoofd en hart

NICOLAB

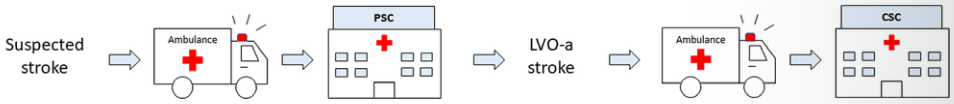
Amsterdam UMC
Universitair Medische Centra

TrianecT
connecting acute care

witte kruis
driven by care

ant neuro
inspiring technology

Current situation:



Ideal situation:

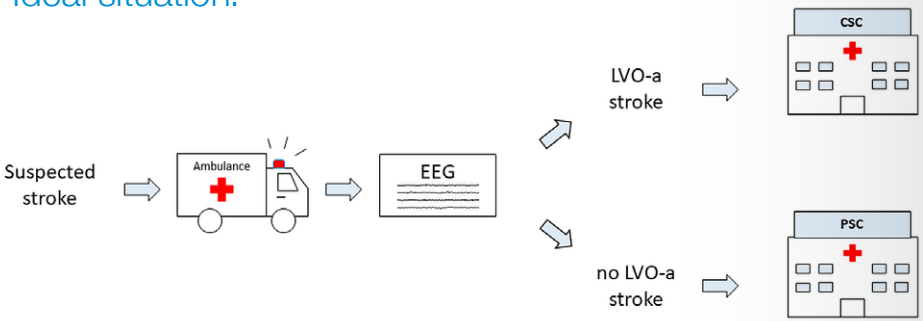


Figure 2: The differences between the current and proposed ideal prehospital workflow for suspected stroke patients [6].

AI-Stroke – Study overview

In the initial phase of the project, ambulance stations across the Netherlands (Ambulance Amsterdam and Witte Kruis Ambulancezorg Alkmaar) are collaborating with the team at Amsterdam UMC to collect EEG data from suspected stroke patients. Patients who are referred to a participating hospital (Amsterdam UMC, OLVG Hospital, and Noordwest Ziekenhuisgroep) are included. Patients clinically suspected of having a stroke as judged by the ambulance personnel, are 18 years of age or older, and their symptoms started <24 hours before the start time of the EEG recording are included. The main exclusion criteria for this study are skin lesions or infections on the head or a (suspected) COVID-19 infection.

Based on the above criteria, dry EEG data are recorded from the suspected stroke patients by the ambulance personnel in the prehospital setting. This group is trained in advance by the research team and are even provided small info sheets (Figure 3). The hardware is packed into an easy to carry,

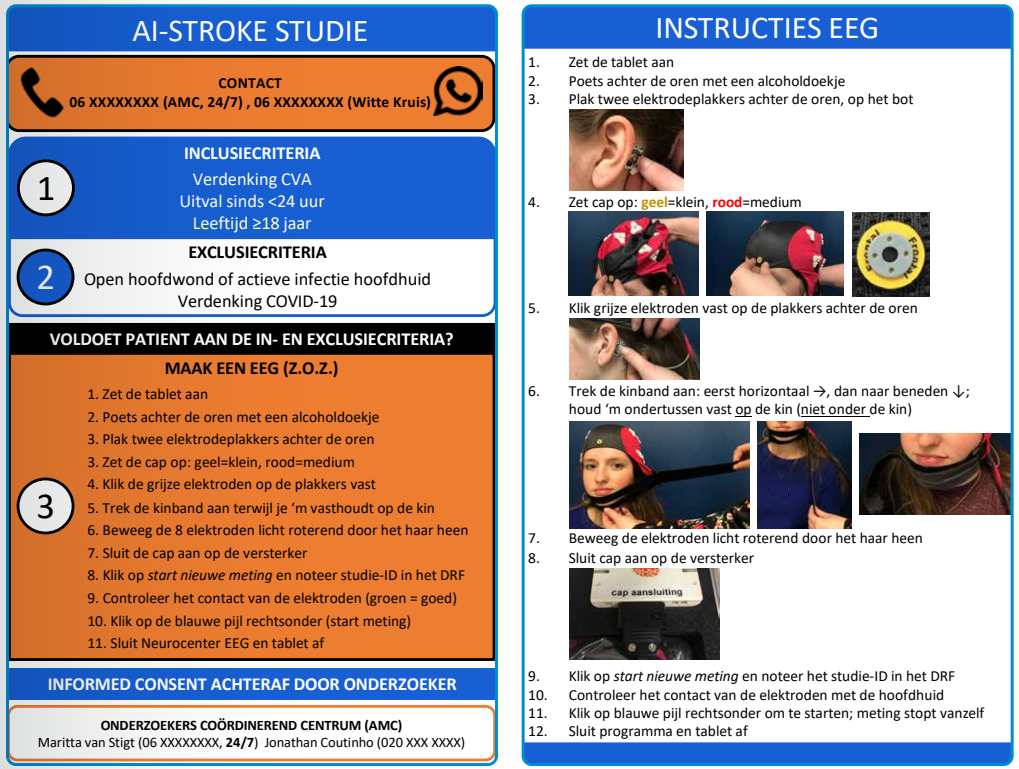


Figure 3: The infosheet provided to participating ambulance stations. The instructions are written in Dutch.

transportable suitcase that is placed in a dedicated station inside the ambulance. The dry EEG recordings are carried out either at the patient's site or inside the ambulance before transport to the nearest PSC. During measurements patients lie supine. Such pre-requisites reduce movement and muscle contraction to ensure that the recorded data is as clean as possible.

To ensure that minimal time is spent in this prehospital setting, the recording software has time limits imposed on every step in the acquisition software. The electrode positioning step where the ambulance personnel optimize electrode-skin contact, is limited to a maximum of 1.5 minutes. The EEG recording then lasts for a maximum of 3 minutes. The acquired data are end-to-end encrypted sent to Amsterdam UMC so that these can be analyzed in retrospect. After obtaining informed consent, for each patient, a copy of the clinical hospital records (demographics, medical history, and medication) is obtained along with the EEG data and stored securely such that only the researchers can access it for their analysis [3].

Technology incorporated in the study

The acute care setting and aim of this study demand the use of fast cap application measures, easy-to-use equipment, good data quality and intuitive acquisition software. The AI-STROKE study makes use of a specially developed 8 channel **wave**guard™ touch cap with electrodes positioned at 10/20 locations FC3, FC4, CP3, CP4, FT7, FT8, TP7, TP8. The reference and the ground electrodes are designed to be external drop-leads with flat snap electrodes which can be attached to hydrogel sticker electrodes and placed behind either ear on the mastoids.

At each of the electrode locations, a dry electrode triplet has been placed to act as one individual electrode. This increases the surface area of scalp contact at each location. Externally, this arrangement also increases the stability of the electrode at each location and prevents any tilting of the electrode, thereby optimizing electrode-skin contact. This cap also includes an adapted chin-strap with Velcro so that strapping and cap application can be relatively faster. Most of all, this **wave**guard™ touch cap ensures the ease of use of the equipment by ambulance personnel that are not traditionally trained on EEG measurement methods. The cap is connected to an 8 channel **eego**™ mini amplifier which is permanently connected to the tablet with the EEG recording software to reduce time in hardware preparations.
The NeuroCenter® EEG software (Clinical Science Systems, Leiden, The Netherlands) is used to record the dry EEG data. The equipment is connected to a tablet that runs this acquisition software within which the **eego**™ SDK is deployed.

Planned analysis

The EEG analysis plan includes a first artifact detection and detection step. Then, EEG features among which the relative delta, theta, alpha and beta power estimation, delta/alpha and theta/alpha ratios as well as delta+theta/alpha+beta ratio are calculated. With these features, a logistic regression algorithm for the detection of LVO-a stroke will be developed. Once more data becomes available, neural networks will be trained with either EEG features or raw EEG data as input. The Nicolab team (Amsterdam, the Netherlands) contributes to this phase by providing their expertise on Artificial Intelligence (AI) to the AI-STROKE project.

Future outlook

This project is not only ground-breaking for prehospital stroke triage, but it also sheds light on the technological challenges in acute stroke research. Primarily, this project shows the need for time-efficient neuroimaging measurement methods such as dry EEG and the feasibility of using dry EEG in an emergency environment. This project has received significant interest and publicity even in national organizations such as the Tweede Kamer (House of Representatives, The Netherlands). ANT Neuro is proud to collaborate with the AI-STROKE team and the TrianecT team, we hope this research will transform the prehospital stroke care chain in the near future.

External Links

ANT Neuro website:	https://www.ant-neuro.com/
waveguard™ **caps:**	https://www.ant-neuro.com/products/waveguard_caps
eego™ mini **solutions:**	https://www.ant-neuro.com/products/eego_mini_series
TrianecT:	https://www.trianect.com/
Clinical Science Systems:	https://clinicalscience.systems/cms/
Nicolab:	https://www.nicolab.com/

References

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Goyal, Mayank, et al. "Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials." The Lancet 387.10029 (2016): 1723-1731.

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Murray, Nick M., et al. "Artificial intelligence to diagnose ischemic stroke and identify large vessel occlusions: a systematic review." Journal of neurointerventional surgery 12.2 (2020): 156-164.

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