Telemedical Brain Computed Tomography Misinterpretation by Stroke Neurologists Is Not Associated with Thrombolysis-Related Intracranial Hemorrhage

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Background: The Stroke Eastern Saxony Network (SOS-NET) provides telecare for acute stroke patients. Stroke neurologists recommend intravenous thrombolysis based on clinical assessment and cerebral computed tomography (CT) evaluation using Alberta Stroke Program Early CT score (ASPECTS). We sought to assess whether ASPECTS misinterpretation by stroke neurologists was associated with thrombolysis-related symptomatic intracranial hemorrhage (sICH). *Methods:* We retrospectively analyzed consecutive SOS-NET patients treated with thrombolytics from July 2007 to July 2012. Experienced neuroradiologists re-evaluated CT scans blinded to clinical information providing reference standard. We defined ASPECTS underestimation as ASPECTS stroke neurologist − ASPECTS neuroradiologist more than 1 point. Primary outcome was sICH by European Cooperative Acute Stroke Study II criteria. Secondary outcome was unfavorable outcome at discharge defined as modified Rankin Scale scores 3 or more. *Results:* Of 1659 patients with acute ischemic stroke, thrombolysis was performed in 657 patients. Complete primary outcome and imaging data were available for 432 patients (median age, 75; interquartile range [IQR], 12 years; National Institutes of Health Stroke Scale score, 12 [IQR, 11]; 52.8% women). Nineteen patients (4.4%) had sICH, and 259 patients (60.0%) had an unfavorable outcome at discharge. Interobserver agreement between ASPECTS assessment was fair ($\kappa = .51$). ASPECTS underestimation was neither associated with sICH (adjusted odds ratio (OR), 1.32; 95% confidence interval (CI), .36-4.83, $P = .68$) nor unfavorable outcome (adjusted OR, 1.10; 95% CI, .47-2.54; $P = .83$). *Conclusions:* Despite fair interrater agreement between stroke neurologists and expert neuroradiologists, underestimation of ASPECTS by the former was not associated with thrombolysis-related sICH in our telestroke network. **Key Words:** Stroke—thrombolysis—telemedicine—hemorrhage—computed tomography.

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Aiming to reduce long-term disability caused by stroke in industrialized countries, stroke units have been established to deliver multidisciplinary care to acute stroke patients. However, stroke unit care is not area-wide available and thrombolysis rates are low, partly because of limited stroke thrombolysis expertise in smaller community hospitals.[1] Clinical networks using telemedicine apply specialized stroke care in the rural setting. Improved clinical outcomes of stroke patients have been shown when telemedicine was combined with the stroke unit concept based on specialized stroke wards and organized stroke care.[2]

We have previously demonstrated that clinically relevant misinterpretation by stroke neurologists was rare when analyzing cerebral computed tomography (CT) scans in telemedicine in real time.[3] Although several studies have confirmed sufficient agreement between stroke neurologists and neuroradiologists for the assessment of cerebral CT scans to identify stroke patients who are eligible for intravenous (IV) thrombolysis,[4] it has not yet been systematically analyzed whether the misinterpretation of cerebral CT scans by stroke neurologists in telemedicine is associated with thrombolysis-related symptomatic intracranial hemorrhage (sICH).

We sought to assess whether the underestimation of early ischemic changes (EIC) by stroke neurologists in real time was associated with thrombolysis-related sICH. We additionally aimed at analyzing whether underestimation of EIC was associated with unfavorable outcome by the time of hospital discharge in the telemedical setting.

Methods

Stroke Eastern Saxony Network

The Stroke Eastern Saxony Network (SOS-NET) has been established as a telemedical stroke network by the Dresden University Stroke Center in 2007 and provides stroke care for 14 peripheral community hospitals. Stroke neurologists from the Dresden University Stroke Center are available 24-7 for telemedical consultations and have all received training on brain CT scan interpretation in acute ischemic stroke by an expert neuroradiologist (RvK).

As previously described, cooperating hospitals telemedically presented all consecutive patients with suspected acute ischemic stroke and potential eligibility for thrombolysis, reduced level of consciousness of unknown etiology, brainstem symptoms, progressive stroke symptoms, or uncertainty about diagnostic or therapeutic procedures, which included patients with ICH or suspected intracranial tumor on the brain CT scan.[3] Community hospitals were equipped with a videoconference system (Meytec, Werneuchen, Germany), and the consulted stroke neurologists at the hub used either a desktop workstation during daytimes or a wireless portable notebook during the night for real-time patient evaluation. Digital Imaging and Communications in Medicine (DICOM)-formatted CT scans were electronically transferred to the SOS-NET server.

Teleconsultations consisted of the patient history, a structured clinical assessment using the National Institutes of Health Stroke Scale (NIHSS) score, and a standardized evaluation of the transferred CT scans using Alberta Stroke Program Early CT score (ASPECTS).[5,6] With the possibility of seeking advice from a neuroradiologist, the stroke neurologist provided a final treatment decision at the end of each teleconsultation. Follow-up CT scans were carried out 12-48 hours after telethrombolysis.

Patients

We performed a retrospective cohort study of prospectively collected data. Whereas we included all patients with teleconsultations regardless of their diagnosis for a 1-year period in our previous study,[3] we included all consecutive SOS-NET patients who had clinically suspected acute ischemic stroke and received IV thrombolysis after telemedical consultation during a 5-year period (July 2007 to July 2012) for the present study. Patients with primary diagnoses other than clinically suspected acute ischemic stroke were excluded from the study. We also excluded patients who did not receive IV thrombolysis after initial recommendation, patients with missing documentation of the primary outcome measure (sICH), patients with magnetic resonance imaging as the primary imaging modality, patients with missing documentation of image assessment by the stroke neurologist, or patients with unavailability of DICOM-formatted CT images for reference assessment by the neuroradiologist.

Clinical data were prospectively collected with SOS-NET quality assurance forms which were completed by the affiliated hospitals according to the German Stroke Registries Study Group guidelines including below-defined outcome measures.[7] Missing data and additional data with clinical relevance (blood pressure before IV thrombolysis, baseline glucose levels, time of symptom onset, and time of IV thrombolysis) were retrospectively derived from in-patient records or were imputed using available data.

This study was approved by our local institutional ethics committee at Technische Universität Dresden (EK293082011).

Image Analysis

The quantification of the EIC extent using ASPECTS and findings of a hyperdense middle cerebral artery sign, hyperdense basilar artery, and dot sign were prospectively documented in the electronic teleconsultation summary.[8-11] Readings from local radiologists at the affiliated community hospitals were not routinely