Diagnosis and treatment of patients with stroke in a mobile stroke unit versus in hospital: a randomised controlled trial

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Summary

Background Only 2–5% of patients who have a stroke receive thrombolytic treatment, mainly because of delay in reaching the hospital. We aimed to assess the efficacy of a new approach of diagnosis and treatment starting at the emergency site, rather than after hospital arrival, in reducing delay in stroke therapy.

Methods We did a randomised single-centre controlled trial to compare the time from alarm (emergency call) to therapy decision between mobile stroke unit (MSU) and hospital intervention. For inclusion in our study patients needed to be aged 18–80 years and have one or more stroke symptoms that started within the previous 2.5 h. In accordance with our week-wise randomisation plan, patients received either prehospital stroke treatment in a specialised ambulance (equipped with a CT scanner, point-of-care laboratory, and telemedicine connection) or optimised conventional hospital-based stroke treatment (control group) with a 7 day follow-up. Allocation was not masked from patients and investigators. Our primary endpoint was time from alarm to therapy decision, which was analysed with the Mann-Whitney U test. Our secondary endpoints included times from alarm to end of CT and to end of laboratory analysis, number of patients receiving intravenous thrombolysis, time from alarm to intravenous thrombolysis, and neurological outcome. We also assessed safety endpoints. This study is registered with ClinicalTrials.gov, number NCT00792220.

Findings We stopped the trial after our planned interim analysis at 100 of 200 planned patients (53 in the prehospital stroke treatment group, 47 in the control group), because we had met our prespecified criteria for study termination. Prehospital stroke treatment reduced the median time from alarm to therapy decision substantially: 35 min (IQR 31–39) versus 76 min (63–94), p<0.0001; median difference 41 min (95% CI 36–48 min). We also detected similar gains regarding times from alarm to end of CT, and alarm to end of laboratory analysis, for eligible ischaemic stroke patients, although there was no substantial difference in number of patients who received intravenous thrombolysis or in neurological outcome. Safety endpoints seemed similar across the groups.

Interpretation For patients with suspected stroke, treatment by the MSU substantially reduced median time from alarm to therapy decision. The MSU strategy offers a potential solution to the medical problem of the arrival of most stroke patients at the hospital too late for treatment.

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Introduction Stroke is a main cause of death worldwide and is one of the most common causes of disability in developed countries.1 About 90% of all strokes are due to cerebral ischaemia, with the remainder due to cerebral haemorrhage.2 The only approved treatment for ischaemic stroke is recanalisation of occluded arteries by thrombolysis with alteplase within the very first hours of symptom onset.3–5 However, implementation of recanalising therapy within this narrow therapeutic window is difficult to achieve in clinical practice because neurological examination, imaging, and laboratory analyses are needed so that haemorrhagic stroke and other contraindications to thrombolysis can be excluded.6–8 An additional time-sensitive intervention for patients with acute stroke is blood-pressure management, which has been associated with improved outcome.9–11

Less than 15–40% of patients with acute stroke arrive at the hospital early enough to receive thrombolytic treatment,6,12 and only 2–5% of patients actually receive it.13–16 Of those patients who do receive state-of-the-art stroke treatment, outcome is closely related to the time to treatment.17–19 Management of acute stroke must be reconfigured if we are to overcome the problem of patients arriving at the hospital too late for treatment.20–22 As a potential solution to this problem, we first designed22 and then studied in clinical practice23 the concept of bringing guideline-adherent stroke treatment directly to the emergency site, as has previously been made possible for patients with myocardial infarction.24 This strategy is based on a specialised ambulance (mobile stroke unit; MSU)24,25 equipped with a CT scanner, a point-of-care laboratory, and a telemedicine


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connection to the hospital. Apart from preliminary clinical observations, no systematic analysis of the benefit of this MSU approach on stroke management has been done. We postulated that in clinical practice prehospital stroke treatment would significantly reduce the detrimental delay in receipt of state-of-the-art stroke therapy. Hence we aimed to compare the times from alarm (emergency call) to therapy decision between the MSU and the optimised standard procedure.

Methods

Participants

In accordance with our protocol, between November, 2008, and July, 2011, we did a randomised, parallel-group, single-centre study at the University Hospital of the Saarland, Homburg, Germany. For inclusion in our study, patients needed to be aged 18–80 years, have one or more stroke symptoms according to the modified recognition of stroke in the emergency room (ROSIER) scale (facial paresis, paresis of arm or leg, aphasia, or dysarthria) that had started within the previous 2–5 h, and have written informed consent provided by the patient or the patient’s legal representative. Our exclusion criteria were uncertain symptom onset (eg, after waking), no focal stroke-like symptoms, and pregnancy. We did not enrol patients if diagnosis and treatment options could not be offered because of defective key equipment in the MSU or the hospital, if unstable medical conditions needed immediate treatment in the intensive care unit, or if patients were secondarily transferred from primary hospitals. We ran our study from 0800 h to 2200 h during the week and from 0800 h to 1800 h at weekends. Our trial protocol and the informed consent and participant information documents were approved by the Ethics Committee of the Medical Association of the Saarland, Germany (118/06, Aug 14, 2006). An independent clinical monitor (Interdisciplinary Centre for Clinical Trials, Mainz, Germany) supervised the trial.

Randomisation and masking

For organisational feasibility, the procedure to be applied to a patient (MSU or standard) was randomised week-wise—ie, all patients entered within a particular week received the same procedure. To achieve balance between both groups regarding potential confounders that might change during the year, such as weather, we chose a block size of 4 weeks to limit the length of time during which the same procedure was used. Our randomisation list was created by an independent statistician (HS) with the SAS procedure PLAN. The statistician also did the statistical analysis.

All emergency calls to the central emergency medical service (EMS) Coordinating Office from a region of up to 30 km around Saarland University Hospital were assessed for reporting of stroke symptoms by the EMS dispatcher (a paramedic) with the modified ROSIER scale and for inclusion and exclusion criteria. If the patient was eligible, either the MSU pathway (involving the MSU team in addition to the regular EMS) or the conventional pathway (involving the regular EMS combined with optimised in-hospital stroke management) was initiated in accordance with the pathway specified for that week in the randomisation list. In the first case, the EMS and the MSU team were notified, and in the latter case, the EMS team and the in-hospital stroke team were notified. Finally, the stroke physician in either the MSU or the hospital confirmed the inclusion and exclusion criteria and obtained written informed consent before the patient was entered into the study. For feasibility of the integration of the MSU strategy into the routine EMS chain and because of the nature of these pathways, the procedure to be applied to a patient was randomly assigned without masking the allocation from the EMS dispatcher, the stroke physician, or the patients.

Procedures

Our MSU programme was integrated into the regular EMS system in a mixed urban and rural setting. The MSU response consisted of the combined dispatch of the MSU and the conventional EMS, which in Germany includes an emergency physician for critically ill patients. The MSU team included a paramedic, a stroke physician, and a neuroradiologist. The MSU team obtained the patient’s history; undertook a neurological examination, CT scan, and laboratory examinations; and, if the patient was eligible, gave thrombolysis directly at the emergency site. The MSU itself was an ambulance equipped, in addition to all standard equipment for primary care, with special equipment: an accumulator-driven and lead-shielded CT scanner (Tomoscan M, Philips, Andover, MA, USA; or, in the last study year, Ceretom, Neurologica, Danvers, MA, USA, allowing multimodal imaging with CT angiography and CT perfusion); a telemedicine...
system (Meytec, Werneuchen, Germany) enabling transmission of digital imaging and communication data obtained by CT scanning or video of clinical examination via the universal mobile telecommunication system to the picture archiving and communication system of the hospital; and a point-of-care laboratory system. The laboratory system allowed the measurement of platelet count, leucocyte count, erythrocyte count, haemoglobin, and haematocrit (PocH 100i, Sysmex, Hamburg, Germany), international normalised ratio and activated partial thromboplastin time (Hemochron Jr, ITC, Edison, NY, USA), and γ-glutamyltransferase, p-amylase, and glucose (Reflotron plus, Roche Diagnostics Mannheim, Germany), as requested by the approval criteria for alteplase and by primary stroke management guidelines.

To avoid comparing the MSU strategy with suboptimum intrahospital stroke management, patients in the control group received optimised conventional stroke management, which included point-of-care laboratory testing instead of testing by the centralised hospital laboratory—a change that achieved important time savings in stroke management. Thrombolysis was given in accordance with all inclusion and exclusion criteria for the approval of alteplase (including the upper age restriction of 80 years and the 3 h therapeutic window relevant during the trial) and primary stroke management guidelines.

Patients were clinically assessed at the time of study enrolment (either before hospital arrival for the MSU group or in the hospital for the control group), after 24 h (±1 h), and at day 7 (±1 day, or last observation carried forward) after study inclusion. Clinical assessment included medical history, neurological examination, and analysis of incidence of safety endpoints and severe adverse events. For neurological examinations we used the National Institutes of Health Stroke Scale (NIHSS, with scores ranging from 0 to 42; higher scores suggest more severe disease), the modified Rankin scale (mRS, with a range from 0, showing no residual symptoms, to 6, showing death), and the Barthel index (with a range from 0, showing complete dependence, to 100, showing no need for help in the activities of daily life). We assessed physiological variables, such as heart function, heart rate, and blood pressure, at baseline and, if necessary (ie, in the case of stroke or cardiopulmonary instability), continued to monitor these variables.

As further variables we recorded baseline epidemiological data, final diagnoses, and further stroke management variables, such as time from symptom onset to alarm, time from alarm to arrival of the MSU or EMS at the scene, distances to hospital in km, and number of patients receiving diagnosis-specific blood-pressure management.

Our primary endpoint was time from alarm to therapy decision and our prespecified secondary endpoints were number of patients with intravenous thrombolysis with alteplase, time from alarm to intravenous thrombolysis, time from alarm to end of CT, and time from alarm to end of laboratory analysis. We assessed stroke management intervals with symptom onset rather than alarm as the starting point. Because intra-arterial recanalisation therapy developed during the years in which we did our study, we added post-hoc endpoints: number of patients with intravenous thrombolysis or intra-arterial recanalisation and time from alarm to intravenous thrombolysis or to intra-arterial recanalisation. We derived stroke management times from those recorded by the EMS Coordinating Office, the CT and laboratory equipment, and by the EMS protocols.

Further secondary endpoints were NIHSS (cutoff value ≤1 or ≥8 points improvement), Barthel index (≥95 points), and mRS scores (≤2) at days 1 and 7 for patients who had stroke.

Our safety endpoints were survival at day 7, incidence of stroke-related or neurological death by day 7 (ie, fatal ischaemic stroke, fatal reinfarction, fatal primary or secondary intracerebral haemorrhage), symptomatic intracranial haemorrhage (defined as any haemorrhage...
Statistical analysis

We prespecified the statistical analyses of our primary and secondary endpoints. We expressed stroke management times as median (IQR) for comparison of our times with those previously reported. We used the Mann-Whitney U test to analyse the primary endpoint (time from alarm to therapy decision) and all secondary endpoints involving time intervals, because this test is robust against deviations from normality. A sensitivity analysis applying the t test was used to confirm results. We calculated differences in medians with the Hodges-Lehmann estimator and respective distribution-free 95% CIs with Moses’ method. We used logistic regression for ordinal responses to analyse the mRS results at days 1 and 7, with baseline mRS as a covariate.

Our estimation of the required sample size was done on the basis of our assumption that data are normally distributed, because the power of the Mann-Whitney U test is slightly overestimated when the real distribution diverges from normality. With an SD of the time between emergency call and therapy decision of 30 min (based on unpublished historical data for the standard procedure in the hospital in which our study was done), a sample size of 100 patients per group would give the analysis about 90% power to detect an advantage of 14 min achieved by the MSU at an α level of 0·025. We scheduled a preplanned interim analysis to be done after the enrolment of 100 patients. With the application of O’Brien-Fleming boundaries, we planned to stop our study for futility if the p value of the interim analysis of the primary endpoint was greater than 0·4, or for proven superiority if the p value was less than 0·0015.24 We assessed all other endpoints only once. We used East software (version 4) for planning our interim analysis and SAS (version 9.2) for our other analyses. This study is registered with ClinicalTrials.gov, number NCT00792220.

Role of the funding source

The sponsors of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The figure shows the trial profile. Because we postulated that prehospital diagnostic work-up and stroke treatment would reduce the delay to therapy decision, we stopped our study when our predefined interim analysis showed the prespecified superiority (p<0·0015) in the primary endpoint.

All patients assigned to the MSU group gave informed consent but two who would have been assigned to the control group did not. We did not lose any patients from our final analysis of our primary endpoint. Table 1 lists baseline demographic characteristics, distances to

Table 2: Primary and secondary endpoints

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>MSU group (n=53)</th>
<th>Control group (n=47)</th>
<th>p value</th>
<th>Difference (95% CI)</th>
</tr>
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<tbody>
<tr>
<td>Primary endpoint</td>
<td></td>
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<tr>
<td>Alarm to therapy decision (min)</td>
<td>35 (31–39)</td>
<td>76 (63–94)</td>
<td>&lt;0·0001</td>
<td>41 (36–48)</td>
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<tr>
<td>Secondary endpoints</td>
<td></td>
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<tr>
<td>Symptom onset to therapy decision (min)</td>
<td>56 (43–103)</td>
<td>104 (80–156)</td>
<td>&lt;0·0001</td>
<td>43 (30–58)</td>
</tr>
<tr>
<td>Number of patients with intravenous thrombolysis</td>
<td>12 (23%)</td>
<td>8 (12%)</td>
<td>0·30*</td>
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<tr>
<td>Alarm to intravenous thrombolysis (min)</td>
<td>38 (34–42)</td>
<td>73 (60–93)</td>
<td>&lt;0·0001</td>
<td>34 (22–54)</td>
</tr>
<tr>
<td>Symptom onset to intravenous thrombolysis (min)</td>
<td>72 (53–108)</td>
<td>153 (126–198)</td>
<td>0·0011</td>
<td>80 (40–115)</td>
</tr>
<tr>
<td>Number of patients with intravenous thrombolysis or intra-arterial recanalisation §</td>
<td>12 (23%)</td>
<td>11 (23%)</td>
<td>0·81*</td>
<td>–</td>
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<tr>
<td>Alarm to intravenous thrombolysis or intra-arterial recanalisation (min)</td>
<td>38 (34–42)</td>
<td>78 (61–110)</td>
<td>&lt;0·0001</td>
<td>44 (27–73)</td>
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<tr>
<td>Symptom onset to intravenous thrombolysis or intra-arterial recanalisation ‡</td>
<td>72 (53–108)</td>
<td>152 (125–209)</td>
<td>&lt;0·0001</td>
<td>80 (46–115)</td>
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<tr>
<td>Alarm to end of CT (min)</td>
<td>34 (30–38)</td>
<td>71 (62–87)</td>
<td>&lt;0·0001</td>
<td>38 (33–43)</td>
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<tr>
<td>Number of patients with intravenous thrombolysis or intra-arterial recanalisation ‡</td>
<td>72 (53–108)</td>
<td>152 (125–209)</td>
<td>&lt;0·0001</td>
<td>80 (46–115)</td>
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<tr>
<td>Alarm to end of laboratory analysis (min)</td>
<td>28 (26–34)</td>
<td>69 (55–81)</td>
<td>&lt;0·0001</td>
<td>38 (32–44)</td>
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<tr>
<td>Symptom onset to end of laboratory analysis (min)</td>
<td>51 (40–95)</td>
<td>99 (70–140)</td>
<td>&lt;0·0001</td>
<td>39 (36–56)</td>
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<tr>
<td>NIHSS at day 1‡</td>
<td>3 (1–10)</td>
<td>4 (2–12)</td>
<td>0·48</td>
<td>1 (–1 to 3)</td>
</tr>
<tr>
<td>NIHSS at day 7‡</td>
<td>1·99</td>
<td>1·00 (0·42–2·41)</td>
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<td>–</td>
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<tr>
<td>mittai at day 1‡</td>
<td>0·77</td>
<td>0·77 (0·39–2·00)</td>
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<td>51</td>
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<td>6</td>
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Unless otherwise specified, data are median (IQR) and tested with the Mann-Whitney U test as prespecified in our protocol, because of unknown distribution of the time differences. We calculated differences in medians with the Hodges-Lehmann estimator and distribution-free CIs with Moses’ method. MSU=mobile stroke unit. NIHSS=National Institutes of Health Stroke Scale. mRS=modified Rankin scale. OR=odds ratio. §Analysed in the stroke patient subgroup. †Post-hoc endpoints that includes all types of recanalising stroke treatments. ‡Logistic regression with baseline mRS as categorical covariate. ⌂Analysed in the stroke patient subgroup.

accompanied by neurological deterioration of at least 4 points in the NIHSS score,21 symptomatic peripheral haemorrhage, and rates of cerebral herniation and symptomatic brain oedema. We also recorded all other serious adverse events.
hospital, times from symptom onset to alarm, baseline disease severity, and diagnoses. No diagnosis of ischaemic or haemorrhagic stroke needed revision during further clinical follow-up. Median times from alarm to the MSU or EMS arriving at the scene were 12 min (IQR 9–16) in the MSU group and 8 min (6–11) in the control group. MSU-based stroke management roughly halved the time from alarm to therapy decision compared with the control group (table 2). Consistent with the findings for our primary endpoint, the stroke management intervals of times from alarm to end of laboratory analysis and end of CT times were also reduced (p<0.0001; table 2). Our analysis showed that the MSU strategy reduced the time from symptom onset to therapy decision compared with the control group (table 2), which was less than 1 h for 30 (57%) of 53 patients in the MSU group but only for two (4%) of 47 patients in the control group.

Recanalising treatments given to patients in the MSU and control groups were intravenous alteplase (eight patients in the MSU group and seven in the control group), bridging of intravenous alteplase with later mechanical recanalisation (four in the MSU group and one in the control group), and mechanical recanalisation alone (none in the MSU group and three in the control group). Together, 12 patients in the MSU group were treated with intravenous thrombolysis in the field.

Although the differences between groups in the numbers of patients with intravenous thrombolysis or with intravenous thrombolysis or intra-arterial recanalisation were not statistically significant, the times from alarm to intravenous thrombolysis and to intravenous thrombolysis or intra-arterial recanalisation were substantially shorter in the MSU group (table 2). We obtained similar significant differences when we used symptom onset rather than alarm as the starting point for these stroke management intervals (table 2).

Indicators of neurological outcome at days 1 and 7 did not substantially differ between the groups (table 2). Six patients (11%) in the MSU group and three patients (6%) in the control group experienced events that were tracked as safety endpoints of the study. Five patients (9%) in the MSU group and two patients (4%) in the control group died of stroke-related or neurological causes (table 3). Altogether, three patients treated with alteplase died (all in the MSU group), and one of the untreated patients with ischaemic stroke (in the MSU group) died. Whereas non-fatal secondary intracranial haemorrhage was not evident in either study group, there was non-fatal cerebral herniation and oedema in one patient in the control group, and there was peripheral haemorrhage in one patient in the MSU group. Table 3 lists additional safety endpoints and severe adverse events.

By contrast with conventional stroke management (no patients in the control group received blood-pressure management), MSU-based stroke management allowed eight patients to receive prehospital pharmacological intervention in blood pressure on the basis of information about the ischaemic or haemorrhagic cause.

Analysis of technical problems related to key equipment showed that CT scanning in the MSU group was unavailable for eight patients because of scanner defects, two patients because of handling problems (scanner dysfunction due to steep streets), and two patients because they were overweight. Intrahospital imaging options did not depend on a single device; therefore, the availability of CT was 100% for the control group. In the control group, the point-of-care laboratory (used also by other departments of the hospital and to assess samples from patients who were not part of our study), was unavailable for ten patients.

### Discussion

Our main findings are that the strategy of prehospital stroke diagnosis and treatment allows therapy decisions a median of 35 min after alarm in clinical reality. Median time from symptom onset to intravenous thrombolysis was 72 min, representing a new timescale in acute stroke management.

Stroke is a medical emergency for which “time is brain”; however, most patients still arrive at hospital too late to receive necessary treatment. We show that
Articles

Panel: Research in context

Systematic review

We searched Medline (1950–2012), the Cochrane Central Register of Controlled Trials in the Cochrane Library, and Embase (1988–2012), with the search terms “prehospital thrombolysis” and “prehospital treatment”. Our search was restricted to reports in English. We restricted our searches to all types of trials including at least three patients with acute ischaemic stroke. We also hand searched relevant journals and the reference lists of included reports.

Interpretation

There are no previous trials of prehospital thrombolysis to treat acute ischaemic stroke. Of the reported findings on prehospital delay in acute stroke treatment, median times from symptom onset to arrival at hospital vary widely, with values ranging from 3 h to 6 h. Additionally, median times from arrival at hospital to thrombolysis range from 66 min to 78 min. For example, a recent large European multicentre registry with 6483 patients reported that the median time from symptom onset to therapy was 68–140 min longer than the median time achieved by the mobile stroke unit strategy. The stroke management times achieved with the mobile stroke unit (MSU) break the reported times for stroke management. Of interventional studies, effects of various measures (eg, public educational campaigns, regulations about transfer of patients to stroke units, preinformation of stroke teams by the emergency medical service, or optimisation of in-hospital processes) on improvement regarding times until treatment have been compared with historical data but not with control groups in a randomised design. For patients with suspected stroke, prehospital stroke treatment roughly halved the interval from alarm to therapy decision. The MSU strategy offers a potential solution to the medical problem of the arrival of most stroke patients at the hospital too late for treatment.

MSU-based stroke management substantially breaks, to our knowledge, all reported times for stroke management: the median time from alarm to therapy decision was 41 min shorter than that for optimised conventional stroke management, with a median time from symptom onset to therapy decision of 56 min. The differences in times from alarm to intravenous thrombolysis and to intravenous thrombolysis or intra-arterial recanalisation between the MSU group and the control group in the subpopulation of patients with stroke were similar to those for the times to therapy decision for the overall population. These times contrast with the times from arrival at hospital to treatment of 60 min that are still the stated goal of present guidelines and with the much larger intervals that are still clinical reality today. Although there is no previously published trial of prehospital stroke diagnosis and treatment, there are several reports of prehospital delay in acute stroke care. The reported median times from symptom onset to arrival at hospital vary strongly, ranging from 3 h to 6 h and median times from arrival at hospital to thrombolysis ranging between 66 min and 78 min. For example, a recent large European multicentre registry study with 6483 patients showed that the median time from symptom onset to intravenous thrombolysis was 140 min, 68 min longer than the median time achieved by the MSU strategy. A further study showed that after prehospital and intrahospital stroke management had been strictly optimised the median time from symptom onset to therapy onset decreased from 149 min to 112 min, which is still roughly 40 min longer than that achieved for the MSU group.

According to the generally accepted “time is brain” concept, such a large reduction in delay should translate into improved outcome. Indeed, animal experimental and clinical evidence shows that time to treatment is the primary determinant of outcome. A recent meta-analysis of the major multicentre thrombolysis trials showed that the number needed to treat for excellent outcome rapidly increases from five in the range of 0–90 min after symptom onset to more than nine in the range of 91–180 min, and up to 15 in the range of 181–270 min (panel).

The integration of our study into the routine EMS system, and the representative study population shown by the demographic variables in table 1, suggest our findings can be generalised—eg, in countries with similar health-care systems. We chose time from alarm to therapy decision as our primary endpoint because it goes beyond the question of whether alteplase treatment is given, but includes decisions on mechanical recanalisation (of large-vessel occlusion seen by prehospital CT angiography) or bridging therapy.

Despite the lack of evidence from randomised trials, an increasing number of findings argue for the relevance of differential blood-pressure management for patients with ischaemic and haemorrhagic stroke and for the time sensitivity of this treatment. Recommendations of relevant guidelines for blood pressure are, indeed, different for ischaemia (ie, systolic values as high as 185–220 mm Hg can be tolerated to enhance cerebral perfusion pressure) and haemorrhage (intervening to target systolic values of 150–160 mm Hg). Our findings show that, in clinical reality, the MSU strategy provides an opportunity for cause-specific blood-pressure management well before hospital arrival.

Despite the substantial differences in stroke management times, our findings show no significant differences between the two study groups in the number of treated patients or in neurological outcomes. The limitations of our study are the lack of power for these and the other secondary endpoints in the subpopulation of stroke patients, the potential effects of previous disability, the relatively short follow-up time of outcome-related
secondary endpoints, and the absence of masking in their assessment. Moreover, we cannot exclude with certainty a potential for bias due to our week-wise randomisation procedure.

Our analyses of safety endpoints and severe adverse events show that event rates for the two groups were within similar ranges. However, such analyses have low power. Although equipment and personnel in the MSU are the same as in the hospital, and although no previous studies suggested that earlier diagnosis and treatment of stroke increases the number of complications, safety aspects must be further assessed, in view of the recorded deaths in patients treated with alteplase in our study.

We enrolled into our study 28% of the patients we screened. This number could, in future trials, be substantially increased if thrombolysis were to be approved for patients older than 80 years. In 2011, the 3 h therapeutic window for use of alteplase, which was one of the main exclusion criteria in our study, was extended to 4.5 h in many countries. Furthermore, improved stroke symptom questionnaires and additional training of the EMS could contribute to more specific identification of stroke.

The costs incurred by the MSU strategy are related to CT scanning, the point-of-care laboratory, and the telemedicine equipment (about €300 000) and to the involvement of the core MSU team, which consists of a paramedic and a stroke physician. Both members of the team are active only in case of emergencies and otherwise work at their regular institutions; thus, the staff costs per treated patient are not substantially greater than for conventional procedures. It remains to be assessed whether the intervention costs are outweighed by reduced costs for the long-term care of stroke patients. The neuroradiologist was included in our study primarily for legal reasons, because in Germany the neurologist is at present not allowed to run the scanner alone. This person could be replaced by a radiology technician or by a neurologist with radiology training in the future. The MSU concept also implies that neuroradiological and even specific neurological expertise could in future be supplied to the regular EMS solely via telemedicine, thereby potentially facilitating integration of the MSU strategy into the differently organised EMS systems in various settings and countries.

In conclusion, although the effect on clinical outcome needs further study in larger (eg, multicentre) trials, the results of this first randomised trial of the MSU strategy of bringing the hospital to the patient with stroke show that guideline-adherent diagnosis and therapy can reliably be delivered within the first 35 min after alarm, thus speeding up acute stroke management.

References
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