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Research Article

# A Structured Stroke Team Algorithm Improves Periprocedural Delays in Patients Undergoing Endovascular Stroke Therapy – Monocentric Evidence of Efficiency and a How-To Guide

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**Abstract**

**Background and Purpose:** Acute stroke care is highly time critical and the increasing use of endovascular stroke therapies in patients with severe stroke adds complexity. We implemented a structured interdisciplinary STROKE TEAM algorithm in analogy to acute trauma care and compared the door-to-intervention delays in patients selected for endovascular stroke therapy in two time intervals before and after its implementation.

**Methods:** The STROKE TEAM is based on 1) a binding appointment of interdisciplinary team members to the STROKE TEAM with clearly-defined tasks, 2) an alert loop summoning the team upon the arrival of a stroke patient, and 3) monthly simulator-based team trainings of technical and non-technical skills. We compared the treatment delays in consecutive patients undergoing interventional stroke therapy before (10/2006-5/2009) and after (10/2012-9/2013) the implementation of the STROKE TEAM.

**Results:** Implementation of the STROKE TEAM more than halved the door-to-thrombolysis time to a median time of 23 minutes. This was accompanied by significantly shorter times for thrombolysis-to-groin puncture (57 *vs*. 91 minutes, $p < 0.05$), door-to-groin puncture (81 *vs*. 163 minutes, $p < 0.01$) and symptom onset-to-groin puncture (152 *vs*. 244 minutes, $p < 0.001$).

**Conclusion:** The STROKE TEAM algorithm significantly shortened door-to-intervention delays via early and structured interaction of stroke physicians and neuroradiologists for every stroke patient in the therapeutic time window.

**Keywords:** Emergency treatment of stroke; Thrombolysis; Thrombectomy

## Introduction

The association between shorter time to treatment and favorable outcome has been robustly shown in patients with acute ischemic stroke for intravenous (IV) thrombolysis [1]. The door-to-needle time (DTN) has emerged as a measure of efficient acute stroke care since the introduction of thrombolysis. Considerable efforts have been made over the years to reduce DTN in dedicated stroke centers [2,3] but also among stroke-ready community hospitals [4]. A recent analysis shows that patients robustly benefit from further small reductions of treatment delays, gaining an average equivalent of one month of additional disability-free life from each 15 minute decrease in treatment delay [5]. To safely administer IV thrombolysis for acute stroke, a complex series of tasks has to be completed within minutes by an interdisciplinary team composed of physicians, nurses, radiologists and technical staff. Additionally, the broader use of endovascular stroke therapies in recent years often requires the involvement of neurointerventionalists and anesthesiologists. With increasing complexicity and bigger teams, coordination of acute stroke care becomes more demanding. Since investments in the "hardware" of hospital infrastructure and additional staff are often limited by globally increasing budgetary constraints, it appears worth wile to introduce structured team work into acute stroke care to save time and improve patients' outcomes. Structured team-based algorithms and team trainings of medical and non-medical skills have been used routinely for many years in acute trauma care [6,7]. We implemented an institutional interdisciplinary STROKE TEAM algorithm based on three simple, inexpensive measures. We hypothesized that especially stroke patients selected for endovascular stroke therapies will benefit from this structured interdisciplinary approach. Therefore, we evaluated the efficiency of the STROKE TEAM on shortening periprocedural delays in a longitudinal cohort study of two prospectively collected cohorts of consecutive patients undergoing endovascular stroke therapies before and after the implementation of the STROKE TEAM.

## Methods

Our interdisciplinary clinical neuroscience center includes a dedicated stroke unit treating approximately 900 stroke patients annually, a considerable number of them referred by smaller hospitals for endovascular stroke therapy. In 2012, we implemented the following three measures to improve acute stroke care: 1)


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establishment of a well-defined STROKE TEAM in analogy to a trauma team, 2) an alarm system via the institutional mobile phones by means of a telephone loop simultaneously informing all members of the STROKE TEAM with an audio announcement "stroke within therapeutic time window", and 3) commitment of all STROKE TEAM members to participate in regular simulator-based team trainings that advocate didactical principles of the advanced cardiac life support (ACLS) teaching system of the American Heart Association such as the appointment of a team leader and an introduction of closed-loop communication strategies [8].

The STROKE TEAM is composed of two junior physicians training in neurology, one from the stroke unit and the other from the emergency department (ED), one senior stroke physician (specialist in neurology), one nurse from the ED, one physician training in Neuroradiology, one radiology technician and one laboratory technician. These team members, who work on different floors of the hospital, are immediately summoned to the ED or their respective work place upon the arrival of a stroke patient. By means of an exact definition of their role and function within the STROKE TEAM (Figure 1), they can contribute their expertise efficiently to achieve the aim of expedited diagnosis and treatment.

Among the two junior physicians in the ED, the physician from the stroke unit who will subsequently care for the patient is the team leader, taking the history and examining the patient before deciding upon the brain imaging modality and announcing whether thrombolysis should be delayed to obtain information on coagulation parameters (approx. 20 minutes with expedited laboratory procedure). Meanwhile, the ED physician is responsible for blood sampling, reliable venous access and the ordering of brain imaging. During the off-hours, these two roles are assigned to the neurology resident in the ED and the resident of the neurological intensive care unit. The senior stroke physician makes the treatment decisions and supervises the process while teaching new members on the team. During the off-hours, this role is assigned to the senior physician on call. Routinely, the algorithm relies on computed tomography (CT) of the brain with CT angiography to rule out brain hemorrhage and inform the STROKE TEAM of a proximal vessel occlusion. Only in a small proportion of cases we use magnetic resonance imaging (MRI).

Simulator-based STROKE TEAM training is provided monthly to all new team members and should be taken once a year by all team members. The training is jointly led by a senior stroke physician and an intensive care nurse. It includes theoretical teaching (introduction to stroke pathophysiology and the penumbra concept, data on the impact of treatment delays on patient outcomes, NIHSS training, review of thrombolysis contraindications, introduction of the roles within the STROKE TEAM and introduction of efficient communication strategies in emergency situations). The theoretical teaching is followed by a simulator-based practical training of the complete algorithm from admission to the initiation of thrombolysis followed by a structured feedback round. The duration of the entire STROKE TEAM training session is 2 h. One principal aim of the STROKE TEAM training is to encourage efficient communication strategies such as respectful interaction, a spirit of shared responsibility, clear statements and closed-loop communication, sharing of information with all team members, and vigilance concerning errors allowing corrections from any team member.

To evaluate the impact of the STROKE TEAM on transition delays from the ED to the angiography suite in patients selected for mechanical recanalization of proximal vessel occlusion (middle cerebral arteries and basilar artery in CT or MR angiography), we analyzed procedural delays from admission to the onset of the recanalizing procedure. Data were retrieved from our institutional quality control registry [9]. Only patients that were admitted primarily to our neuro-center were included, not secondary referrals for interventional stroke therapy. We compared two prospectively-collected cohorts of consecutive patients. The pre-STROKE TEAM-cohort was treated from October 2006 to May 2009 [9]. The post-STROKE TEAM-cohort was treated after the implementation of the new algorithm from October 2012 to September 2013. Data are given as median ($25^{th}$, $75^{th}$ percentile). Statistical significance was tested with Chi Square Test or Mann-Whitney Test using IBM SPSS, Version 20 (IBM, Armonk, New York, USA).

## Results

In the year following the establishment of the STROKE TEAM (10/2012-09/2013), we administered thrombolysis to 65 patients, with a median DTN of 22 min ($25^{th}$-$75^{th}$ percentile 16-30 min, data not shown). 14 of these patients were selected for additional endovascular stroke therapy and another 5 patients were selected for endovascular stroke therapy only, mostly due to contraindications to IV thrombolysis such as anticoagulation or recent major surgery. Comparing the baseline characteristics (age, sex, onset to admission time, thrombolysis rate) (Table 1) of the pre-STROKE TEAM-cohort (treated from 2006 to 2009) to the post-STROKE TEAM-cohort (2012/2013), we found that the post-STROKE TEAM-cohort was significantly older (median age 78 vs. 68 years, $p = 0.006$), had a tendency towards a lower male-to-female ratio and a higher i.v. thrombolysis rate, whereas the interval between symptom recognition and admission to our hospital showed no relevant difference between groups. Regarding the transition of patients from the ED to the angiography suite, the faster DTN, which was halved by the introduction of the STROKE TEAM from a median time of 58 minutes to a median time of 23 minutes, was accompanied by significant shortenings of the door to angiography (groin puncture) times, IV thrombolysis to angiography times, and symptom onset to angiography times (Table 1).

## Discussion

We show that the relatively simple and non-technical measure of implementing a dedicated STROKE TEAM with defined tasks of all team members, regular training and an emphasis on efficient communication significantly reduces periprocedural delays such as the DTN. This was particularly valuable for patients selected for interventional stroke therapy, even though the main purpose of the STROKE TEAM was to improve standard stroke care with IV thrombolysis. We consider this to be a "positive side effect" of enhanced early interdisciplinary communication between neurologists and neuroradiologists assigned to the STROKE TEAM.

This observational study was directed at the effects of the implementation of the STROKE TEAM on periprocedural delays within our neuro-center in patients selected for endovascular stroke therapies. Therefore, we present a rather small number of 19 patients receiving endovascular therapy within the year of the STROKE

TEAM implementation after primary admission to our neuro-center. Patients secondarily referred to our neuro-center for endovascular stroke therapy after receiving acute care (including thrombolysis in a "drip and ship" approach if non-contraindicated) at another hospital were not included in this analysis. These 19 patients, however, are consecutive and non-selected and their periprocedural delays are compared to a well-characterized "historic" cohort of consecutive patients treated from 2006 to 2009. The nature of data collection (pseudonomized quality control without individual follow-up) does not allow the detection of an influence on clinical outcomes. However, subgroup analyses of the IMS-III trial showed a clear link between time to reperfusion and clinical benefit, emphasizing the importance of the factor time in the context of endovascular stroke therapy [10] that has also been documented by the recently published MR CLEAN trial [11].

## Conclusion

Our findings impressively show the positive impact of organizational efforts on the quality of stroke care. A STROKE TEAM composed of neurologists, neuroradiologists and emergency nurses with a standardized algorithm, defined tasks and regular team trainings significantly improves DTN as a quality measure of acute stroke care. Patients with severe strokes selected for endovascular stroke therapies seem to benefit particularly from these measures. Our findings reflect the individual responsibility but also the individual resources that dedicated stroke physicians can dispose of by shaping a dedicated STROKE TEAM according to the requirements of their individual hospital environment. All the measures taken in the implementation of our STROKE TEAM were definitely low-cost and demanded little but the resolute intention of all involved professionals to improve acute stroke care in our hospital. Or as the distinguished finish stroke neurologist Markku Kastephrased it: "We should not only demand more of hospital administration, or the chairpersons of our department to optimize the organization of inpatient stroke care, but also look in the mirror to find the person who must take on the challenge to improve local stroke services" [12].

## Disclosures

Waltraud Pfeilschifter received a research grant from Boehringer Ingelheim for a project that aims at implementing the STROKE TEAM in a regional stroke network. Helmuth Steinmetz received personal compensation from Boehringer Ingelheim. All other authors have no disclosures.

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