

CHAPTER 2

Achieving a door-to-needle time of 25 minutes in thrombolysis for acute ischemic stroke: a quality improvement project

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A B S T R A C T

Background

Providing intravenous thrombolysis with short door-to-needle time is the result of a complex process that requires specific work standards. To expedite care for acute ischemic stroke patients, close collaboration between all participating health care professionals is required. The aim of this project was to reduce in-hospital treatment delay for acute ischemic stroke patients through the introduction of a standard operating procedure and by creating higher and sustained awareness of the importance of intravenous thrombolysis.

Methods

This study was set up as a before-versus-after study, divided into a preintervention period, an immediate postintervention period, and a late postintervention period. During the study, a standard operating procedure was implemented that defined the targeted standard of care to be provided to all acute stroke patients. Involved health care professionals received regular feedback to create greater awareness of the importance of this time-driven protocol.

Results

The median door-to-needle time decreased significantly, from 60 minutes in the preintervention period to 30 minutes in the immediate postintervention period ($p < 0.001$), and compared with the immediate postintervention period it decreased significantly further, to 25 minutes, in the late postintervention period ($p < 0.001$). The proportion of patients with a door-to-needle time < 30 minutes and < 20 minutes increased significantly across the 3 study periods ($p < 0.001$).

Conclusions

The door-to-needle time for acute ischemic stroke patients can be reduced through the introduction of a standard operating procedure and by creating higher and sustained awareness of the importance of intravenous thrombolysis among health care professionals involved.

Introduction

Intravenous thrombolysis with recombinant tissue plasminogen activator (rt-PA) significantly improves the chance of recovery in acute ischemic stroke patients, but its benefit is strongly time-dependent.¹⁻³ Because of the importance of rapid treatment initiation, national and international guidelines emphasize the importance of initiating the intravenous thrombolysis as soon as possible after ischemic stroke onset.⁴ Providing intravenous thrombolysis with short door- to-needle time is the result of a complex process that requires specific work standards. To expedite care for acute ischemic stroke patients, close collaboration between all participating health care professionals is required. Because hospitals are dynamic environments that operate with many people rotating in and out of jobs, 24 hours a day, 7 days a week, differing work methods may compromise patient safety and may result in treatment delay. Furthermore, it is of vital importance that all health care professionals participating in the process of intravenous thrombolysis are aware of the time-dependent effects of this treatment.

To guide health care professionals through the process of intravenous thrombolysis, a written document detailing all necessary steps, including precautions, to complete the process of intravenous thrombolysis may be useful. Such a document is called a standard operating procedure and is generally defined as a detailed written instruction designed to achieve uniformity in the performance of a specific process.

The aim of this quality improvement project was to reduce in-hospital treatment delay for acute ischemic stroke patients through the introduction of such a standard operating procedure and by creating higher and sustained awareness of the importance of this time-driven protocol among all health care professionals involved in the process.

Methods

Design and Participants

This study was set up as a before-versus-after study, divided into 3 periods: the preintervention period (January 1, 2007-April 30, 2009), the immediate postintervention period (May 1, 2009-December 31, 2010), and the late postintervention period (January 1, 2011-December 31, 2012). All acute ischemic stroke patients who received intravenous thrombolysis at the Sint Lucas Andreas Hospital, a community hospital in Amsterdam, between January 1, 2007, and December 31, 2012, were enrolled in the study. The study is based on a prospective stroke registry of consecutive ischemic stroke patients treated with intravenous thrombolysis in the Sint Lucas Andreas Hospital since 2007. This database is used to drive iterative quality of care improvement for ischemic stroke patients. We obtained institution review board approval to conduct this analysis.

Interventions

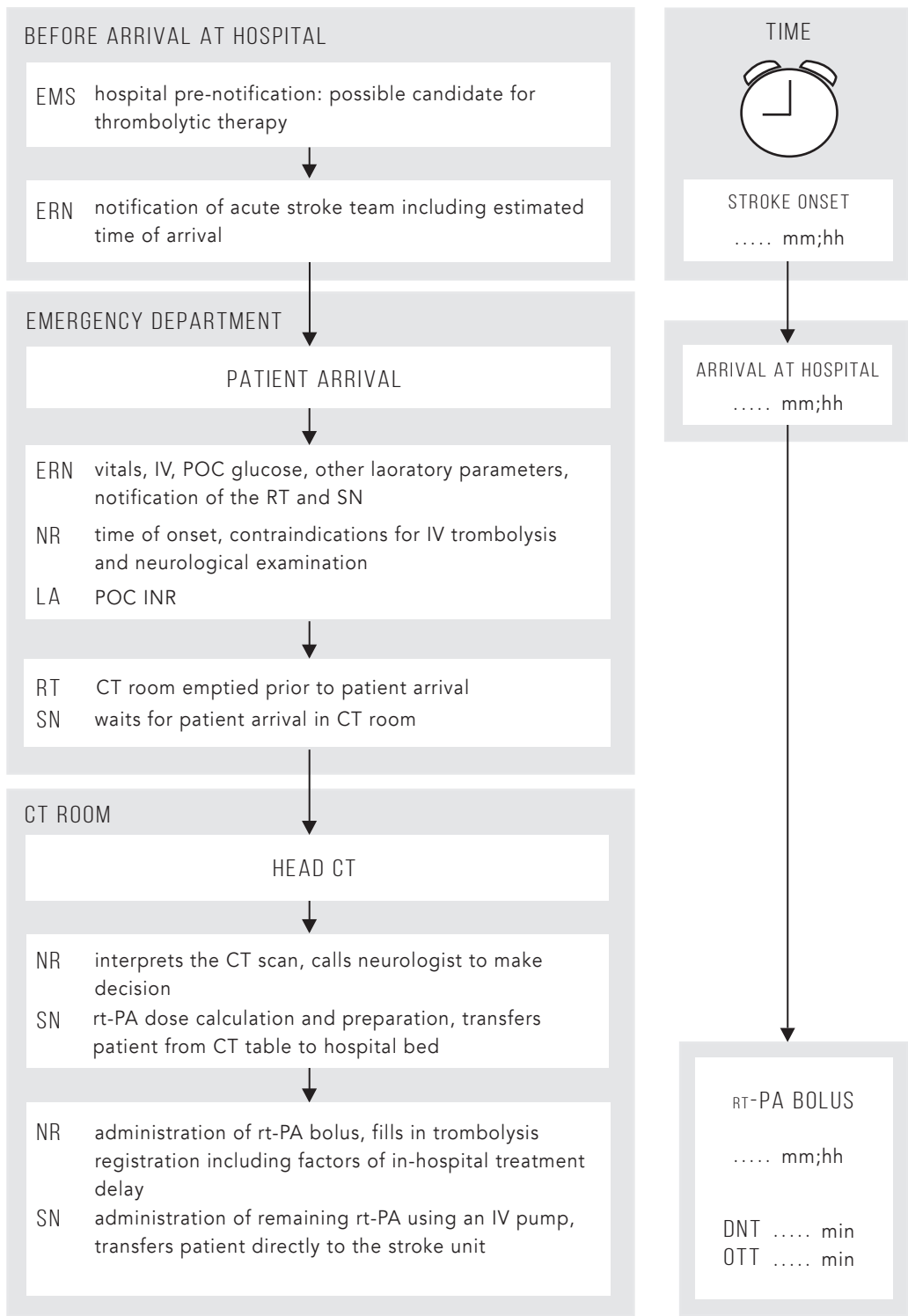
First, a multidisciplinary team consisting of a neurologist, a neurology resident, a stroke nurse, and an emergency department nurse analyzed the existing process pathway of intravenous thrombolysis. Second, the team implemented several systemic improvements to improve patient flow and reduce in-hospital treatment delay (Table 1). Third, the team developed a standard operating procedure that defined the targeted standard of care to be provided to all patients eligible for intravenous thrombolysis. This standard operating procedure described all necessary steps, including precautions, to complete the process of intravenous thrombolysis in acute ischemic stroke patients (Figure 1). In addition, it defined the roles and responsibilities of every member of the participating departments at each moment during the process. The standard operating procedure became effective on May 1, 2009. This marked the beginning of the immediate postintervention period. Instructional meetings were held for several weeks before the standard operating procedure became effective. These meetings

TABLE 1 Systemic improvements incorporated in the standard operating procedure

Systemic improvement	Description
The formation of an acute stroke team	A team consisting of a neurologist, a neurology resident, a stroke nurse, an emergency department nurse, a radiology technician and a laboratory analyst were immediately available, 24 hours a day, 7 days a week.
The introduction of hospital pre-notification	Health care professionals working at the emergency medical dispatcher service notified the hospital's emergency department when a possible candidate for intravenous thrombolysis was being transported. This allowed the complete acute stroke team to be prepared before patient arrival at the emergency department.
The use of a point-of-care laboratory	The laboratory analyst was equipped with a point-of-care INR device. This device offers a simple and fast way of directly determining if a patient is using vitamin K antagonists. It allowed this key laboratory examination to be transferred from the centralized hospital laboratory to the patient in the emergency room. In addition to the INR, glucose was also tested with a point-of-care device.
The achievement of CT priority	CT priority was achieved for patients eligible for intravenous thrombolysis. The CT room was cleared prior to hospital arrival of a possible candidate for thrombolysis.
Administering the rt-PA bolus on the CT table	After performing a head CT, patients were immediately transferred from the CT table to a hospital bed and the rt-PA bolus was subsequently administered in the CT room. This was followed immediately by administration of the continuous infusion. After the start of the continuous infusion patients were directly transferred to the stroke unit of our hospital.

FIGURE 1 Standard operating procedure

CHAPTER 2: ACHIEVING A DOOR-TO-NEEDLE TIME OF 25 MINUTES IN THROMBOLYSIS FOR ACUTE ISCHEMIC STROKE: A QUALITY IMPROVEMENT PROJECT



were held to increase awareness among the health care professionals involved about the importance of intravenous thrombolysis for acute ischemic stroke patients and its time-dependent benefit. The meetings were repeated regularly, and, as a reminder, the standard operating procedure was printed on “pocket cards” and distributed to all health care professionals involved.

In the late postintervention period, the interventions were extended into a long-term sustainability program, including annual instructional meetings. In addition, the standard operating procedure was evaluated regularly, based on in-hospital treatment delay factors using an annual quality cycle. These in-hospital treatment delay factors were recorded in the prospective stroke registry in which each individual acute ischemic stroke patient was registered directly after treatment.

Outcomes Measures

The primary outcome of this study was the median door-to-needle time, defined as the median time between hospital arrival and administration of the rt-PA bolus, during the 3 study periods described previously. Baseline data were collected through medical record review. The patient’s age, sex, door-to-needle time, in-hospital treatment delay factors, and possible complications were determined. Secondary outcomes were the intravenous thrombolysis rate (number of ischemic stroke patients treated with intravenous thrombolysis divided by the total number of ischemic stroke patients), the percentage of patients treated within 60 minutes, the percentage of patients treated within 30 minutes, the percentage of patients treated within 20 minutes, in-hospital delay factors, and complication rates.

Abbreviations: EMS = emergency medical dispatcher service; ERN = emergency room nurse; LA = laboratory analyst; NR = neurology resident; POC = point of care; RT = radiology technician; rt-PA = recombinant tissue plasminogen activator; SN = stroke nurse.

Statistical Analysis

All statistical analyses were carried out using IBM SPSS statistics version 20. Dichotomous data are described as numbers and percentages, and continuous data are presented as means with standard deviations. For non-normal distributed outcomes, we reverted to median values and interquartile range. Differences among the study periods were analyzed with the Mann-Whitney U test for comparison of 2 groups and the Kruskal-Wallis test for comparison of 3 groups. Differences in measures with a dichotomous outcome were analyzed with chi-square tests. A 2-tailed $p < 0.05$ indicated statistical significance.

Results

Baseline Characteristics

In total, 2696 ischemic stroke patients were admitted to the neurology department during the entire study period (January 2007-December 2012). Of this total, 316 patients were treated with intravenous thrombolysis because of an acute ischemic stroke. All of the 316 patients (41 in the preintervention, 90 in the immediate postintervention, and 185 in the late postintervention periods) were enrolled in this study. Median patient age was 74 years (interquartile range [IQR] 62-82), and 177 (56%) of the patients were men. Baseline characteristics were similar among the 3 study periods (Table 2).

Primary and Secondary Outcome Analysis

Primary Outcome

The median (IQR) door-to-needle time was significantly different across the 3 study periods ($p < 0.001$) (Table 2). The median door-to-needle time decreased significantly, from 60 minutes (41-65 minutes) in the preintervention period, to 30 minutes (25-40 minutes) in the immediate postintervention period ($p < 0.001$) (Figure 2). In addition, compared with the immediate postintervention period, the median

TABLE 2 Demographic parameters, outcome and safety measurements

	Pre-intervention n=41	Immediate post-intervention n=90	Late post-intervention n=185	p-value
Age (years), median (range)	70 (57-79)	76.5 (62-83)	75 (62-83)	0.179*
Men, n (%)	22 (53.7)	48 (53.3)	107 (57.8)	0.739#
Ischemic stroke patients, n	828	917	951	
Percentage of ischemic stroke patients treated with IV thrombolysis, %	5.0	9.8	19.5	<0.001#
Median DNT (IQR), min	60 (41-65)	30 (25-40)	25 (20-37)	<0.001*
DNT <60 min, %	70.7	98.9	94.1	<0.001#
DNT <30 min, %	2.4	51.1	71.9	<0.001#
DNT <20 min, %	2.4	15.6	35.1	<0.001#
Symptomatic intracranial hemorrhage <36 h, n (%)	3 (7.3)	3 (3.3)	9 (4.9)	0.606#
Serious systemic hemorrhage <36 h, n (%)	1 (2.4)	1 (1.1)	1 (0.5)	0.516#

Abbreviations: DNT = door-to-needle time; IQR = interquartile range; IV = intravenous; OTT = onset-to-treatment-time; SD = standard deviation.

*Groups were compared by Kruskal-Wallis test.

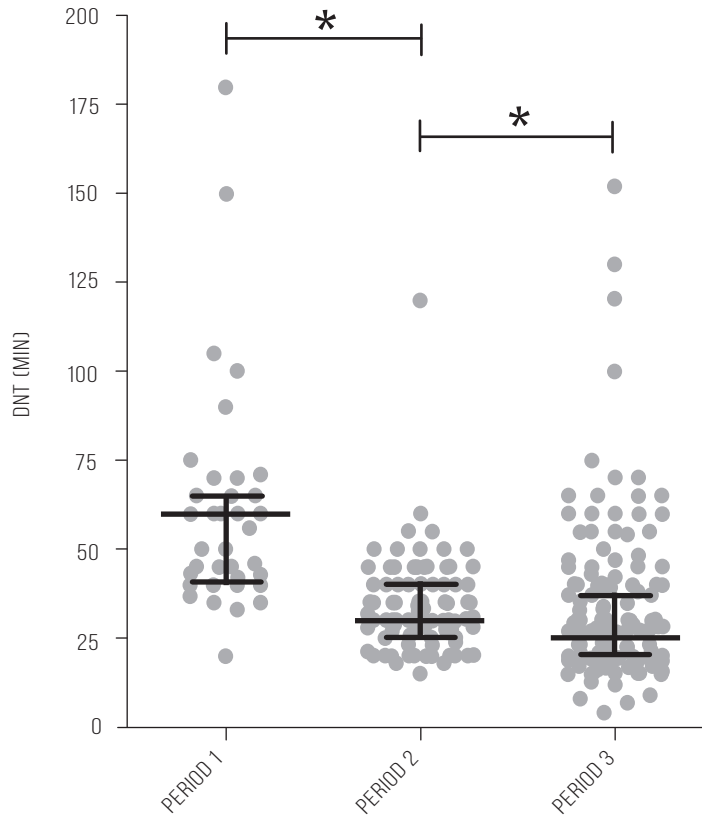
#Groups were compared by chi-squared test.

(IQR) door-to-needle time significantly decreased further, to 25 minutes (20-37 minutes) in the late postintervention period ($p < 0.001$) (Table 2, Figure 2).

Secondary Outcome

The intravenous thrombolysis rate increased across the 3 study periods, from 5.0% in the preintervention period to 9.8% in the immediate postintervention period and to 19.5% in the late postintervention period. The proportion of patients with a door-to-needle time <60

FIGURE 2 Scatter plots showing median and interquartile range of annual door-to-needle times



Data are median and interquartile range. Period 1 = the preintervention period; Period 2 = the immediate postintervention period; Period 3 = the late postintervention period. * $p < 0.001$ by Mann-Whitney U test.

minutes increased significantly, from 70.7% in the preintervention period to 98.9% in the immediate postintervention period ($p < 0.001$); compared with the immediate postintervention period, it decreased nonsignificantly to 94.1% in the late postintervention period ($p = 0.111$) (Table 2). The proportion of patients with a door-to-needle time < 30 minutes significantly increased, from 2.4% in the preintervention

period to 51.1% in the immediate postintervention period ($p < 0.001$); compared with the immediate postintervention period, it significantly increased further, to 71.9% in the late postintervention period ($p < 0.001$) (Table 2). In addition, the proportion of patients with a door-to-needle time < 20 minutes significantly increased, from 2.4% in the preintervention period to 15.6% in the immediate postintervention period ($p = 0.036$); compared with the immediate postintervention period, it significantly increased further, to 35.1% in the late postintervention period ($p < 0.001$) (Table 2).

To determine if the reduction of in-hospital treatment delay came at the expense of patient safety, complication rates between the study periods were compared. No significant differences in complication rates concerning symptomatic intracranial hemorrhage ($p = 0.606$) or serious systemic hemorrhage ($p = 0.516$) were found (Table 2).

The standard operating procedure was evaluated regularly, based on in-hospital treatment delay factors. Before the introduction of the standard operating procedure, the international normalized ratio was a major cause of delay in the evaluation of possible candidates for intravenous thrombolysis and often lasted more than 30 minutes. After the introduction of the standard operating procedure, factors that continued to be associated with in-hospital treatment delay included difficulty obtaining peripheral venous access and the immediate unavailability of computed tomography (CT), despite the achievement of CT priority for all possible candidates for intravenous thrombolysis.

Discussion

In this quality improvement project, the door-to-needle time in intravenous thrombolysis for acute ischemic stroke patients was significantly reduced through the introduction of a standard operating procedure and by creating higher and sustained awareness of the importance of this time-driven protocol among all health care professionals involved. The standard operating procedure included multiple simple systemic improvements, which can easily

be implemented in daily care for acute ischemic stroke patients. These interventions had an immediate positive impact on in-hospital treatment delay and this effect appeared to be sustainable and even improved over an extended period. Although the largest reduction in in-hospital treatment delay was achieved in the immediate postintervention period, the median door-to-needle time significantly decreased further to 25 minutes in the late postintervention period. We presume that this further decrease in door-to-needle time in the late postintervention period is the direct result of the annual instructional meetings and the knowledge gained through the increasing number of patients treated annually.

Multiple previous studies have demonstrated the effect of different single interventions on in-hospital treatment delay for patients with acute ischemic stroke. These interventions included the introduction of preadmission hospital notification,⁵⁻⁸ the introduction of a stroke code system,⁹ the introduction of an all-points alarm,¹⁰ the formation of an acute stroke team,¹¹ the introduction of point-of-care laboratory examinations,¹² the introduction of a standardized thrombolysis procedure,^{13,14} and the use of Toyota's Lean Manufacturing Principles and Value Stream Analysis.¹⁵ The effect of multiple interventions on in-hospital treatment delay in intravenous thrombolysis was demonstrated by a study by Meretoja et al in the Helsinki University Central Hospital.¹⁶ In their study, a series of interventions was implemented between 1998 and 2011 to reduce in-hospital treatment delay for acute ischemic stroke patients. These interventions included the involvement of the emergency medical dispatcher service, the use of hospital prenotification, the use of an alarm and preordering of tests, no delay in CT interpretation, premixing of rt-PA, delivery of rt-PA on the CT table, the CT being relocated to the emergency room, the achievement of CT priority, rapid neurological examination, preacquisition of disease history, the use of point-of-care laboratory investigations, and reduced imaging. These interventions resulted in a significant reduction of door-to-needle time, with half of the

patients being treated within 20 minutes after hospital arrival.¹⁶ Our study confirms the impact of multiple, simple systemic improvements on in-hospital treatment delay for acute ischemic stroke patients and shows that short door to needle times can be accomplished in a community hospital. Furthermore, in our study this effect appeared to be sustainable and even improved over an extended period. In addition, our results demonstrate that a short door-to-needle time can be achieved without relocating the CT to the emergency room, although doing so might reduce the door-to-needle time even further. The results of our study, with respect to in-hospital treatment delay, compare favorably with those reported in previous analyses of large international stroke registries. In these registries, the percentage of patients treated with a door-to-needle time of less than 60 minutes ranged between 27% and 38%, compared with 94% in our study.^{17,18} In addition, median door-to-needle times from the American Heart Association/American Stroke Association Get With The Guidelines–Stroke program and the Safe Implementation of Treatment in Stroke–International Stroke Thrombolysis Registry were 75 and 65 minutes, respectively, compared with 25 minutes in our study.^{17,19} To reduce in-hospital delay for acute ischemic stroke patients, the American Heart Association/American Stroke Association began a national initiative in 2010 to assist hospitals in increasing the proportion of patients treated with intravenous thrombolysis within 60 minutes after hospital arrival. The goal of this initiative, called “Target: Stroke,” is to achieve a door-to-needle time of less than 60 minutes in at least 50% of acute ischemic stroke patients.²⁰

This study has several limitations. First, the number of patients included in the preintervention period is relatively small. However, even with the small number of patients in the preintervention period, we were able to demonstrate a significant decrease in door-to-needle time. Second, although the reduction of in-hospital treatment delay of intravenous thrombolysis will likely translate into improved outcomes for our patients, the present study did not assess patient outcomes.

Third, because of the multiple concomitant systemic improvements incorporated in the standard operating procedure, it is not possible to determine how much each step contributed to the overall reduction of the door-to-needle time.

In summary, the door-to-needle time for acute ischemic stroke patients can be substantially reduced through the introduction of a standard operating procedure and by creating higher and sustained awareness of the importance of this time-driven protocol among all health care professionals involved. The standard operating procedure can easily be implemented in daily care for acute ischemic stroke patients. The effect of these interventions on door-to-needle time appeared to be sustainable, and even improved, over an extended period.

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