Effect of a revised thrombolysis protocol on the door-to-needle time in acute ischemic stroke patients: a quasi-experimental study

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Abstract

Title: Effect of a revised thrombolysis protocol on the door-to-needle-time in acute ischemic stroke patients.

Background: Intravenous thrombolysis treatment for acute ischemic stroke patients that can only be applied up to 4.5 hours within the onset of symptoms. Time from arrival at the hospital to start of thrombolytic treatment, “door-to-needle-time” is important to measure the quality of care. A revised thrombolysis protocol was introduced with an acute stroke team as part of this protocol to reduce the door-to-needle-time. Accuracy for activation of the acute stroke team is important because no activation of this team leads to undertriage.

Aim: Evaluate the effect of the revised protocol on the door-to-needle-time and the accuracy of activations of this team.

Method: A quasi-experimental pretest/post-test study was conducted on the emergency department in a regional hospital to compare the door-to-needle-time between the groups before and after implementation of the revised thrombolysis protocol and was analysed using descriptive statistics. Over- and undertriage rates of activation of the acute stroke team were calculated for the after group.

Results: A reduction of the median door-to-needle-time of 17 minutes was found in the after group. A reduction in more than half of the time was observed in the subinterval CT-to-needle-time. The undertriage rate was 22.4% and the overtriage rate was 64.8% for activating the acute stroke team.

Conclusion: The revised thrombolysis protocol has shown a significant reduction in the door-to-needle-time in patients who received intravenous thrombolytic therapy. A relatively high undertriage rate was found, which is important to reduce because it can worsen patient outcomes. The relatively high overtriage rate should be reduced without increasing the undertriage rate.

Recommendations: Further research of the door-to-needle-time is needed when patients in the future are directly admitted at the CT-scan. Next to that, the reason for undertriage should be further explored.

Keywords: thrombolysis, door to needle time, acute stroke team, emergency nurse [MeSH]

Dutch summary

Titel: Effect van het geoptimaliseerde trombolyse protocol op de door-to-needle-tijd bij patiënten met een acuut herseninfarct.
Achtergrond: Intraveneuze trombolyse behandeling voor patiënten met een herseninfarct kan alleen worden toegediend binnen 4,5 uur na het ontstaan van de symptomen. Tijd van aankomst in het ziekenhuis tot de start van de trombolyse behandeling, de “door-to-needle-tijd” wordt gebruikt om de kwaliteit van zorg te meten. Om de door-to-needle-tijd te verkorten werd het geoptimaliseerde trombolyse protocol ingevoerd, waarvan het trombolyseteam een onderdeel is. Het nauwkeurig oproepen van het trombolyseteam is belangrijk omdat het niet activeren van dit team kan leiden tot ondertriage.
Doel: Effect van het geoptimaliseerde trombolyse protocol evalueren aan de hand van de door-to-needle-tijd en de nauwkeurigheid van het oproepen van het trombolyseteam.
Methode: Een quasi-experimenteel pretest/post-test studie werd uitgevoerd binnen de spoedeisende hulp van een regionaal ziekenhuis om de door-to-needle-tijd voor en na de implementatie van het geoptimaliseerde protocol te meten, welke werd geanalyseerd door middel van beschrijvende statistiek. Voor de na-groep werden over- en ondertriage percentages berekend voor het oproepen van het trombolyseteam.
Resultaten: Een verkorting van de mediane door-to-needle-tijd van 17 minuten werd gevonden in de na-groep. Het ondertriage percentage was 22.4% en het overtriage percentage was 64.8% voor het oproepen van het trombolyseteam
Conclusie: Het geoptimaliseerde trombolyse protocol liet een significante verkorting van de door-to-needle-tijd zien bij patiënten welke intraveneuze trombolyse ontvingen. Een relatief hoog ondertriage percentage werd gevonden, belangrijk is om deze te verlagen omdat dit nadelige gevolgen kan hebben voor patiënten. Het relatieve hoge overtriage percentage zou verlaagd moeten worden zonder de ondertriage te laten verhogen.
Aanbevelingen: Vervolg onderzoek van de door-to-needle-tijd is nodig wanneer patiënten in de toekomst direct opgevangen worden op de CT-scan. Daarnaast, de reden van ondertriage moet verder uitgezocht worden.

Zoektermen: trombolyse, door to needle tijd, trombolyse team, spoedeisende hulp verpleegkundige [MeSH]

Background

Approximately 17 million patients in the world suffer from stroke each year, which causes almost six million deaths.[1] Acute ischemic stroke (AIS) accounts for 75% of all stroke patients.[2] AIS is the result of an obstruction within a blood vessel supplying blood to the brain.[3] Many survivors of stroke have disabilities and cognitive deficits.[4] Thrombolysis with intravenous recombinant tissue plasminogen activator (rtPA) is the treatment of choice for patients with AIS,[5] to dissolve blood clots to restore cerebral blood flow.[6] Intravenous rtPA can only be applied up to 4.5 hours within onset of symptoms, and the benefit of intravenous rtPA treatment for AIS patients is strongly time dependent.[5, 7] Delays in treatment will inevitably translate into worse outcomes.

Time from arrival at the hospital to start of intravenous rtPA treatment, the “door-to-needle time” (DNT) is an important performance indicator to measure the quality of care for AIS patients. The standard for the DNT is a median of 30 minutes or less for 80% of all AIS patients treated with intravenous rtPA.[8] In the Netherlands, a wide variation in the DNT is observed between hospitals[9], depending on the process management of each individual hospital.[10] Patient-relating factors, such as fluctuating neurological deficit and uncertainty about symptom onset, delay the DNT.[11] In addition, previous studies showed that there is room for improvement in the in-hospital logistics.[10-12]

Incorrect triage and technical problems are factors associated with in-hospital delay.[11] To minimise delays, organising optimal acute care is a crucial step in improving outcomes after AIS to minimise delay in DNT. Previous studies have shown positive results of a revised protocol and the introduction of an acute stroke team on the DNT.[13-15] In a revised protocol, time wasting activities were avoided, resulting in an optimization of the in-hospital process. In addition to a revised thrombolysis protocol, the introduction of an acute stroke team is important. This team must be able to coordinate, evaluate, and treat stroke patients in a rapid but effective manner.[16] The introduction of an acute stroke team and the revised thrombolysis protocol will hereafter be called the revised thrombolysis protocol, see Figure 1 for a flow chart of this protocol. Before the patient arrives at the emergency department (ED), pre-notification of the ambulance or general practitioner leads to activation of the acute stroke team and the immediate preparation of the CT scan. All professionals in this multidisciplinary team are notified that a possible thrombolysis patient will arrive.

For activation of the acute stroke team, emergency nurses play a major role in triaging patients, based on the pre-notification of the previous health care provider, and make crucial decisions, which can influence the DNT time.[11] An outcome of triage is to activate the right

team and resources, which are necessary for patient treatment. Triage-decision making is affected by task complexity, conflict, nursing experience, education, and expertise.[17] Emergency nurses must be able to make accurate decisions in a relatively brief time, based on a referrer, to activate an acute stroke team when a patient with possible AIS is identified. Ideal criteria for activation of this team should be 100% sensitive, which means it should identify all possible AIS patients. However, the unnecessary activation of an acute stroke team leads to overtriage, which could result in unnecessary load on the acute stroke team professionals. No activations of an acute stroke team for possible AIS patients leads to undertriage. It is important to have low undertriage rates because undertriage can worsen patient outcomes.[18]

To improve DNT, minimize delays, and improve quality of care, the revised thrombolysis protocol was introduced in 2015. It is essential to reduce the DNT because faster treatment has results in better patient outcomes. Additionally, no previous studies have examined the accuracy of activations of an acute stroke team.

Research Questions:

The primary research question of this study is as follows: “What is the effect of the revised thrombolysis protocol at the emergency department on the door-to-needle time in patients with AIS who received intravenous thrombolytic therapy?”

Furthermore, the following question will be answered: “What are the over- and undertriage rates of acute stroke team activations at the emergency department in patients with AIS?”

Method

Design

A quasi-experimental pretest/post-test design was conducted[19, 20] to evaluate the effect before and after the introduction of the revised thrombolysis protocol on the DNT for AIS patients. This study was conducted at the ED in a large regional hospital in the Netherlands and was approved by the Medical Research Ethics Committee of Twente (K16-16) and the board of directors of the hospital.

Study population

The population consisted of all consecutive patients with symptoms of stroke presented to the ED during two periods: before and after the revised thrombolysis protocol. The acute stroke team was introduced in January 2015. The period of February 1 to December 31, 2014 is reported as the “before group” and the period of February 1 to December 31, 2015 is reported as the “after group”. February was chosen so that the staff could become to the revised thrombolysis protocol. Patients were eligible if they met the following inclusion criterion: symptoms of stroke presented to the ED. To evaluate the accuracy of activations of the acute stroke team, only patients of the after group were included. Patients from clinical units and outpatient clinics in the hospital who were eligible or received rtPA treatment for intravenous thrombolysis were excluded because these patients were not presented to the ED.

Sample

In this study, a consecutive sample[19] was used because all patients were included who were registered in the Stroke Database Enschede and met the inclusion criterion over the two specific time intervals.

Intervention

The revised thrombolysis protocol involves the following: (1) activation of an acute stroke team and (2) logistic process optimization. The acute stroke team will be activated based on the pre-announcement of a possible thrombolysis patient from a previous health care provider, such as an ambulance or general practitioner. To activate this team, the patient must have symptoms of stroke and the symptom onset must be within the time window of 4.5 hours before presentation. The acute stroke team includes emergency nurses, a neurology resident, an on-call neurologist, a radiology resident, an on call radiologist, a radiology technician, and laboratory personnel. All professionals in this multidisciplinary team are notified that a possible thrombolysis patient will arrive, which leads to immediate preparation

of the CT scan. The logistic process optimization includes presence of the acute stroke team professionals at the ED before the patient's arrival and administration of the rtPA immediately after the CT scan is ready in the same room, after which the patient is admitted to the stroke unit. All professionals were trained with the revised thrombolysis protocol.

Data collection and procedures

Data were retrospectively derived by a data manager and a researcher from the following databases: the Stroke Database Enschede (ESS) and the Emergency Department database (E-care). All data were registered in both databases by professionals during the process of care for patients in daily practice. The ESS database is an ongoing registration of all patients with Transient Ischemic Attack (TIA) and ischemic stroke admitted at the stroke unit. For both groups, the following demographic data were collected from this database: age, gender, National Institutes of Health Stroke Scale (NIHSS) score, vascular risk factors, and history. To measure time intervals, also the symptom-to-door time (SDT), door-to-CT scan time (DCT), CT scan-to-needle time (CNT), and the DNT were collected from this database. Definitions of these time intervals are shown in Table 1. E-care is the database that supports the medical care process in the ED all performed actions were registered in this system. For the after group, the following data were collected: activation of the acute stroke team (to evaluate the accuracy of activations), received rtPA treatment, and the referring healthcare provider.

In July 2015, the E-care database for registration of the activation of an acute stroke team was changed. A check box was added in the E-care database in which can be indicated that the acute stroke team was activated. Data was collected in the same way before and after this change. Free text fields were studied for indications of acute stroke team activations. Based on these free text descriptions, activation of the stroke team was per patient labelled as follows: (1) yes, (2) no, (3) description of thrombolysis but activation of acute stroke team not described, (4) unclear, and (5) other. Labelling was chosen per patient because the registration of the acute stroke team activations was not always correctly documented by health care professionals in the E-care database, so only yes and no answers would not accurately reflect reality. An example of label 3 is that, in daily practice, when a possible thrombolysis patient was pre-announced by a previous health care provider (ambulance or general practitioner), the acute stroke team was activated, which was not always reported in the E-care database. Therefore, we decided on label 3 when there was a description of a thrombolysis patient in the E-care system and in daily practice, the acute stroke team would

be activated. An example of unclear is that the patient met the criteria of a possible stroke patient, but whether the acute stroke team was activated was undescribed in the E-care database. Patients with the label other were initially referred to another specialty, for example, to internal medicine with symptoms of vomiting, dizziness, and double vision. A researcher with an emergency nursing background labelled team activations for all patients in categories in cases of doubt, cases were discussed with a second researcher to reach consensus. Later, these labels were combined in order to determine true positive, true negative, false positive, and false negative activations and over- and undertriage rates.

Data analysis

For comparison of baseline data before and after the revised thrombolysis protocol, descriptive statistics were used. Dichotomous data were described as numbers and percentages, continuous data as means and standard deviations. Differences between the groups were analysed by the independent t test for continuous data and the X^2 test for categorical parameters. Non-normally distributed data were presented as median and interquartile ranges and were analysed by the Mann-Whitney U test. In the after situation the under- and overtriage rates were calculated using a sensitivity and positive predictive value (PPV) calculation. The complement of the sensitivity can be seen as the undertriage rate, which refers to the proportion of patients who were not seen by an acute stroke team despite receiving rtPA treatment (1-sensitivity). The overtriage rate is defined as the proportion of patients with no rtPA treatment among those who were seen by an acute stroke team (1-PPV). Statistical analysis was performed using IBM SPSS statistics, version 22.0.[22]

Results

A total of 675 patients with suspected strokes were admitted to the ED in 2014 before the revised thrombolysis protocol and 723 patients in the after period in 2015: see Figure 2. Out of these, 99 (14.7%) patients in 2014 were treated with rtPA and 107 (14.8%) patients in 2015.

Baseline characteristics

No significant differences in patient characteristics were found between both groups. Mean ages for both groups was 71 years. In the before group, 52.3% were female and, in the after group, 47.9%. For both groups, the median NIHSS score was 3 (IQR: 1-6). There were no statistically significant differences in vascular risk factors between both groups. In the before group, there were significantly more patients with TIA in the history of vascular diseases. Patient characteristics are summarized in Table 2.

DNT

Median DNT was significantly shorter in the after group than in the before group. Patients in the after group had a 17 minutes shorter median DNT than patients in the before group (40 vs 23 minutes; $p < 0.01$). In the after group, 72.9% had a median of 30 minutes or less. Most reduction was observed in the subinterval CTN, which was 11 minutes shorter in the after group (19 vs 8 minutes; $p < 0.01$): see Table 3.

Over- and undertriage rates of acute stroke team activation

A total of 723 patients in the after group with suspected strokes were admitted to the ED, of which 107 patients were treated with rtPA. The acute stroke team was correctly activated in 64 cases for patients who received rtPA and were defined as true positives. In 19 cases, the pre-announcement indicated that the patient was a possible thrombolysis patient: these cases were defined as true positive despite the fact that activation of the acute stroke team was not described. In eight cases, the acute stroke team was not activated while patients received rtPA: these cases, therefore, were defined as false negative. In 16 cases, the activation of the acute stroke team was unclear: these were considered not activated and, therefore, also defined as false negatives. A total of 616 patients did not receive rtPA. In 111 of these cases, the acute stroke team was activated, and therefore, these cases were defined as false positives. In 42 cases, the pre-announcement indicated that the patient was a possible thrombolysis patient, but the activation of the acute stroke team was not described: these cases were considered activated and defined as false positives. In 402

cases, the acute stroke team was indeed correctly not activated and these cases were defined as true negatives. Most of the true negative defined patients did not met the time window criterion of 4.5 hours of symptom onset before presentation. The activation of the acute stroke team was unclear in 44 cases who received no thrombolysis: these were considered not activated and defined as true negatives. Seventeen cases were considered not activated, because patients were initially referred to a specialty other than neurology, and were defined as true negatives. The sensitivity of accuracy for the activation of the acute stroke team was 77.6%, and the PPV was 35.2%. The rate of undertriage for activating the acute stroke team was 22.4% and the rate of overtriage for activating the acute stroke team was 64.8%: see Table 4. In cases defined as false positives, it is possible that activations of the acute stroke team were correct: these patients were defined as overtriage because rtPA treatment was not indicated after assessment of the acute stroke team.

In eight of the cases the acute stroke team was certainly not activated but should have been because these patients received rtPA. Five of these cases were referred by a general practitioner and three by the ambulance services. In three cases, symptoms of stroke were described and the patient met the time window criterion. Based on the pre-announcement information known, the acute stroke team should have been called, according to the revised thrombolysis protocol.

DNT of the activation acute stroke team and no activation acute stroke team

In the activation acute stroke team group the median DNT was significantly shorter than in the no activation acute stroke team group for patients who receiving rtPA. Patients in the activation acute stroke team group had a 11 minutes shorter median DNT than the no activation acute stroke team group (32 vs 21 minutes; $p < 0.01$): see Table 5.

Discussion

The present study evaluated the effect of the revised thrombolysis protocol on the DNT in patients who had received intravenous rtPA. A significant reduction of the median DNT of 17 minutes was found in the after group. Most reduction was seen in the subinterval CTN, with a reduction in more than half of the time. This is most likely the result of the revised thrombolysis protocol, in which the rtPA is administered immediately after the CT-scan, in the same room. Furthermore, the accuracy of activating the acute stroke team was evaluated. The overall rate of undertriage was 22.4%, and the overall rate of overtriage was 64.8%. A 11 minutes shorter median DNT was found in the group activation acute stroke team, compared to the group no activation acute stroke team for patients who received rtPA. Correct activation of the acute stroke team reduced also the DNT for AIS patients.

The median DNT we found is comparable with previously reported short DNTs in other studies.[11, 23] A Finnish study found that half of the patients were treated within a median DNT of 20 minutes: however, in this study, patients were directly admitted to the CT scan and not first to the ED.[23] In a Dutch study, with comparable hospital logistic as ours, they found a median DNT of 25 minutes.[11] The DNT in our population was relatively high in the before group: after the revised thrombolysis protocol this decreased significantly, although still only 72.9% of the patients had a DNT of 30 minutes or less, which is less than the current standard of 80%.[8] Another study, conducted in Washington in a comparable setting, evaluated interventions to optimise the process of intravenous rtPA treatment and also found a reduction of the median DNT.[24] However, median DNT was higher in the before situation than ours namely 60 minutes and reduced in the after situation to 39.[24] This is a considerably longer median DNT compared to our study.

Several studies reported that a pre-notification from an ambulance or general practitioner improves the in-hospital treatment time.[25-27] To the best of our knowledge, this is the first study that investigated the accuracy of the activation of an acute stroke team based on pre-notification and over- and undertriage rates of such a team. No guidelines or target was found for under- and overtriage rates of acute stroke teams. The undertriage rate of 22.4% is relatively high compared to the guidelines of a maximum of 5% undertriage in the American College of Surgeons (ASC-COT), used for the prehospital triage of trauma patients, which is comparable to the triage of stroke patients in this study.[18] For both patient populations, a (trauma or acute stroke) team will be activated when a patient is identified. In this study, eight cases were found when the acute stroke team certainly not was activated, of which, in three cases, it was clearly described that the patients had stroke symptoms and were referred

within the time window of 4.5 hours. In two of these cases, it was described that the neurologist resident will assess the patient at arrival whether or not thrombolysis was indicated. This is not in accordance with the revised thrombolysis protocol and leads to delay. It might be possible that the undertriage rate was relatively high because the registration of the activation of the acute stroke team was not always documented in the medical record by medical professionals. In trauma patients, an overtriage rate up to 30% to 50% overtriage is accepted to maintain a maximum of 5% undertriage.[18] The overtriage rate in this study was relatively high (64.8%) compared to the ASC-COT guideline. Rates of over- and undertriage in this study are based on the need for rtPA treatment. It might, therefore, be possible that the rate of overtriage was relatively high because potential thrombolysis patients met the criteria for activating the acute stroke team, but when the patient arrived at the ED, the patient did not receive rtPA treatment (e.g., due to contra-indications or absence of symptoms). Despite the fact that activations of the acute stroke team were correct, these patients were defined as overtriage because no rtPA treatment was given. This means that the overtriage rate, in reality, will be lower, and it is expected that it will meet the criteria of the ASC-COT guidelines.

An earlier study examined the prevalence of pre-notifications of stroke patients to evaluate whether the pre-notification protocol was being followed by ambulance services.[27] In the pre-notification protocol of that study, the patient had to meet five criteria in order to activate a stroke team for possible thrombolysis patients. One of these criteria was that a patient must have a positive Face Arm Speech Test (FAST) to detect stroke symptoms. In the guidelines of our study, the criterion was that patients must have symptoms of stroke. This is a broad criterion in contrast to the more specific FAST criteria. FAST reached high levels of detection and diagnostic accuracy of stroke: [28] these criteria could be a guide to detect possible thrombolysis patients based on the pre-notification of the previous referrer, which could lead to lower undertriage rates.

Strengths and limitations

A strength of this study was the inclusion period of almost two years, which means that the study could include a fairly large patient population with no difference in the baseline characteristics. The population in this study is representative of other studies.[10, 11] Additionally, there were no missing values in the data set of the DNT, which lead to high reliability of this part of the study. Also, after combining data from the two databases (ESS and E-care), there was a 100% match of the data.

Some limitations must be discussed. In this study, data were retrospectively derived: as a consequence, the accuracy of the data was dependent on the accuracy with which it was documented by healthcare professionals during the care process. Registration of the activation of the acute stroke team, especially, was poor and not always correctly documented. We, therefore, decided to study free text fields in all patient records in order to determine activation status of the acute stroke team. A researcher with an emergency nursing background labelled team activations for all patients in categories so that over- and undertriage rates could be more accurately reflect realty

Recommendations for practice and further research

The revised thrombolysis protocol shows a shorter median DNT, and therefore, it should be used in practice at all times. When patients are directly admitted at the CT scan, the DNT could be shortened even more. Registration should be improved, especially activation of the acute stroke team and the reason why a possible thrombolysis patient did not receive rtPA treatment, in order to display the overtriage rates even more reliable in the future. Moreover, the FAST criteria could guide in the detection of possible thrombolysis patients in contrast to the broad criterion that patients must have symptoms of stroke, to lower undertriage rates. Further research of the DNT is needed when future patients are directly admitted at the CT scan. Furtermore, the over- and undertriage rates should be further explored to gain insight into how much patients actually are defined as overtriage, as well as the reason for undertriage.

Conclusion

A significant reduction of the DNT was found in patients who received intravenous rtPA therapy after the introduction of the revised thrombolysis protocol, including activation of an acute stroke team. Furthermore, a relatively high undertriage rate (22.4%) was found, which should be reduced because undertriage can worsen patient outcomes. The relatively high overtriage rate (64.8%) should also be reduced without increasing the undertriage rate.

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Figure and tables.

Figure 1. The flow-chart of the revised protocol for thrombolysis

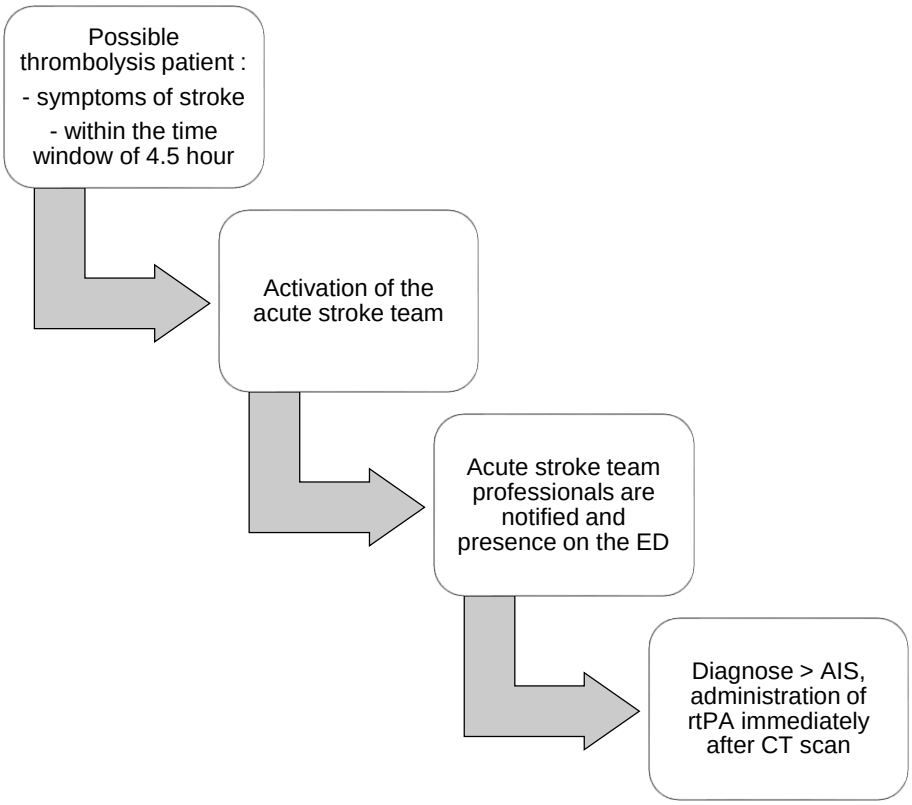

Figure 2. Flow chart of selection patients.

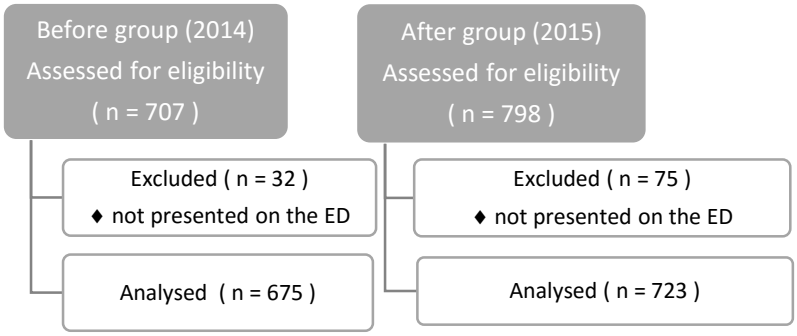

Table 1. Definitions of the time intervals.

DNT (door-to-needle time)	Time between the moment of patient arrival at the hospital to start of intravenous trPA treatment
SDT (symptom-to-door time)	Time between the moment of onset symptoms to patient arrival at the hospital.
DCT (door-to-CT time)	Time between the moment of patient arrival at the hospital to the CT-scan.
CTN (CT-to-needle time)	Time between the CT-scan to the start of intravenous rtPA treatment.

Table 2. Patient characteristics per group.

	2014 (before) (N = 675)	**2015 (after) (N=723)**	**p-value**
Number of patients who received intravenous rtPA treatment, n (%)	99 (14.7)	107 (14.8)	0.94
Age in years, mean (SD)	71.0 (13.7)	70.8 (13,5)	0.75
Female, n (%)	353 (52.3)	346 (47.9)	0.10
NIHSS score* at admission, median, (IQR)	3 (1 - 6)	3 (1 - 6)	0.53
Vascular risk factors, n (%)			
Atrial fibrillation	136 (20.1)	172 (23.8)	0.10
Hypertension	479 (71.0)	482 (66.7)	0.08
Diabetes Mellitus	197 (29.2)	189 (26.1)	0.20
Dyslipidemia	504 (74.7)	569 (78.7)	0.07
Atherosclerosis	540 (80.0)	585 (80.9)	0.67
Positive family anamneses (<60 year)	124 (18.4)	117 (16.2)	0.28
Smoking	155 (23.0)	160 (22.1)	0.71
History of vascular diseases, n (%)			
Ischemic stroke	124 (18.4)	149 (20.6)	0.29
TIA**	114 (16.9)	90 (12.4)	0.02
Myocardial ischemia	100 (14.8)	115 (15.9)	0.57

* NIHSS: National Institutes of Health Stroke Scale [29]

** TIA: Transient Ischemic Attack

Table 3. Door-to-needle time of patients who received intravenous rtPA treatment before and after the revised thrombolysis protocol.

	2014 (before) N = 99	**2015 (after) N = 107**	**Difference**	**p-value***
Time in minutes,	Median (IQR)	Median (IQR)	(minutes)	
Door – to needle time (DNT)	40 (29-55)	23 (18-32)	- 17	<0.01
Onset symptoms – to-door time (SDT)	83 (57 - 119)	73 (45 – 125)	- 10	0.32
Door – to CT-scan time (DCT)	17 (13-26)	15 (11 - 19)	- 2	<0.01
CT-scan – to start rtPA treatment time. (CTN)	19 (14 -28)	8 (5 - 14)	- 11	<0.01

* Determined by use of the Mann-Whitney U test.

Table 4. Calculating sensitivity, positive predictive value, under triage and over triage in the after group.

	Intravenous rtPA treatment	**No intravenous rtPA treatment**	**Total**
Activation acute stroke team	True positive (TP) 64 (label 1) + 19 (label 3) **= Total 83**	False positive (FP) 111 (label 1) + 42 (label 3) **= Total 153**	236
No activation acute stroke team	False negative (FN) 8 (label 2) + 16 (label 4) **= Total 24**	True negative (TN) 402 (label 2) + 44 (label 4) + 17 (label 5) **= Total 463**	487
Total	107	616	723

Sensitivity = TP/ (TP+FN) = 83/(83+24), PPV = TP/(TP+FP) = 83/(83+153), overtriage = (1 – PPV) = (1 – 0.352), undertriage = (1- sensitivity) (1 –0.776).
Label 1 = yes
Label 2 = no
Label 3 = description of thrombolysis, activation acute stroke team not described
Label 4 = unclear
Label 5 = other

Table 5. Door-to-needle time between activation acute stroke team group and no activation acute stroke team group of the overall after group who received rtPA treatment.

	Activation acute stroke team group N = 83 (64+19)	**No activation acute stroke team group N = 24 (8 +16)**	**Difference**	**p-value***
Time in minutes	Median (IQR)	median (IQR)	(Minutes)	
Door – to needle time (DNT)	21 (17-29)	32 (22.75-61)	11	<0.01
Onset symptoms – to-door time (SDT)	73 (47 – 129)	76.50 (37.25 -	3.5	0.516
Door – to CT-scan time (DCT)	14 (11 - 17)	109.25)	5	<0.01
CT-scan – to start rtPA treatment time.	7 (5 - 11)	19 (14-32.50)	7	0.019
(CTN)		14 (6.25 -21.50)		

* Determined by use of the Mann-Whitney U test.