Hospital Variation in Time to Endovascular Treatment for Ischemic Stroke

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ORIGINAL RESEARCH

Hospital Variation in Time to Endovascular Treatment for Ischemic Stroke: What Is the Optimal Target for Improvement?

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BACKGROUND: Time to reperfusion in patients with ischemic stroke is strongly associated with functional outcome and may differ between hospitals and between patients within hospitals. Improvement in time to reperfusion can be guided by between-hospital and within-hospital comparisons and requires insight in specific targets for improvement. We aimed to quantify the variation in door-to-reperfusion time between and within Dutch intervention hospitals and to assess the contribution of different time intervals to this variation.

METHODS AND RESULTS: We used data from the MR CLEAN (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands) Registry. The door-to-reperfusion time was subdivided into time intervals, separately for direct patients (door-to-computed tomography, computed tomography-to-computed tomography angiography [CTA], CTA-to-groin, and groin-to-reperfusion times) and for transferred patients (door-to-groin and groin-to-reperfusion times). We used linear mixed models to distinguish the variation in door-to-reperfusion time between hospitals and between patients. The proportional change in variance was used to estimate the amount of variance explained by each time interval. We included 2855 patients of 17 hospitals providing endovascular treatment. Of these patients, 44% arrived directly at an endovascular treatment hospital. The between-hospital variation in door-to-reperfusion time was 9%, and the within-hospital variation was 91%. The contribution of case-mix variables on the variation in door-to-reperfusion time was marginal (2%–7%). Of the between-hospital variation, CTA-to-groin time explained 83%, whereas groin-to-reperfusion time explained 15%. Within-hospital variation was mostly explained by CTA-to-groin time (33%) and groin-to-reperfusion time (42%). Similar results were found for transferred patients.

CONCLUSIONS: Door-to-reperfusion time varies between, but even more within, hospitals providing endovascular treatment for ischemic stroke. Quality of stroke care improvements should not only be guided by between-hospital comparisons, but also aim to reduce variation between patients within a hospital, and should specifically focus on CTA-to-groin time and groin-to-reperfusion time.

Key Words: brain ischemia ■ quality improvement ■ reperfusion ■ stroke ■ thrombectomy

In patients with acute ischemic stroke, shorter times to endovascular treatment (EVT) are strongly associated with more favorable outcomes.[1,2] This association is found on several outcomes, such as mortality, reperfusion grade after EVT, and the functional outcome, measured with the modified Rankin Scale score at 3 months.[1,2] Because of this established strong association, process measures, such

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CLINICAL PERSPECTIVE

What Is New?

- In patients with acute ischemic stroke, variation in door-to-reperfusion time is mostly explained by computed tomography angiography-to-groin time and groin-to-reperfusion time, and less by patient characteristics.
- There is more variation in door-to-reperfusion time within hospitals than between hospitals.

What Are the Clinical Implications?

- Quality of stroke care improvements should not only be guided by between-hospital comparisons, but also aim to reduce variation between patients within a hospital, and should specifically focus on computed tomography angiography-to-groin time and groin-to-reperfusion time.

Nonstandard Abbreviations and Acronyms

CTA	computed tomography angiography
EVT	endovascular treatment
MR CLEAN	Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands

as door-to-reperfusion time, are suitable for measuring quality of stroke care. Quality improvement can be guided by the comparison of hospitals with each other and by the comparison of patients within a hospital. Insight in variation between and within hospitals, including the contribution of different time intervals (door-to-computed tomography [CT], CT-to-CT angiography [CTA], CTA-to-groin, and groin-to-reperfusion times) to this variation, may contribute to improvement of quality of ischemic stroke care.

We aimed to quantify the variation in door-to-reperfusion time between and within Dutch EVT hospitals and to assess the contribution of different time intervals to this variation.

METHODS

We used data from the MR CLEAN (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands) Registry. This is a prospective observational study in all 17 centers performing EVT in the Netherlands. All patients who underwent EVT for acute ischemic stroke in the anterior or posterior circulation between March 16, 2014, and November 1, 2017, were registered. EVT was defined as entry into the angiography suite and having arterial puncture. Details on the study design and methods were described previously.[3] The central medical ethics committee of the Erasmus MC, University Medical Center Rotterdam, the Netherlands, evaluated the study protocol and granted permission to perform the study as a registry (MEC-2014-235). In compliance with the General Data Protection Regulation, source data are not available for other researchers. Information about analytic methods, study materials, and scripts of the statistical analyses are available from the corresponding author on reasonable request.

Patients

For the purpose of this study, we used the following inclusion criteria: age of ≥18 years; groin puncture within 6.5 hours after stroke onset; treatment in a MR CLEAN Registry trial center; intracranial proximal arterial occlusion in the anterior circulation (intracranial carotid artery, internal carotid artery terminus, middle [M1/M2] cerebral artery, or anterior [A1/A2] cerebral artery) demonstrated by CTA, magnetic resonance angiography, or digital subtraction angiography. The analyzed data comprised patients who were treated with EVT between March 16, 2014, and November 1, 2017. We focused this analysis on patients who presented at the emergency departments of the participating hospitals. Patients with in-hospital stroke were excluded from this analysis.

Outcomes

The primary outcome measure was door-to-reperfusion time, defined as the total time in minutes between arrival of the patient in an EVT hospital and the end of the EVT procedure. The latter was defined as time Expanded Thrombolysis in Cerebral Infarction 2B was achieved, or if no reperfusion was achieved, time of the last contrast bolus.[3] Analyses were stratified for patients presented directly at an EVT hospital (direct patients) and patients transferred from a primary stroke center (transferred patients). The total door-to-reperfusion time was divided in intervals formed by the sequential performed imaging and treatments during the entire process from door to reperfusion. The time intervals for direct patients were the following: door-to-CT, CT-to-CTA, CTA-to-groin, and groin-to-reperfusion (or last contrast bolus) times. In transferred patients, diagnostic imaging (CT and CTA) was already performed in the primary stroke center. Therefore, we limited the time intervals for this group to door-to-groin time and groin-to-reperfusion time (or last contrast bolus). We focused on intervals that can directly be influenced by the stroke teams in the EVT hospitals.

Missing Data

All baseline data were reported as crude data. For each time interval, we investigated extreme minimum and maximum outliers. These outliers were considered as incorrect and recoded as missing (Table S1). All missing variables were imputed with multiple imputation with R (package, MICE) based on relevant covariates and outcomes.

Statistical Analysis

For descriptive purposes, we grouped hospitals into tertiles based on the mean door-to-reperfusion time per hospital for patients directly presented at an EVT hospital. We used an ordinal logistic regression model to analyze the association between door-to-reperfusion time (as a continues variable) and the modified Rankin Scale score at 3 months and presented common odds ratio (OR) with 95% CI.

We used linear mixed models to examine the amount of variation in the door-to-reperfusion time between and within hospitals, explained by each time interval. All models included hospital-specific random intercepts to account for patient clustering within each hospital.[4,5]

We started with model 1, which only contained a hospital-specific random intercept and no covariates. This model provides the intraclass correlation coefficient, which describes the proportion of the total variance that is attributable to clustering within hospitals, in our case the between-hospital variance in door-to-reperfusion time. The remaining total variance is attributable to within-hospital variation between patients. To investigate the contribution of case-mix on the between-hospital and within-hospital variation in door-to-reperfusion time, we added case-mix variables to the model. Model 2 contained the following variables: a hospital-specific random intercept, age, sex, history of atrial fibrillation, history of hypertension, history of diabetes, history of myocardial infarction, history of peripheral artery disease, history of ischemic stroke, history of hyperlipidemia, prestroke modified Rankin Scale score, baseline National Institutes of Health Stroke Scale score, onset-to-door time, admission during off hours, and the anatomical location of occluded artery. To investigate how much of the between-hospital and within-hospital variation in door-to-reperfusion time was attributable to each time interval, after adjustment for case-mix, we added each time interval to model 2 in a cumulative way. Model 3A contains a hospital-specific random intercept, case-mix, and door-to-CT time. Model 3B contains a hospital-specific random intercept, case-mix, door-to-CT time, and CT-to-CTA time. Model 3C contains a hospital-specific random intercept, case-mix, door-to-CT time, CT-to-CTA time, and CTA-to-groin time. Model 3D contains a hospital-specific random intercept, case-mix, door-to-CT time, CT-to-CTA time, CTA-to-groin time, and groin-to-reperfusion time. The proportional change in variance was used to estimate the amount of variance explained by each model compared with model 1.[6,7] To calculate the attribution of each variable individually to the variance, the proportional changes in variance of the models were subtracted.

In a separate analysis, we investigated the influence of potentially delaying factors on the door-to-reperfusion time of patients who presented directly at the EVT hospital, by adding systolic blood pressure (≥185 mm Hg) requiring blood pressure–lowering therapy, intravenous alteplase treatment, and general anesthesia to the case-mix adjusted model. For transferred patients, models 1 and 2 were the same as described above. Model 3A contains a hospital-specific random intercept, case-mix, and door-to-groin time. Model 3B contains a hospital-specific random intercept, case-mix, door-to-groin time, and groin-to-reperfusion time. We considered repetition of imaging (CT or CTA) in an EVT hospital to be a delaying factor for transferred patients. All statistical analyses were performed with R statistical software (version 3.6.1).

$$\text{PCVh} = \frac{\text{Vh1} - \text{Vh3}}{\text{Vh1}}$$

h indicates hospital level (between-hospital variance) could be replaced by p: patient level (within-hospital variance); h1 or p1, model with only hospital as random intercept; h3 or p3, model with case-mix variables and time intervals; PCVh, proportional change in variance at hospital level; and V, variance.

RESULTS

In total, 3637 patients were registered in the MR CLEAN Registry between March 16, 2014, and November 1, 2017. First, we excluded 457 patients, mostly because of occlusion in the posterior circulation or treatment starting after 6.5 hours from the onset of symptoms (Figure 1). Then, we excluded 325 patients with in-hospital stroke. The remaining 2855 patients were used for analysis. From these patients, 1244 (44%) presented directly at an EVT hospital and 1611 (56%) were transferred from a primary stroke center to an EVT hospital.

Patient Characteristics

For patients who arrived directly at an EVT hospital, median door-to-reperfusion time was 147 minutes (interquartile range, 116–185 minutes), and the median varied between hospitals from 121 to 184 minutes. The median door-to-reperfusion time for transferred patients was 93 minutes (interquartile range, 70–283

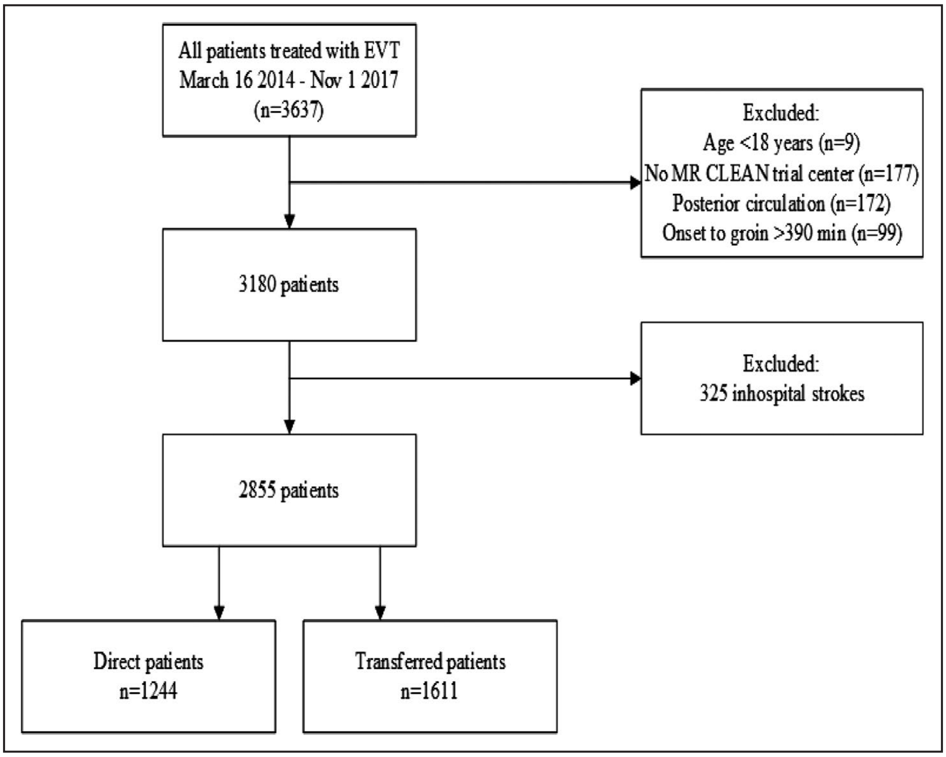

Figure 1. Flowchart of MR CLEAN (Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands) Registry patients selected for analysis.
EVT indicates endovascular treatment.

minutes) and varied between hospitals from 75 to 112 minutes. There were only minor differences in age and medical history between the tertiles of hospitals (Table 1). There was a difference in the percentage of transferred patients between the tertiles (62% versus 61% versus 37%). There was also a difference in the use of general anesthesia between the tertiles (7% versus 27% versus 54%). Of the case-mix variables, only location of occluded artery, onset-to-door time, and admission during off hours were associated with door-to-reperfusion time (Table S2). An increased door-to-reperfusion time was associated with worse functional outcome (modified Rankin Scale score at 3 months) for direct and transferred patients (per 10 minutes, common OR 0.92 [95% CI: 0.91–0.94] and common OR 0.93 [95% CI: 0.91–0.95], respectively).

Variation Between Hospitals for Patients Directly Presented at an EVT Hospital

Of the total variation in door-to-reperfusion time for patients directly presented at an EVT hospital, 9% was attributable to between-hospital variation (Table 2). Case-mix variables explained only 2% of the total between-hospital variation in door-to-reperfusion time (Figure 2A). CTA-to-groin puncture time explained 83% of the between-hospital variation in case-mix adjusted door-to-reperfusion time, whereas groin-to-reperfusion time explained an additional 15%. The correlation between these time intervals and door-to-reperfusion time is shown in Figure S1A and S1B. In a separate analysis, delaying factors in door-to-reperfusion time, such as a high baseline systolic blood pressure (≥185 mm Hg), treatment with intravenous alteplase treatment, or general anesthesia, explained 8% of the between-hospital variation in door-to-reperfusion time.

Variation Within Hospitals for Patients Directly Presented at an EVT Hospital

Of the total variation in door-to-reperfusion time for patients directly presented at an EVT hospital, 91% was attributable to within-hospital variation (Table 2 and Figure 3). Case-mix variables explained 7% of the total within-hospital variation in door-to-reperfusion time (Figure 2A). CT-to-CTA time explained an additional 13%, CTA-to-groin time explained 33%, and groin-to-reperfusion time explained 42% of the within-hospital variation in door-to-reperfusion time. Delaying factors explained 3% of the within-hospital variation in door-to-reperfusion time.

Table 1. Baseline Characteristics per Hospital Tertiles of the Mean Door-to-Reperfusion Time of Direct Patients

Characteristic	Total	Tertile 1 (range, 128–146 min)	Tertile 2 (range, 146–158 min)	Tertile 3 (range, 163–188 min)	*P* value
No. of patients	2855	1006	1277	572	
No. of centers	17	5	6	6	
Age, y	72 (61–81) (2855)	73 (63–81)	71 (59–79)	72 (62–82)	0.072
Men, %	52 (1491/2855)	52	52	53	0.951
Atrial fibrillation, %	24 (662/2818)	27	21	24	0.002
Hypertension, %	52 (1455/2797)	59	49	46	<0.001
Diabetes, %	16 (440/2833)	15	16	14	0.619
Myocardial infarction, %	14 (381/2798)	15	14	9	0.003
Peripheral artery disease, %	9 (246/2798)	13	6	8	<0.001
Previous ischemic stroke, %	16 (463/2832)	17	16	15	0.650
Hyperlipidemia, %	30 (816/2728)	39	25	25	<0.001
Baseline NIHSS score	16 (11–19) (2816)	16 (11–20)	15 (11–19)	16 (11–19)	0.083
Prestroke modified					0.105
Rankin scale score, %					
0	70 (1943/2793)	68	68	75	
1	13 (363/2793)	15	13	10	
2	7 (193/2793)	7	8	5	
≥3	11 (294/2793)	10	11	10	
Transfer from primary stroke center, %	56 (1611/2855)	62	61	37	<0.001
Intravenous alteplase treatment, %	80 (2278/2847)	80	80	80	0.743
Level of occlusion, %*					0.010
ICA	5 (130/2740)	4	5	7	
ICA-T	22 (590/2740)	23	20	22	
M1	58 (1590/2740)	58	60	56	
M2	15 (409/2740)	15	15	16	
Other (M3/anterior)	1 (21/2740)	0.2	1	0.4	
Collaterals, %					0.054
Grade 0	6 (171/2673)	8	5	7	
Grade 1	37 (978/2673)	37	35	39	
Grade 2	39 (1028/2673)	37	40	39	
Grade 3	19 (496/2673)	18	20	16	
Onset-to-door time, min	135 (65–188) (2753)	140 (81–191)	137 (70–189)	103 (52–175)	<0.001
Off hours, %†	64 (1837/2855)	64	65	63	0.491
General anesthesia, %	26 (686/2677)	7	27	54	<0.001
Systolic blood pressure (≥185 mm Hg), %	9 (249/2784)	8	10	9	0.164

Categorical variables are presented as percentage (n/N). Continuous variables are presented as median (interquartile range) (N). ICA indicates intracranial carotid artery; ICA-T, internal carotid artery terminus; middle (M1/M2/M3) cerebral artery; and NIHSS, National Institutes of Health Stroke Scale.

*Based on computed tomography angiography.

†Admission between 5:00 PM and 8:00 AM, on weekends, or a national holiday.

Variation Between and Within Hospitals for Transferred Patients

Of the total variation in door-to-reperfusion time for transferred patients, 3% was attributable to between-hospital variation (Table 3). This between-hospital variation was explained by door-to-groin time (56%) and groin-to-reperfusion time (44%) (Figure 2B). The delaying factor of repetition of imaging explained 31% of the between-hospital variation in door-to-reperfusion time. The within-hospital variation in door-to-reperfusion

Table 2. Multilevel Regression Analysis of Door-to-Reperfusion Time of Patients Directly Presented at an EVT Hospital

Variable	Model 1 Empty model	Model 2 Case-mix	Model 3A Door-CT time	Model 3B CT-CTA time	Model 3C CTA-groin time	Model 3D Groin-reperfusion time
Proportional change in variance*						
Between hospitals	Reference	0.02	−0.14	−0.32	0.85	1.00
Within hospitals	Reference	0.07	0.12	0.25	0.58	1.00
ICC	0.09	0.09				

Model 1: hospital. Model 2: hospital and case-mix. Model 3A: hospital, case-mix, and door-to-CT time. Model 3B: hospital, case-mix, door-to-CT time, and CT-CTA time. Model 3C: hospital, case-mix, door-to-CT time, CT-CTA time, and CTA-to-groin time. Model 3D: hospital, case-mix, door-to-CT time, CT-CTA time, CTA-to-groin time, and groin-to-reperfusion time. The ICC describes the proportion of the total variance that is attributable to clustering within hospitals, in our case the between-hospital variance in door-to-reperfusion time. The remaining total variance is attributable to within-hospital variation between patients. The proportional change in variance describes the change of the between-hospital and within-hospital variation in door-to-reperfusion time in each model compared with model 1. The individual attribution of each added variable on the variation in door-to-reperfusion time can be calculated by subtracting the proportional changes in variance of each model. These numbers are shown in Figure 2. CT indicates computed tomography; CTA, CT angiography; EVT, endovascular treatment; and ICC, intraclass correlation coefficient.

*A negative sign indicates that the time interval increased the variance.

time of transferred patients was explained by case-mix (3%), door-to-groin time (40%), and groin-to-reperfusion time (57%).

DISCUSSION

In this study, we quantified between-hospital and within-hospital variation in door-to-reperfusion time in patients with acute ischemic stroke treated with EVT in Dutch EVT hospitals. We found that door-to-reperfusion time varies between hospitals, but even more within hospitals. This variation in door-to-reperfusion time is mostly explained by CTA-to-groin time and groin-to-reperfusion time, and less by patient characteristics.

Our results imply that workflow improvement strategies should primarily target the reduction of variation within hospitals. This is in line with a study that showed that most variability in quality of care occurred at the patient level (82%) within hospitals.[8] The ability to identify the cause of variation is fundamental for health care improvement.[9] Variation is often seen as a source of errors or issues with the system.[10] Investigation of causes and attributable factors on this variation may help in reducing variation and improving procedures. The within-hospital variation in door-to-reperfusion time is much larger than the between-hospital variation in door-to-reperfusion time. We do not have one clear explanation for the large within-hospital variation in door-to-reperfusion time. We tried to explain the within-hospital variation in door-to-reperfusion time by adding potentially delaying factors (eg, systolic blood pressure [≥185 mm Hg] requiring blood pressure–lowering therapy, intravenous alteplase treatment, and general anesthesia) to the model. However, these variables did not explain the variation. There are many other factors that could influence the time intervals and could be different between patients. For example, there are structure measures, such as the availability of an interventionist or angiographic suite and hospital case volume. But there are also process measures, such as the persistence of the interventionist to achieve reperfusion and difficulties in procedures as tortuosity of the vascular tree. Most of these factors are difficult to measure. Almost no case-mix variable was associated with door-to-reperfusion time. However, admission during off hours showed a significant association with the door-to-reperfusion time of direct patients. Previous research showed that admission during off hours was associated with a slight delay in start of endovascular treatment in patients with acute ischemic stroke.[11] This may mean that there is potential for improvements of workflow times during off hours.

The between-hospital variation is low. This could be attributable to the standardization of processes in the treatment with EVT of patients with an ischemic stroke. Moreover, Dutch EVT hospitals need to meet various high-quality standards, which could reduce the between-hospital variation. The total variation in door-to-reperfusion time is therefore mainly explained by within-hospital variation.

CTA-to-groin time and groin-to-reperfusion time were important drivers of between-hospital and within-hospital variation in door-to-reperfusion time. Of all time intervals, CTA-to-groin time is the largest. This probably explains why CTA-to-groin time contributed most to the variation in door-to-reperfusion time for patients directly presented at an EVT hospital. Various improvement strategies focusing on reduction of between-hospital variation in door-to-reperfusion times have been suggested. A meta-analysis about different strategies for workflow improvement showed that the most promising workflow intervention types concerned anesthetic management, in-hospital patient transfer management, prehospital management, teamwork,

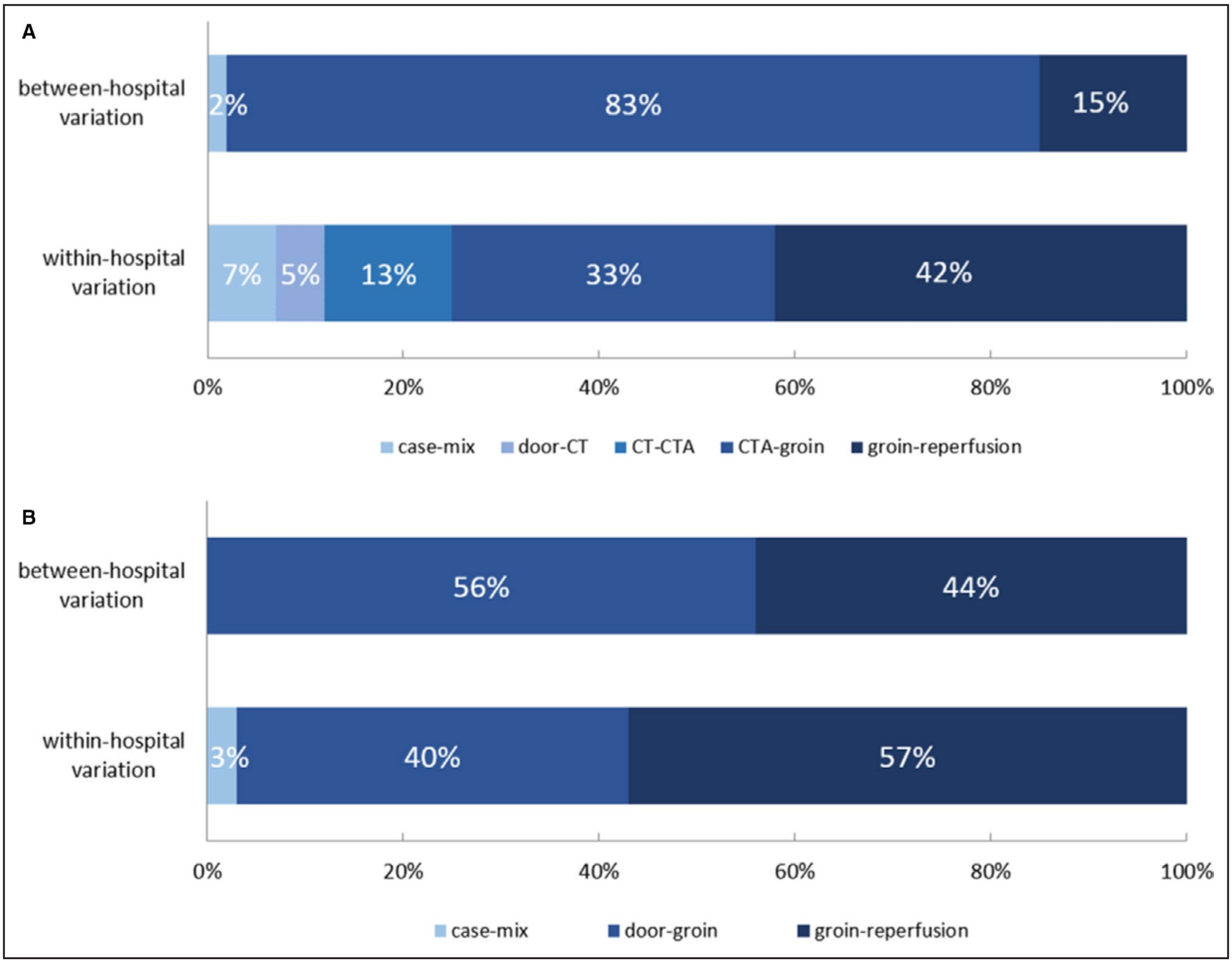

Figure 2. The contribution of each added variable to the variation in door-to-reperfusion time.
A, Direct patients. **B**, Transferred patients. CT indicates computed tomography; and CTA, CT angiography.

and feedback on performance.[12] Performance feedback was the most effective intervention in this meta-analysis. To better estimate the (magnitude of the) effect of performance feedback, a stepped wedge cluster randomized controlled trial can be used. With this study design, hospitals instead of individual patients are randomized subsequently (in "steps"), which makes it possible to take time trends into account. Such a study has recently been started in the Netherlands: Performance feedback on quality of care in hospitals performing thrombectomy for ischemic stroke.[13] In this study, the effectiveness of monitoring and performance feedback is being investigated. This feedback consists of process and outcome measures, shown in 3 monthly feedback reports. Local quality improvement teams of every hospital will make improvement plans and can evaluate their actions every 3 months. This study aims to reduce the between-hospital variation in process measures and hopefully will give insight in delaying factors on time to treatment. However, quality improvement should not only focus on the comparison of hospitals and between-hospital variation, but also on within-hospital variation.

Our study has some limitations. We did not have information on whether CT-perfusion was performed, and we know that this varied between hospitals at the moment of our data registration. We expect the influence on variation in door-to-reperfusion time to be small, because we observed that the time interval of CT-to-CTA (in which CT-perfusion is performed) did not explain the between-hospital variation in door-to-reperfusion time.

We included all relevant case-mix variables available in our data, but we could have missed variables associated with door-to-reperfusion time. However, based on our analyses, we expect that case-mix variables are less important in the explanation of variation in door-to-reperfusion time.

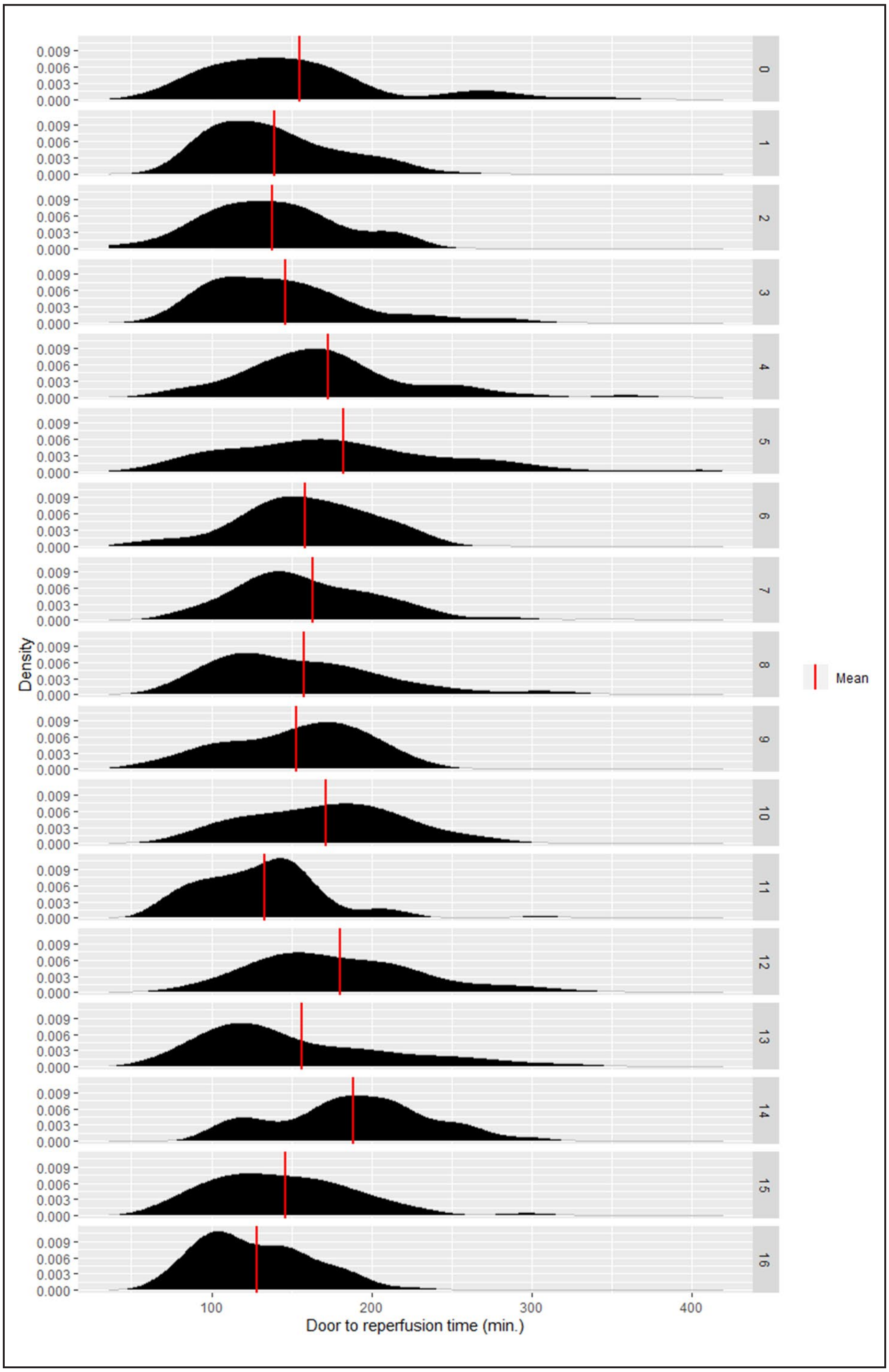

Figure 3. Density plots per hospital of door-to-reperfusion time of patients directly presented at an endovascular treatment hospital (crude data).

CONCLUSIONS

Door-to-reperfusion time varies between, but even more within, hospitals providing endovascular treatment for ischemic stroke. Quality of stroke care improvements should not only be guided by between-hospital comparisons, but also aim to reduce variation between patients within a hospital, and should specifically focus on CTA-to-groin time and groin-to-reperfusion time.

Table 3. Multilevel Regression Analysis of Door-to-Reperfusion Time of Transferred Patients

Variable	Model 1 Empty model	Model 2 Case-mix	Model 3A Door-groin time	Model 3B Groin-reperfusion time
Proportional change in variance*				
Between hospitals	Reference	−0.07	0.56	1.00
Within hospitals	Reference	0.03	0.43	1.00
ICC	0.03	0.04		

Model 1: hospital. Model 2: hospital and case-mix. Model 3A: hospital, case-mix, and door-to-groin time. Model 3B: hospital, case-mix, door-to-groin time, and groin-to-reperfusion time. The ICC describes the proportion of the total variance that is attributable to clustering within hospitals, in our case the between-hospital variance in door-to-reperfusion time. The remaining total variance is attributable to within-hospital variation between patients. The proportional change in variance describes the change of the between-hospital and within-hospital variation in door-to-reperfusion time in each model compared with model 1. The individual attribution of each added variable on the variation in door-to-reperfusion time can be calculated by subtracting the proportional changes in variance of each model. These numbers are shown in Figure 2. ICC indicates intraclass correlation coefficient.

*A negative sign indicates that the time interval increased the variance.

APPENDIX

MR CLEAN Registry investigators

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Supplemental Material

Tables S1–S2
Figure S1

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SUPPLEMENTAL MATERIAL

Table S1. Extreme minimum and maximum outliers of each time interval, for patients directly presented at an EVT hospital and for transferred patients.

Time interval	Extreme minimum outlier	Extreme maximum outlier	% missing values including outliers
Door-CT time	0 minutes	> 200 minutes	3%
CT-CTA time	none*	> 200 minutes	3%
CTA-groin time	≤ 5 minutes	> 300 minutes	3%
Groin-reperfusion time			
Direct	none*	> 300 minutes	10%
Transferred	none*	> 300 minutes	9%
Door-groin time	none*	none*	5%
Door-reperfusion time			
Direct	none*	> 500 minutes	11%
Transferred	none*	> 500 minutes	13%

* there were no outliers

Table S2. Multilevel model, association between case-mix variables and door-to-reperfusion time.

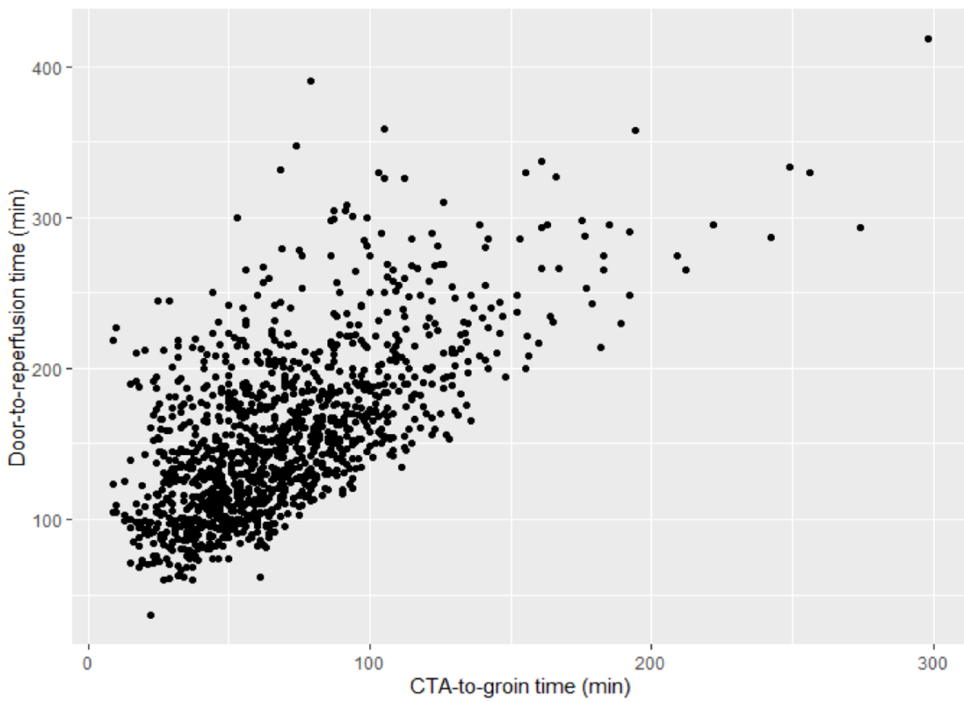
	Direct patients	Transferred patients
Case-mix variables	adjusted beta, 95% CI	adjusted beta, 95% CI
Age	0.03 (-0.20-0.26)	-0.04 (-0.21-0.12)
Men	-2.23 (-8.48-4.03)	2.81 (-1.33-6.96)
Atrial fibrillation	-1.58 (-8.93-5.76)	-2.21 (-7.03-2.62)
Hypertension	4.30 (-2.37-10.97)	1.84 (-3.02-6.71)
Myocardial infarction	-4.50 (-13.33-4.33)	2.10 (-4.02-8.21)
Previous stroke	0.10 (-8.13-8.34)	1.14 (-4.55-6.83)
Peripheral artery disease	9.37 (-1.32-20.06)	-3.34 (-11.16-4.47)
Diabetes Mellitus	5.16 (-3.24-13.56)	2.78 (-3.17-8.74)
Hyperlipidemia	-6.75 (-13.73-0.24)	0.12 (-6.57-6.80)
NIHSS at baseline, per point	-0.09 (-0.59-0.42)	0.37 (-0.01-0.75)
Pre-stroke modified Rankin Scale		
0	reference	reference
1	4.46 (-4.76-13.67)	-2.16 (-8.52-4.20)
2	6.24 (-5.35-17.84)	0.25 (-8.18-8.69)
≥ 3	5.70 (-4.08-15.48)	-0.99 (-9.26-7.27)
Location of occluded artery		
M1	reference	reference
M2	8.02 (0.21-15.82)	-0.72 (-7.52-6.09)
Intracranial ICA	20.83 (6.26-35.40)	8.42 (-1.85-18.69)
ICA-T	13.31 (5.66-20.97)	7.47 (1.81-13.13)
Other (Anterior/M3)	28.98 (-2.08-60.05)	18.52 (-9.44-46.49)
Onset to door time, minutes	-0.05 (-0.09--0.01)	-0.06 (-0.09--0.03)
Admission during off hours*	22.10 (16.11-28.09)	1.43 (-3.46-6.32)

* Admission between 5:00 PM and 8:00 AM, on weekends, or a national holiday

CI, confidence interval, NIHSS, National Institutes of Health Stroke Scale, M1/M2/M3, 1st, 2nd and 3rd segment of the middle cerebral artery, ICA, internal carotid artery, ICA-T, internal carotid artery terminus.

Figure S1. A) Correlation between CTA-to-groin time and door-to-reperfusion time. B) Correlation between groin-to-reperfusion time and door-to-reperfusion time.

A



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