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Highly Visible Wall-Timer to Reduce Endovascular Treatment Time for Stroke

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Abstract

BACKGROUND: Endovascular therapy for acute ischemic stroke has revolutionized clinical care for patients with stroke and large vessel occlusion, but treatment remains time sensitive. At our stroke center, up to half of the door-to-groin time is accounted for after the patient arrives in the angio-suite. Here, we apply the concept of a highly visible timer in the angio-suite to quantify the impact on endovascular treatment time.

METHODS: This was a single-center prospective pseudorandomized study conducted over a 32-week period. Pseudorandomization was achieved by turning the timer on and off in 2-week intervals. The primary outcome was angio-suite-to-groin time, and secondary outcomes were angio-suite-to-intubation time, groin-to-recanalization time, and 90-day modified Rankin scale. A

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stratified analysis was performed based on type of anesthesia (ie, endotracheal intubation versus not).

RESULTS: During the 32-week study period, 97 mechanical thrombectomies were performed. The timer was on and off for 38 and 59 cases, respectively. The timer resulted in faster angio-suite-to-groin time (28 versus 33 minutes; P=0.02). The 5-minute reduction in angio-suite-to-groin was maintained after adjusting for intubation status in a multivariate regression (P=0.02). There was no difference in the 90-day modified Rankin scale between groups. The timer impact was consistent across the 32-week study period.

CONCLUSIONS: A highly visible timer in the angio-suite achieved a meaningful, albeit modest, reduction in endovascular treatment time for patients with stroke. Given the lack of risk and low cost, it is reasonable for stroke centers to consider a highly visible timer in the angio-suite to improve treatment times.

Keywords

mechanical thrombectomy; quality improvement; stopwatch; timer

Endovascular therapy for acute ischemic stroke has revolutionized clinical care for stroke patients with large vessel occlusion, but treatment remains time sensitive.[1] Nearly 2 million neurons die every minute,[2] and shorter recanalization times are associated with a more favorable outcome.[3,4] The American Heart Association's *Target: Stroke* initiative aims to achieve a door-to-device time ≤60 and 90 minutes for transferred patients and patients arriving through the emergency department, respectively.[5] Faster treatment remains a focus of local and international quality improvement efforts.

At our comprehensive stroke center, prior workflow modifications have reduced imaging time and patient transport time. However, up to half of the door-to-groin time is accounted for after the patient arrives in the angio-suite. During acute treatments, providers are not often provided continuous feedback and perception of time is unreliable in high acuity settings.[6] In time-sensitive clinical care, a highly visible timer can keep providers better informed and reduce treatment time.[7] Specifically in the context of acute stroke, displaying a large timer reduced door-to-needle time for intravenous alteplase treatment.[8]

Here, we apply the concept of a highly visible timer in the angio-suite to quantify the impact on endovascular treatment time for stroke.

METHODS

Study Design and Patients

This was a single-center prospective pseudorandomized study to test the impact of a highly visible timer on stroke treatment times in the angio-suite. This study was conducted at the hospital of the University of Pennsylvania over a 32-week period – September 14, 2020 through April 25, 2021. Pseudorandomization was achieved by turning the timer on and off in 2-week intervals. Patients were eligible if they were receiving endovascular therapy for acute ischemic stroke with large vessel occlusion as per routine clinical care. The University of Pennsylvania institutional review board approved the study as *quality improvement* and granted a waiver of informed consent. Authors complied with the Standards for Quality Improvement Reporting Excellence guidelines (Supplemental Methods). The anonymized data that support the findings of this study are available from the corresponding author upon reasonable request.

Timer Workflow

A highly visible digital timer (BTB Sign Co, Ltd) was installed in each angio-suite with a large push-button starter in close proximity to the timer and suite entrance (Figure A, B). When a patient with acute stroke was transported to the angio-suite for endovascular therapy, a stroke fellow activated the timer. The timer was programmed to count up from zero, displaying 4 digits (MM:SS). At the completion of the procedure, the nurse documented the relevant times and reset the timer. Stroke fellows were made aware of the timer on-off schedule and to ensure schedule compliance, timers were unplugged from the power source during prespecified "off" weeks.

Clinical Data Collection

All clinical, imaging, and time-related variables were abstracted from a preexisting endovascular stroke database. This clinical database collects critical metrics of all stroke cases treated with endovascular therapy, including all time points evaluated in this project. Time points were prospectively recorded in a stroke navigator within the electronic health record, and the stroke navigator in turn populates this database. The following time points were collected: (1) hospital arrival, (2) angio-suite arrival, (3) anesthesia intubation time, (4) endotracheal intubation, (5) groin puncture, and (6) recanalization. Clinical variables included demographics, National Institutes of Health Stroke Scale score, vessel occlusion, and procedural outcome as measured by the expanded treatment in cerebral ischemia score. Clinical outcome was assessed by hospital discharge and 90-day modified Rankin scale (mRS).

Hospital arrival time was recorded from the electronic health record. Angio-suite arrival time was recorded by the angio-suite nurse (when the patient passes though the room threshold). Anesthesia initiation time and endotracheal intubation time were recorded by stroke team personnel. Groin puncture was defined as the time of needle puncture and was recorded by the angio-suite nurse. During the study period, groin puncture was performed after endotracheal intubation (when applicable), a practice that was consistent among the center's interventionalists. Groin puncture was typically performed by a neuro-interventional fellow, under the supervision of a faculty member. Recanalization time was defined as the time of pass that achieved the final recanalization score and was recorded by the angio-suite nurse. In the case of treatment in cerebral ischemia 0, no recanalization time was recorded. These variables were abstracted from the database and anonymized to create the study data set.

Statistical Analysis

Continuous and ordinal variables were summarized by mean and SD or median and interquartile range if normally or nonnormally distributed, respectively. Categorical variables were summarized by proportions. Between group differences were evaluated by *t* tests for continuous normally distributed variables, Wilcoxon-Mann-Whitney tests for nonparametric variables, or chi-square tests for categorical variables. A stratified analysis was performed based on whether or not patients required endotracheal intubation for the procedure, and multivariate regression was used to evaluate the effect of the intervention (timer) on treatment time while accounting for endotracheal intubation and which inter-ventionalist was performing the procedure. Secondarily, the study period was broken into 8-week blocks (ie, block 1, 2, 3, 4), and study block was included in the multivariate model to assess whether the timer's impact on treatment time was stable over time. Analyses were performed using Stata 15.1 (StataCorp LLC. College Station, TX, 2017).

RESULTS

During the 32-week study period, the timer was on for 16 weeks and off for 16 weeks. A total of 97 mechanical thrombectomies were performed. The timer was on and off for 38 and 59 cases, respectively. Baseline clinical and imaging characteristics were similar between the 2 groups, as presented in Table 1. For the overall cohort, the mean angio-suite-to-groin (ATG) time 31 (±10) minutes. Thirty-four (of 97) patients received intravenous thrombolysis before endovascular therapy. ATG time was similar in patients who did and did not receive intravenous thrombolysis, 30 (±9) minutes versus 31 (±11) minutes (P=0.64). Table 2 summarizes the treatment times based on timer status. Most notably, the timer resulted in a 5-minute reduction in the mean ATG time, 28 (±10) minutes versus 33 (±9) minutes (P=0.02). During the 3 months before the study period, the mean ATG time was 33 (±13) minutes, which was not significantly different than when the timer was turned off (P=0.71). The timer did not affect groin-to-recanalization time. Seventy-two (of 97) thrombectomies occurred during standard daytime hours, defined as 7 am–6 pm, Monday to Friday. The timer was associated with a 5-minute reduction in mean ATG time both during standard daytime hours and after hours, but only 25 subjects were included in the after-hours subgroup, so this did not reach statistical significance. Eighty percent of the overall cohort underwent endotracheal intubation for the procedure, equally distributed between the 2 groups. Endotracheal intubation was associated with a longer ATG time, 33 (±10) minutes versus 23 (±9) minutes (P=0.0002). Among patients who underwent intubation, the timer resulted in a reduction in angio-suite-to-intubation time (Table 2). Very few patients did not undergo endotracheal intubation, but in this subgroup the timer had a similar impact on the ATG point estimate but did not reach statistical significance (Table 2). After adjusting for intubation status in a multivariate regression, the timer was still associated with a 5-minute reduction in ATG time (P=0.02). However, the timer was not associated with a change in 90-day mRS (Table 2). To assess the durability of the intervention, the 32 weeks were organized into 8-week blocks and incorporated into a multivariate regression in which the timer was still associated with a 5-minute reduction in ATG time (P=0.03).

DISCUSSION

In this single-center prospective pseudorandomized study, a highly visible timer in the angio-suite reduced the mean ATG time by 5 minutes, independent of the effect of anesthesia/intubation. Although the absolute time reduction is relatively small, this represents a 15% reduction in angio-suite treatment time without introducing cost or risk to the patient. Improving endovascular workflow can decrease treatment times and likely improve outcomes,[9] but this study was not powered to reveal a small change in mRS. The current study describes a simple, low-cost intervention that can easily be implemented in stroke centers aiming to reduce angio-suite treatment times.

A highly visible timer has been previously studied during other components of acute stroke care. Marto et al implemented a countdown timer in the emergency room, where it improved door-to-needle time for alteplase by 13.5 minutes,[8] based on a before-and-after analysis as opposed to randomization. Fousse et al mounted a timer in the computed tomography room where a treating physician was required to provide active feedback by pressing a button during critical steps of patient care (ie, examination, imaging, etc). This intervention was deployed in a pseudorandomized fashion, similar to the current study, and reduced the time required for several components of the acute stroke evaluation.[10] Although only 18 patients were treated with intravenous alteplase, the timer achieved an impressive door-to-needle time reduction from 47 to 19 minutes. Even fewer were treated with endovascular therapy (n=15), but the timer in the computed tomography room did not affect door-to-groin time. The current study applied the concept of a highly visible timer in a new location where it could be more reasonably expected to improve treatment times within the angio-suite. The mechanism by which it affects behavior is not entirely clear but may represent a Hawthorne effect in which cuing or feedback is not explicitly necessary. It is unclear how this passive approach might compare with more active strategies in which team members would be required to press the button to indicate completion of critical steps or in which the timer provided auditory reminders to the team. The intervention studied here was limited to the angio-suite, so it stands to reason that a mobile timer that travels with the patient from hospital arrival through revascularization may achieve the greatest impact, but this approach has not yet been rigorously studied.

Similar to prior timer-based stroke studies,[8,10] the current study failed to demonstrate an impact on long-term functional outcome. Given the coarseness of the mRS, and the relatively small potential impact of the intervention, a substantially larger study would be required to reveal a shift in mRS score, or alternative outcome measures could be considered. Based on the HERMES pooled analysis, every 9 minutes of treatment delay causes 1 out of every 100 patients to suffer a higher 90-day mRS.[4] Combining time-saving measures will likely have an additive effect and thereby increase the likelihood of achieving better outcomes. Settecase et al reported that after implementing a combination of workflow modifications, including a “stroke cart,” parallel staff workflow, and an emphasis on conscious sedation, ATG time was reduced by nearly 50%.[11]

Our study has several limitations. First, a sample size calculation was not performed a priori. The study was conducted in a single center thus limiting generalizability, particularly because endovascular workflows and treatment times vary among institutions, mostly with respect to intubation and general anesthesia. As previously mentioned, traditional outcome measures are coarse, so in future work, more sensitive measures could be considered. There is the possibility of observer bias, which we could not limit given the unblinded nature of our intervention, but the crux of this intervention relies on the Hawthorne effect to some degree, so it might be reasonable to consider it on the causal pathway rather than overt bias. It is also worth noting that interventionalists might be inclined to prolong times when the timer was turned off, but it seems unlikely interventionalists would jeopardize care to ensure positive study results. Finally, although the pseudorandomized design helps limit confounding, it does not prove durability of the intervention, but it is reassuring that the impact of the timer was consistent throughout the duration of the study. This does not exclude the possibility that the timer had variable affects across providers.

In conclusion, a highly visible timer in the angio-suite achieved a potentially meaningful, albeit modest, reduction in endovascular treatment time for stroke. A mobile timer that travels with the patient from hospital arrival through revascularization may present an opportunity for greater time savings. A larger multicenter study would be necessary to measure a potential impact on long-term functional outcome and to confirm generalizability. Nevertheless, given the lack of risk and very low cost, it is reasonable for stroke centers to consider using a highly visible timer in the angio-suite to improve stroke treatment times.

Disclosures

Dr Scott E Kasner discloses that he receives grant funding from WL Gore and Associates, Bristol-Myers Squibb, Medtronic, and Genentech. He also has consulting agreements with Diamedica, Bristol-Myers Squibb, Bayer, Medtronic, Abbvie, Abbott, and AstraZeneca; and receives royalties from UpToDate and Elsevier. Dr Jan-Karl Burkhardt discloses that he is on the scientific advisory board and consultant for Longeviti Neuro Solutions. He is also a consultant for Q'Apel Medical. The rest of the authors have no disclosures.

Nonstandard Abbreviations and Acronyms

ATG	angio-suite-to-groin time
GA	general anesthesia
eTICI	expanded treatment in cerebral ischemia
mRS	modified Rankin scale

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CLINICAL PERSPECTIVE

What Is New?

- In this single-center prospective pseudorandomized study conducted over a 32-week period we apply the concept of a highly visible timer in the angio-suite to quantify the impact on endovascular treatment time. This is a novel location of a timer in the study of stroke care.

What Are the Clinical Implications?

- Throughout the study period we showed a 5-minute reduction in treatment times. Although this time reduction is relatively small, it represents a 15% reduction in our angio-suite treatment time. A larger multicenter study would be necessary to measure a potential impact on long-term functional outcome and to confirm generalizability. Nevertheless, given the lack of risk and very low cost, it is reasonable for stroke centers to consider using a highly visible timer in the angio-suite to improve stroke treatment times.

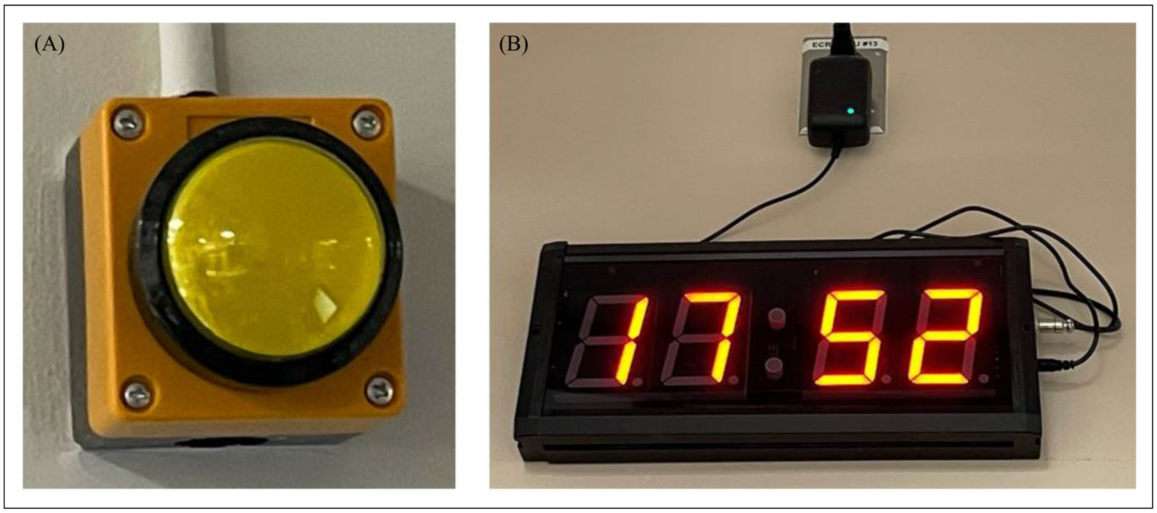

Figure. Push-button and angio-suite wall timer.
(**A**) Large visible push button located inside the angio-suite. Button push upon patient entry starts timer clock. (**B**) Timer clock located in a highly visible area in the angio-suite. The size of each digit is 3″ . Timer was unplugged during “OFF” weeks to prevent accidental use. Currently shown, timer counting to 17 minutes and 52 seconds.

Table 1.

Baseline Medical and Clinical Characteristics of Timer ON and OFF Groups

	Timer ON (n=38)	Timer OFF (n=59)	*P* value
Age (y)	72 (14)	70 (16)	0.48
Sex (%) female	61%	42%	0.07
Body mass index	28 (7)	27 (7)	0.36
Baseline NIHSS score	15 (11–24)	14 (9–22)	0.24
Admission ASPECTS	8 (7–9)	8 (7–9)	0.81
Occlusion location			0.15
ICA	8%	10%	
M1	53%	46%	
M2	21%	39%	
Basilar	11%	3%	
P1	8%	2%	
Infarct core volume (mL)	12 (0–18)	10 (0–28)	0.20
Penumbra volume (mL)	81 (64–123)	88 (60–160)	0.75
Admission logistics			
Intravenous thrombolysis	42%	31%	0.24
Standard daytime hours	71%	79%	0.39
Transfer from other facility	76%	79%	0.74
Direct to angio-suite (if transfer)	24%	23%	0.90

Continuous variables are reported as mean (SD) if normally distributed. Non-normal continuous variables or ordinal variables are reported as median (IQR). Categorical variables are reported as proportions. *P*-values are calculated by *t* test, Wilcoxon–Mann–Whitney, or chi-square tests, accordingly. ASPECTS indicates Alberta Stroke Program Early CT Score; ICA, internal carotid artery; IQR, interquartile range; M1, first segment of the middle cerebral artery; M2, second segment of the middle cerebral artery; NIHSS, National Institutes of Health Stroke Scale;and P1, first segment of the posterior cerebral artery.

Table 2.

Summary of Treatment Times in Timer ON and OFF Groups

	Timer ON (n=38)	Timer OFF (n=59)	*P* value
Overall ATG time (min)	28 (10)	33 (9)	0.02
Standard daytime hours ATG time (min)	27 (10)	32 (11)	0.04
After-hours ATG time (min)	29 (7)	34 (9)	0.20
Groin-to-recanalization time (min)	34 (19–50)	36 (18–65)	0.79
Hospital-arrival-to-groin time (min)	50 (34–82)	54 (40–95)	0.39
GA (%)	79%	81%	0.77
eTICI (%) ≥2b	89%	86%	0.66
90-d mRS	3 (3–4)	3 (1.5–4.5)	0.49
90-d mRS 0–2 (%)	37%	38%	0.96
Patients who received GA	(n=30)	(n=48)	
ATG time if intubated in angio-suite (min)	31 (9)	36 (10)	0.04
Angio-suite-to-intubation time (min)	13 (7)	17 (7)	0.04
ATG time if arrived intubated	23 (16–30)	22 (19–26)	0.71
Patients who did not receive GA	(n=8)	(n=11)	
ATG time (min)	20 (15–26)	26 (17–32)	0.39

Continuous variables are reported as mean (SD) if normally distributed. Non-normal continuous variables or ordinal variables are reported as median (IQR). Categorical variables are reported as proportions. *P* values are calculated by *t* test, Wilcoxon–Mann–Whitney, or chi-square tests, accordingly. ATG indicates angio-suite arrival to groin puncture; eTICI, expanded treatment in cerebral ischemia; GA, general anesthesia; IQR, interquartile range; and mRS, modified Rankin scale.