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Using body cameras to quantify the duration of a Code Stroke and identify workflow issues: a continuous observation workflow time study

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ABSTRACT

Objective 'Code Stroke' (Code) is used in health services to streamline hyperacute assessment and treatment delivery for patients with ischaemic stroke. However, there are few studies that detail the time spent on individual components performed during a Code. We sought to quantify the time taken for each process during a Code and investigate associations with modifiable and non-modifiable factors.
Design Continuous observation workflow time study.
Setting and participants Recordings of 100 Codes were performed at a high-volume primary stroke centre in Melbourne, Australia, between January and June 2020 using a body camera worn by a member of the stroke team.
Main outcome measures The main measures included the overall duration of Codes and the individual processes within the Code workflow. Associations between variables of interest and process times were explored using linear regression models.
Results 100 Codes were captured, representing 19.2% of all Codes over the 6 months. The median duration of a complete Code was 54.2 min (IQR 39.1–74.7). Administrative work performed after treatment is completed (median 21.0 min (IQR 9.8–31.4)); multimodal CT imaging (median 13.0 min (IQR 11.5–15.7)), and time between decision and thrombolysis administration (median 8.1 min (IQR 6.1–10.8)) were the longest components of a Code. Tenecteplase was able to be prepared faster than alteplase (median 1.8 vs 4.9 min, p=0.02). The presence of a second junior doctor was associated with shorter administrative work time (median 10.3 vs 25.1 min, p<0.01). No specific modifiable factors were found to be associated with shorter overall Code duration.
Conclusions Codes are time intensive. Time spent on decision-making was a relatively small component of the overall Code duration. Data from body cameras can provide granular data on all aspects of Code workflow to inform potential areas for improvement at individual centres.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Body cameras are a novel method of capturing workflow data from Code Strokes.
⇒ The approach provides granular data regarding time points and staffing, with precision to the second, allowing for accurate measurement of all tasks performed during a Code.
⇒ Body cameras allow for more objective analysis of workflow and overcome the cost and working hour restrictions of human observers.
⇒ In this study, only one body camera was used at a time, limiting the ability to record tasks being performed in parallel off-screen.
⇒ Only 100 Codes were recorded, with few instances of uncommon delay factors such as intubation, ultrasound-guided cannulation and blood pressure management.

INTRODUCTION

Timely thrombolysis from stroke onset is associated with favourable functional outcomes, an effect which diminishes with every minute and hour delay.[1 2] Similarly, longer transfer time out of primary stroke centres to comprehensive stroke centres for endovascular thrombectomy (EVT) is associated with poorer functional outcomes for patients.[3] 'Code Stroke' (Code) streamlines hyperacute care for patients with ischaemic stroke in the emergency department (ED).[4 5] Codes facilitate rapid access to thrombolysis and/or EVT by implementing a combination of best-practice strategies to reduce door-to-needle time (DNT).[6]

Despite continued quality improvement initiatives at our centre resulting in sustained improvements in DNT, our median DNT has stagnated in recent years.[7] Time-and-motion studies are an effective way of characterising and quantifying potential workflow issues.[8] Results from these studies provide insights for teams to adjust and improve clinical practice and resource allocation. Video studies have been useful in a variety of time-critical settings including emergency and resuscitation situations for review and training purposes.[9 10]

We sought to understand the workflow during a Code Stroke on a granular level by measuring the total duration of running a Code and to capture as many objective variables affecting workflow, such as the number of staff involved, and the time spent during a Code on performing key tasks, including decision-making.

METHODS

Setting

Box Hill Hospital (BHH) is a high-volume primary stroke centre in metropolitan Melbourne, Australia. It services a primary and secondary catchment of approximately 1.1 million people.[11] In 2020, the stroke team attended 1230 Codes, 75 patients received thrombolysis with 36 patients transferred to a comprehensive stroke centre for EVT.

Local stroke team processes

The Code response team at BHH comprises a neurology registrar or fellow (Australian postgraduate year (PGY) 4+) with an acute stroke nurse (ASN), a hospital medical officer ('HMO', Australian PGY 2+) and a research nurse typically being available during working hours. Working hours were defined as 08:00–17:00, evening shifts as 17:00–22:00 and overnight as 22:00–08:00. Codes could be activated by paramedics via pre-notification to the hospital, on arrival by a triage nurse or an ED doctor. Once a Code is activated, local protocols allow for the patient to be transported direct to CT without initial assessment from the neurology team to streamline patient care. A Code is considered 'stood down' once it is known that the patient will not receive hyperacute treatment for any reason. This can occur before, during or after CT imaging. Either the neurology registrar, fellow or neurologist has the authority to stand down the Code, including cancellation of perfusion imaging, if they find the patient to be ineligible for reperfusion therapy. The final treatment decision is discussed with the neurologist in-charge via telephone (not usually present at the Code).

Body camera video recording

We conducted a continuous observation workflow time study[8] of 100 Codes at BHH between January and June 2020. All adult cases where the registrar/fellow or ASN was called to assess a patient via a Code were eligible for inclusion in this study. This included after-hours and overnight Codes to provide a comparison for in-hours versus out-of-hours decision-making. The on-call neurology registrar/fellow or ASN (referred henceforth as the 'wearer') was provided with a portable body-worn camera (bodycam) capable of recording video and audio. The device is a Miufly EH15 bodycam with standard video and audio recording capability.[12] Purchase of the device was funded by the first and last authors. Only one member of the team wore the camera at a time. Each team member was encouraged to record as many consecutive Codes as possible during a shift. Not all Codes could be recorded due to simultaneous Codes or camera availability. Recordings could be stopped early at the discretion of the wearer for patients requiring sensitive discussion or planned withdrawal of care. These recordings were deleted and excluded from the study. A screening log was maintained for all recordings and Code Stroke activation was confirmed with the local stroke database. There were several reasons for excluding a recording including inappropriate setting (eg, palliative situation), contemporaneous Codes where there was only one camera in operation or inability to obtain consent (due to workload or patient discharged). The wearer was not required to document the reason for exclusion, which was at the discretion of the wearer. Codes involving the donning of personal protective equipment (PPE) in response to the global COVID-19 pandemic were excluded because it obscured the audio and video, and local infection control protocols did not permit our bodycam to be worn external to PPE. All recordings were reviewed within 30 days by at least one of the investigators. Once the data were collected, the recording was permanently deleted. No copies or transcripts of the recording were made.

Standard protocol approvals, registrations and patient consent

Each patient was informed of the recording on first contact and cases being recorded were indicated by a sign (see online supplemental methods). To ensure the patient's care was not compromised by the study, written informed consent for this study was only obtained after the patient had received all appropriate reperfusion treatment or the Code was stood down. For patients who were transferred for EVT, consent was obtained when they returned to BHH. For patients unable to consent, consent was obtained from an appropriate person responsible identified in accordance with local regulations. Patients or persons responsible who did not consent to the study were excluded and recordings deleted immediately.

All relevant staff members who could appear in the background (from the ED, radiology department and ambulance paramedics) were briefed on the confidentiality measures and opt-out procedure. These staff members were not required to sign study consent form. Recordings with staff who opted out were to be excluded from this study but no requests to opt out occurred during the study period.

Statistical analysis

Non-overlapping time points within the Code Stroke were chosen to illustrate the workflow as a single linear process reflective of the patient's journey in the ED. Examples of tasks performed in parallel within each interval are demonstrated in figure 1. All specified intervals and complete definitions of these are available in online supplemental table 1. Our main outcome measure was the 'team journey', defined as the total duration the

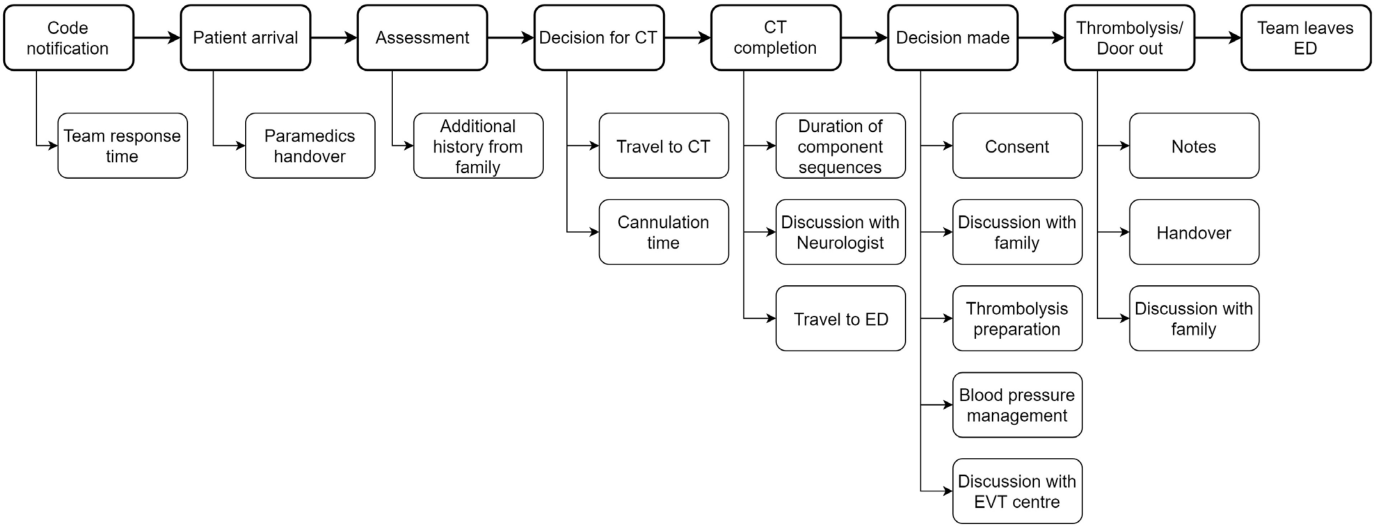

Figure 1 Sample representation of the patient journey during a Code Stroke with examples of component processes included during each time interval. The key processes in the top line are mutually exclusive, with its component processes able to occur in parallel and may overlap with other processes. ED, emergency department; EVT, endovascular thrombectomy.

team spent on a Code, calculated from the time of Code notification to the time the team leaves the ED.

The default process once a Code is activated is for the patient to undergo multimodal CT imaging (non-contrast CT, CT angiogram and CT perfusion). If the registrar/fellow was not able to assess the patient prior to transport to the CT scanner, the time to assessment and decision for CT was given a value of zero. For all other tasks which could be completed concurrently with a previous task, the duration was assigned a zero value for the purposes of statistical calculations, implying instantaneous completion of a task.

Descriptive statistics and regression models were performed in R studio V.4.0.5. Differences between categorical variables were assessed using the Kruskal-Wallis rank-sum test. Associations between variables of interest (see online supplemental table 2) and the duration of each task were examined using linear regression models. The final models were selected using the Akaike information criterion in a stepwise, forward selection process using the olsrr package in R. The models were assessed for multicollinearity and variables with variable inflation factor (VIF) larger than 5 were removed from the model and recalculated, resulting in VIF less than 2 in the final models.

Patient and public involvement

Outside of the panel members and laypersons comprising the ethics committee who provided feedback to the protocol in the initial ethics approval of the study, patients/members of the public were not involved in the design, conduct or reporting of this study.

RESULTS

A total of 19.2% of all Codes at BHH during the study period were recorded. A comparison of the bodycam cohort and overall Code Stroke population is shown in table 1.

Workflow

The median team journey was 54.2 min (IQR 39.1–74.7). This can be further stratified by treatment group as demonstrated in figure 2. Modifiable in-hospital factors, including number of staff, were not associated with a shorter team journey. A shorter team journey was however associated with two factors: decision to stand down the Code before imaging and prehospital intravenous cannulation (online supplemental table 3).

Median times of the component processes are visualised in figure 3. Key performance measures are summarised in table 2 with detailed timing of other processes shown in online supplemental table 4. Median duration of multimodal CT was 13.0 min (IQR 11.5–15.7) with the non-contrast portion being 3.7 min (IQR 3.0–4.4). Longer door-to-CT time was associated with the patient being offloaded in an ED cubicle prior to CT (35.0±8.3 min predicted delay, p<0.001). Conversely, shorter door-to-CT time was associated with pre-notification of the Code. No association was seen between duration of pre-notification and door-to-CT time.

Sixty patients arrived without an intravenous cannula in situ. Of these, 29 patients required cannula insertion by the team, which consumed a median 3.1 min (IQR 2.1–7.3). A total of 10.3% of cannulations (3 of 29) required portable ultrasound-guided insertion. With ultrasound, the time taken for cannulation ranged from 10.0 to 17.3 min. Treatment implementation was completed in a median of 8.1 min (IQR 6.1–10.9) (n=12). This included tasks such as obtaining consent for treatment, obtaining collateral history from family members, mixing the thrombolytic agent, phone calls to neurologists and blood pressure management. Tenecteplase

Table 1 Comparison of patient and Code Stroke characteristics between the study cohort and overall Code Stroke population at Box Hill Hospital during the study period (January–June 2020)

Characteristic	Bodycam cohort (n=100)	Overall (n=522)
Age, years (median (IQR))	75.5 (62–81)	76 (63–85)
Male, no (%)	53 (53)	275 (52.7)
NIHSS (median (IQR))	2 (0–5)	2 (0–6)
Baseline mRS, no (%)	(n=99)	
0	73 (74)	243 (54.4)
1	7 (7)	76 (17.0)
2	7 (7)	51 (11.4)
3	12 (12)	65 (14.5)
4	0	11 (2.5)
5	0	1 (0.2)
Pre-notified Codes, no (%)	62 (62)	370 (70.9)
Code initiator, no (%)		
Ambulance paramedic	68 (68)	437 (83.7)
ED triage/doctor	31 (31)	66 (12.6)
Inpatient	1 (1)	19 (3.6)
Code stood down, no (%)	87 (87)	477 (91.4)
Discharge diagnosis, no (%)		
Ischaemic stroke	47 (47)	193 (37.0)
Transient ischaemic attack	13 (13)	47 (9.0)
Haemorrhagic stroke	1 (1)	43 (8.2)
Stroke mimic	39 (39)	239 (45.8)
Received thrombolysis, no (%)	13 (13)	28 (5.4)
Transferred for EVT, no (%)	6 (6)	15 (2.9)
Enrolled in clinical trial, no (%)	9 (9)	14 (2.7)
Time of presentation, no (%)		
Working hours 08:00–17:00	75 (75)	338 (64.8)
Evening 17:00–22:00	20 (20)	105 (20.1)
Overnight 22:00–08:00	5 (5)	79 (15.1)
Day of presentation, no (%)		
Weekday	80 (80)	384 (73.6)
Weekend	17 (17)	120 (23.0)
Public holiday	3 (3)	18 (3.4)

ED, emergency department; EVT, endovascular thrombectomy; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale.

(n=7) was able to be prepared faster than alteplase (n=6) (median 1.8 vs 4.9 min, p=0.02).

The time after treatment is implemented or Code is stood down was considered as 'administrative work'. Tasks occurring during this time included typing notes, charting, handover and discussion or debrief with the patient and/or family. The median administrative work time for all Codes was 21 min (IQR 9.8–31.4). In univariable and multivariable analyses, the presence of a neurology HMO was associated with shorter administrative work time (median 10.3 vs 25.1 min, p<0.01). Conversely, if the research nurse was present, or during overnight Codes (where no HMO was present), the administrative work time was longer.

Staffing

All Codes were attended by a neurology registrar/fellow. There was at least one HMO present at 35% of Codes, but there was no HMO for overnight Codes. Stroke nurse attendance was 80.3% for Codes during weekday working hours. There was only one team member at 25% of Codes, two members in 49% of Codes, and 26% of Codes had three or more members present. The median response time between Code notification and arrival of the stroke team was 7.7 min (IQR 5.0–16.7) (n=89). Longer response times were seen overnight, on weekends and on public holidays. Our model predicted that the team would arrive an estimated 23.6±4.4 min later for overnight Codes compared with evenings (p<0.01).

Decision-making time

The first decision point identified was the decision to proceed with imaging or not. This occurred in a median 3.5 min (IQR 1.9–6.1) (n=84). This was found to be associated with the severity of the stroke, time of day and the presence of a neurology HMO (online supplemental table 3). The second major decision point was the decision for thrombolysis and/or EVT. Figure 2 demonstrates the median door-to-decision times for each situation stratified by imaging and treatment received. Treatment decision time was taken as the point the wearer confirmed verbally that they were proceeding with thrombolysis, EVT or standing down the Code. Door-to-decision time was defined as the time from patient arrival to the time a decision was made for thrombolysis, EVT or to stand down the Code. Public holidays and non-English-speaking background were associated with slower door-to-decision time, while more severe symptoms and prehospital intravenous cannulation shortened it (online supplemental table 3). There was no statistically significant difference in door-to-decision time with time of day, stroke nurse presence or Code pre-notification.

Ideal DNT

The data allowed us to calculate a theoretical ideal DNT of 21 min at our centre, visualised in figure 4. This model assumes the stroke team is pre-notified and has arrived before the patient; the decision to proceed with CT is performed instantaneously; clinical assessment is performed en route to CT; and the decision to thrombolyse can be made within the time to complete full multimodal CT imaging. Currently, thrombolysis is typically performed after perfusion and CT angiography, an addition which we have found to be only 10 min beyond the non-contrast CT.

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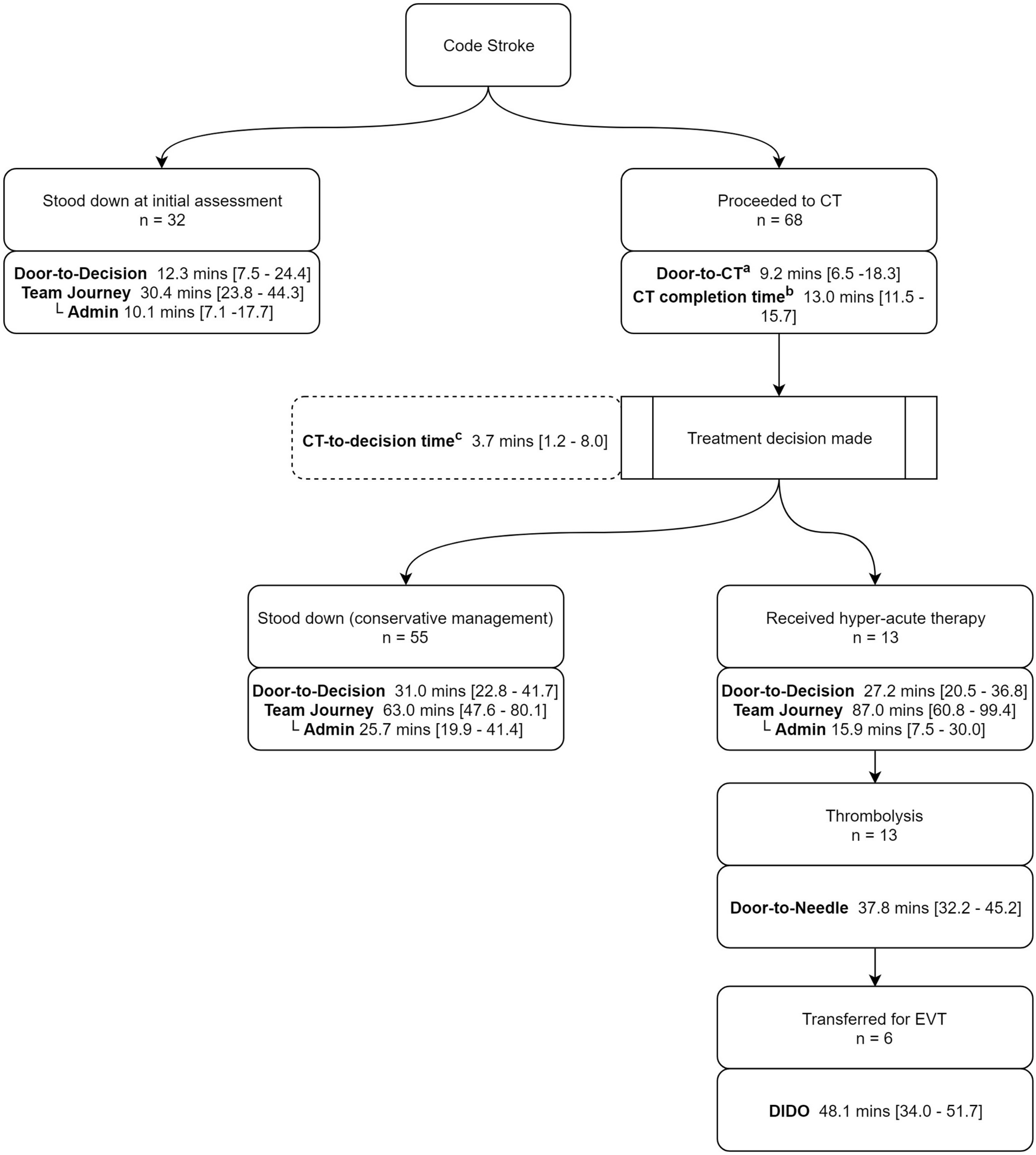

Figure 2 Decision-making and team journey metrics stratified by imaging and treatment group. Team journey is defined as the total time spent by the stroke team on a Code. [a]Door to CT (n=52). [b]CT completion time (n=50). [c]CT-to-decision time (n=59). Admin, administrative work (charting, notes, handover); DIDO, door-in-door-out time; EVT, endovascular thrombectomy.

DISCUSSION

The bodycam has allowed us to characterise our Code workflow and identify issues unique to our centre. Our findings show that Code Stroke is a time-intensive task, with a Code consuming a median of 54 min within the workday of the stroke team. A large proportion of this is spent on administrative work after reperfusion treatment is administered. Decision-making, however, only comprises a small part of the Code. The bodycam has also allowed us to capture non-standardised data such as time of decision, cannulation variables and number of staff, all with precision to the second. From this, we were

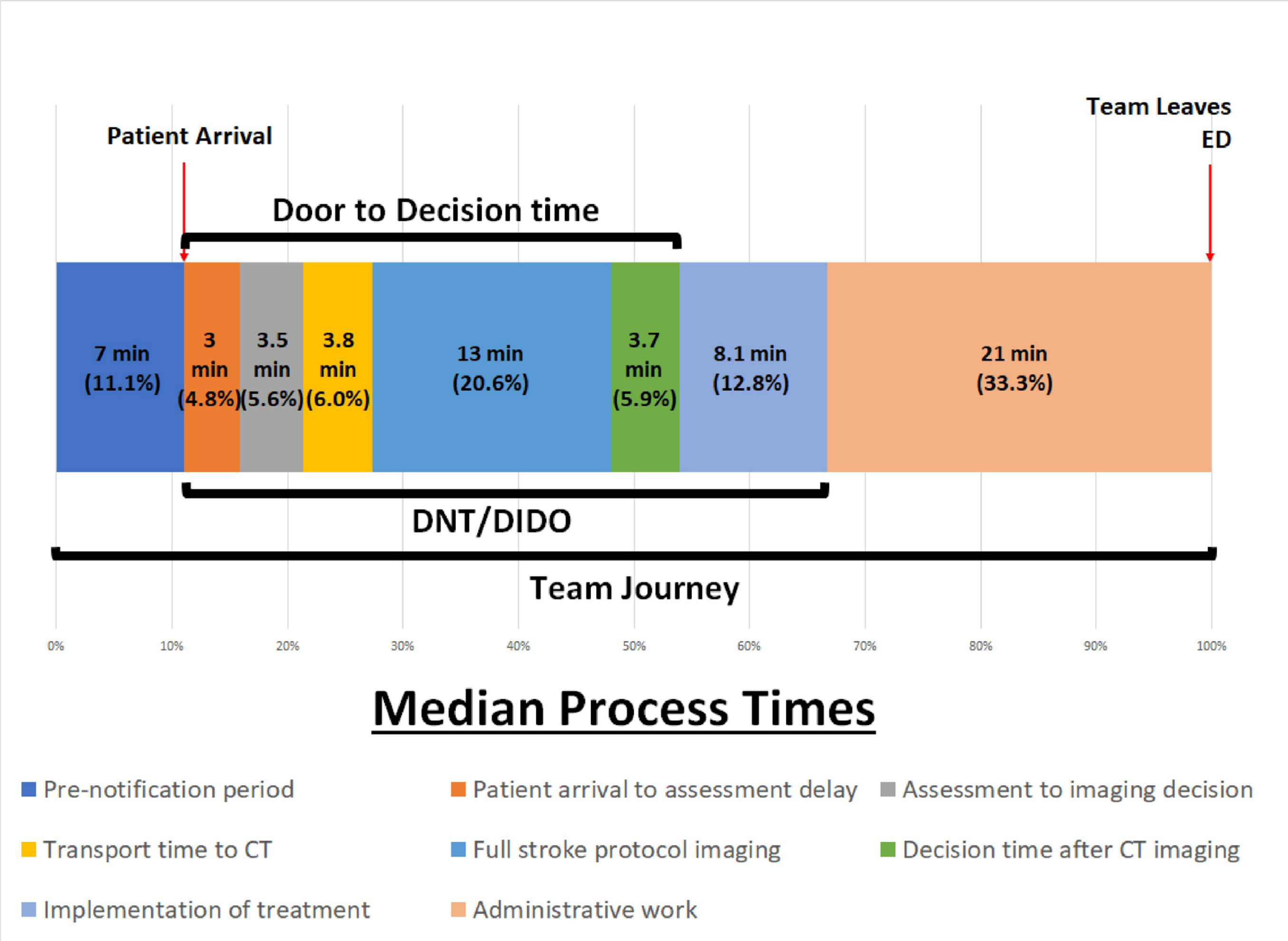

Figure 3 Timeline demonstrating the median time of each key process during a Code Stroke. The percentage values reflect the task duration as a proportion of the sum of all median process times. Team journey is defined as the total time spent by the stroke team on a Code. DIDO, door-in-door-out time; DNT, door-to-needle time; ED, emergency department.

able to quantify the time saved when using tenecteplase compared with alteplase; time to decision-making and an ideal DNT for our centre. These are powerful data that can be replicated at other centres to identify local bottlenecks and barriers to Code Stroke workflow.

Personal recording devices have now become readily accessible to the public and are easy to operate. Studies using these devices would allow researchers to obtain both time and location information not available to fixed camera set-ups.[13] Self-reported data are highly unreliable[8] and are unable to provide the level of detail required for our purposes. Trained human observers have been used in previous studies but labour costs and training are expensive and time-consuming. ED scribes are not routinely used in Australia. The cost of providing an observer outside of traditional work hours would be prohibitive. Video capture of Code Stroke also has the potential to reduce inter-rater variability by allowing the event of interest to be reviewed both remotely and during office hours. Furthermore, the ability to pause and rewind may reduce the likelihood of inaccurate or missing data when using human observers, especially when many tasks occur in parallel during a Code. It has also been shown that the physical presence of an observer can change the practice

Table 2 Summary statistics for key time metrics in this study

Time metric	n	Median (IQR) (min)	Range (min)
CT completion to decision made	59	3.7 (1.2–8.0)	0–31.5
Door-to-CT	52	9.2 (6.5–18.3)	4.3–117.2
Door-to-decision	83	25.2 (14.9–37.5)	4–115
Door-to-needle	13	37.8 (32.2–45.2)	25.0–63.0
Door-in-door-out	6	48.1 (34.0–51.7)	28.6–61.3

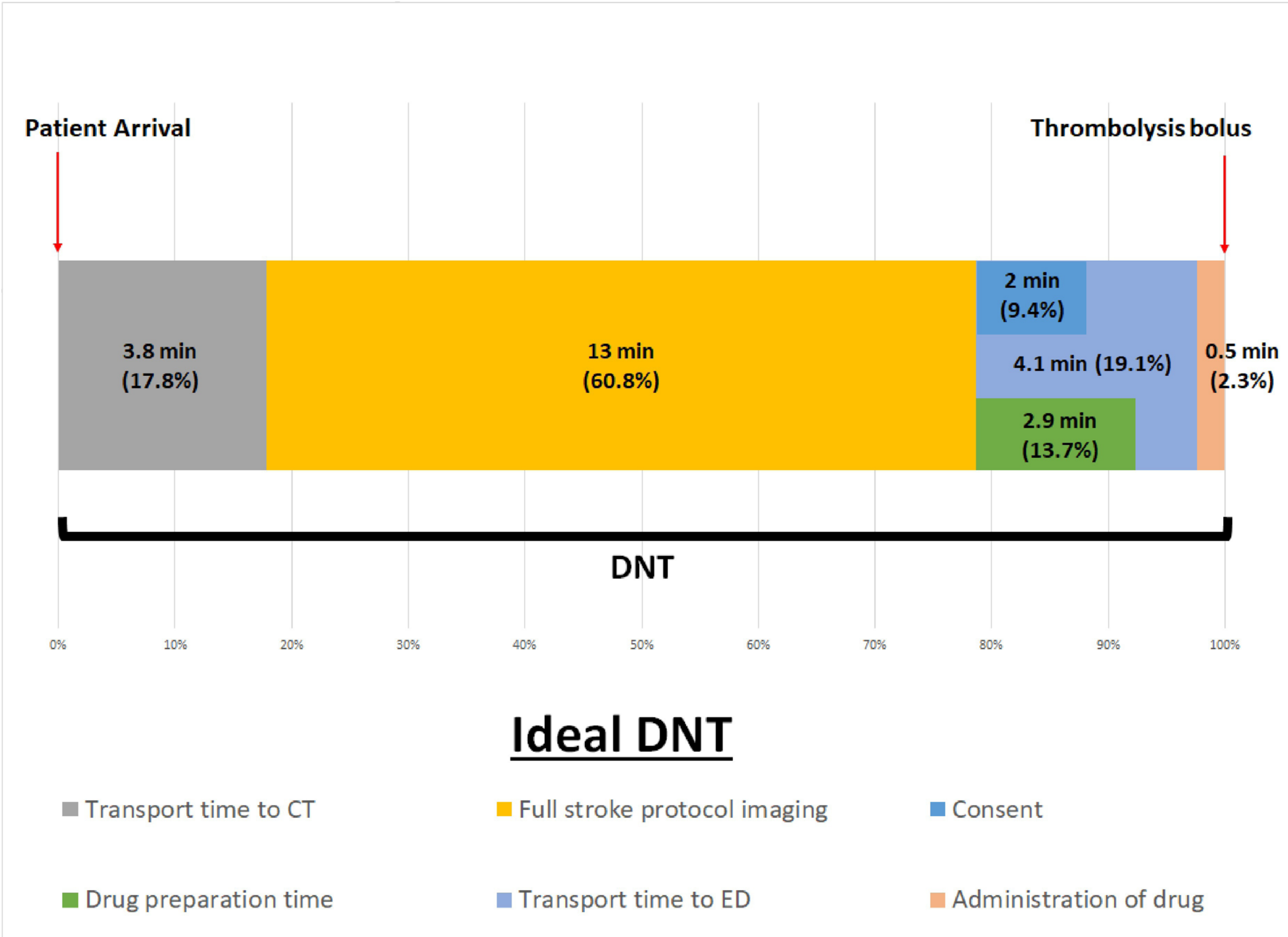

Figure 4 Timeline demonstrating the components of the ideal DNT at our centre of 21.4 min. The percentage values reflect the task duration as a proportion of the ideal DNT. DNT, door-to-needle time; ED, emergency department.

of the study subjects,[14] which could be minimised using personal recording devices.[13 15] Without the bodycam, we would not have been able to obtain these granular data as previous attempts with using trained observers have failed.

The current model in Melbourne allows for paramedics to activate a Code without detailed discussion with the receiving medical team. This results in a low proportion of patients being treated at Codes. This Code response increases staffing demands and the workload on individual clinicians. Around one-third of our Codes occur after hours and a quarter occur on weekends or public holidays. At a centre with a daily average of four Code Strokes, time spent on Codes can total nearly half the working hours of a standard shift. Even for Codes stood down on clinical assessment alone, the team would still be engaged in ED for a median of 30.4 min. Our data suggest that in centres with more than eight Codes per day, more than one stroke team may be required.

Contrary to anecdotal evidence, actual decision-making time once the information and imaging data have been gathered only represented 5.9% (3.7/63.1 min) of the overall Code Stroke process or 9.8% (3.7/37.8 min) of DNT. This time period represented the time spent in discussion with the neurologist. Instead, we have found that most of the time spent by the team at any Code is on administrative work. Surprisingly, administrative work for Codes which were stood down after imaging consumed the longest time despite not receiving treatment. One explanation is that this group is more likely to encompass stroke mimics or more complex decision-making scenarios, often requiring more time spent on handover and family discussions. Importantly, we did not find that purely increasing the number of staff attending a Code would reduce the team journey despite savings in administrative time. However, the extra team member could allow for tasks to be shared and the neurology registrar's time to be used more efficiently.

The benefit of reperfusion therapy in acute stroke is highly time sensitive but translation of this knowledge to real-world practice has been slow. Individual centres have reported significant improvements in treatment metrics over the last few decades, spearheaded by local stroke champions and region-wide programmes but it is clear we can improve on the status quo.[7 16 17] There is increasing interest in the benefits of mobile stroke units.[18 19] These units undoubtedly shorten treatment times by bringing the scanner and thrombolytics to the patient, yet they are resource intensive. Before widespread deployment of these units, it would seem logical to improve and maximise the efficiency of care at existing primary stroke centres where these already exist.[20]

Through bodycam data, we have found that local efforts to improve Code Stroke protocols[7] have reduced the discrepancy between in-hours and after-hours decision-making time despite the team physically arriving later. Our data have informed us that patients not eligible for clinical trials requiring multimodal imaging could be thrombolysed 9 min faster based on non-contrast CT alone. Second, we calculated for our centre that the lack of prehospital intravenous cannulation and direct-to-CT protocol potentially adds 14 and 35 min of delay to workflow, respectively, confirming again the importance of these within the Code Stroke protocol.[7] Bodycam studies could be replicated at other centres to identify delays unique to each centre and to quantify resources required to optimise treatment delivery.

Limitations

There are several limitations to this study. First, the recordings were not made on consecutive Code Strokes and the proportion of overnight recordings was lower in the study cohort. Partly, this occurred due to the limited number of cameras and the limitations of handing over the cameras between shifts. Yet, the bodycam allowed us to record a good proportion of after-hours Codes (25%), which would otherwise have been difficult to obtain if using a human observer. Our recruitment method may also explain the higher proportion of patients enrolled in trials and receiving reperfusion treatment compared with the overall cohort (13% vs 5.4%). We have noted that, at our centre, the proportion of patients receiving thrombolysis has decreased over time as total Code Stroke activations have increased, due to a larger number of non-stroke diagnoses. The proportion of patients receiving thrombolysis ranged from 6% to 12% between 2016 and 2019.[7] As such, the number of reperfusion cases captured in this study is within the expected range.

Second, we did not examine associations between DNT/door-in-door-out and patient-related factors such as blood pressure management or need for sedation.[21] We found that these situations occurred infrequently with no patients in this cohort requiring intubation or sedation for CT imaging. Larger-scale bodycam studies would be able to examine associations between patient or logistical factors and treatment times. Although this was not included in our study, the bodycam can also be used to provide qualitative data from clinician interactions and the ability to review the dynamic decision-making in complex cases that are not reflected in mock scenarios. Multiple bodycams could also be used to record the activity of other stroke team members and capture if any duplication of tasks occurred. This would be particularly helpful to further time the micro-tasks performed within administrative work time. However, this work is resource intensive as over 84 hours of footage was reviewed to yield the data for 100 patients in this study.

CONCLUSION

Bodycams are a convenient and feasible method of collecting data on Code Strokes. Clinical practices vary between different centres and this is a useful tool for stroke teams to examine their workflow and identify areas for quality improvement initiatives.

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Contributors JZWW and PC conceived and designed the study. JZWW obtained ethics approval. JZWW, TF and KS were involved in training required staff for the study. JZWW, TF, KS, PSWP, FKN-FHT, PGG and CS were involved in data collection. JZWW and PSWP were involved in data linkage and analysis. JZWW and PC drafted and finalised the manuscript. PC is the guarantor of the study.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval This study involves human participants and was approved by the Eastern Health Human Research Ethics Committee (reference number: E19/020/58177). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplemental information.

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REFERENCES

1 Meretoja A, Keshtkaran M, Tatlisumak T, *et al*. Endovascular therapy for ischemic stroke: save a minute-save a week. *Neurology* 2017;88:2123–7.
2 Emberson J, Lees KR, Lyden P, *et al*. Effect of treatment delay, age, and stroke severity on the effects of intravenous thrombolysis with

alteplase for acute ischaemic stroke: a meta-analysis of individual patient data from randomised trials. *Lancet* 2014;384:1929–35.
3 McTaggart RA, Moldovan K, Oliver LA, *et al*. Door-in-door-out time at primary stroke centers may predict outcome for emergent large vessel occlusion patients. *Stroke* 2018;49:2969–74.
4 Meretoja A, Weir L, Ugalde M, *et al*. Helsinki model cut stroke thrombolysis delays to 25 minutes in Melbourne in only 4 months. *Neurology* 2013;81:1071–6.
5 Meretoja A, Strbian D, Mustanoja S, *et al*. Reducing in-hospital delay to 20 minutes in stroke thrombolysis. *Neurology* 2012;79:306–13.
6 Fonarow GC, Smith EE, Saver JL, *et al*. Improving door-to-needle times in acute ischemic stroke: the design and rationale for the American heart association/american stroke association's target: stroke initiative. *Stroke* 2011;42:2983–9.
7 Park PSW, Frost T, Tan S, *et al*. The quest to reduce stroke treatment delays at a Melbourne metropolitan primary stroke centre over the past two decades. *Intern Med J* 2022;52:1978–85.
8 Lopetegui M, Yen P-Y, Lai A, *et al*. Time motion studies in healthcare: what are we talking about? *J Biomed Inform* 2014;49:292–9.
9 Mann CJ, Heyworth J. Comparison of cardiopulmonary resuscitation techniques using video camera recordings. *J Accid Emerg Med* 1996;13:198–9.
10 Mann FA, Walkup RK, Berryman CR, *et al*. Computer-Based videotape analysis of trauma resuscitations for quality assurance and clinical research. *J Trauma* 1994;36:226–30.
11 Eastern Health, Melbourne, Australia. eastern health strategic plan 2017-2022. In: Eastern Health. 2017:42.
12 Amazon.com. MIUFLY 1296P HD waterproof police body camera with 2 inch display, night vision, built in 32G memory and GPS. 2019. Available: Amazon.Com, Inc [Accessed 1 Jul 2019].
13 Weinger MB, Gonzales DC, Slagle J, *et al*. Video capture of clinical care to enhance patient safety. *Qual Saf Health Care* 2004;13:136–44.
14 Sedgwick P, Greenwood N. Understanding the Hawthorne effect. *BMJ* 2015;351:h4672.
15 Pringle M, Stewart-Evans C. Does awareness of being video recorded affect doctors' consultation behaviour? *Br J Gen Pract* 1990;40:455–8.
16 Ormseth CH, Sheth KN, Saver JL, *et al*. The American heart association's get with the guidelines (GWTG) -stroke development and impact on stroke care. *Stroke Vasc Neurol* 2017;2:94–105.
17 Kamal N, Jeerakathil T, Stang J, *et al*. Provincial door-to-needle improvement initiative results in improved patient outcomes across an entire population. *Stroke* 2020;51:2339–46.
18 Grotta JC, Yamal J-M, Parker SA, *et al*. Prospective, multicenter, controlled trial of mobile stroke units. *N Engl J Med* 2021;385:971–81.
19 Ebinger M, Siegerink B, Kunz A, *et al*. Association between dispatch of mobile stroke units and functional outcomes among patients with acute ischemic stroke in Berlin. *JAMA* 2021;325:454–66.
20 Lees KR. Does my district need a mobile stroke unit? *N Engl J Med* 2021;385:1043–4.
21 Choi PMC, Tsoi AH, Pope AL, *et al*. Door-in-door-out time of 60 minutes for stroke with emergent large vessel occlusion at a primary stroke center. *Stroke* 2019;50:2829–34.