Turnaround Time of Acute Multi-Modal Stroke Imaging Should Not Be More Than 11 Minutes

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Abstract

Background: Multimodal stroke imaging (Non-contrast CT, CT perfusion and CT angiogram) is essential to acute stroke assessment, there is currently no benchmark for this key process from real world data.

Methods: Retrospective review of the turnaround time of consecutive multimodal imaging performed for acute stroke assessment at two high volume stroke centers in Australasia from July to September 2019.

Results: 252 imaging studies were included from both sites. The overall median time from acquisition to imaging availability was 13 minutes (IQR 11- 16). The median for Christchurch and Box Hill were 11 minutes (IQR 10 – 12) and 15 minutes (IQR 13 – 19) respectively.

Conclusions: Multimodal stroke imaging turnaround time of 11 minutes is a reasonable benchmark.

Background

Perfusion imaging is recommended for selection of patients for reperfusion therapies beyond 4.5 hours for intravenous thrombolysis and 6 hours for endovascular thrombectomy.¹ Despite best practice guideline recommendations, computed tomography perfusion (CTP) is not routinely available or accepted partly due to perceived additional time required for acquisition, processing and interpretation, which may result in delay to reperfusion therapy.² In the IMS 3 study, the addition of multimodal imaging to non-contrast computed tomography (CT) did not result in a delay to thrombolysis.³ In the multi-center EXTEND trial, the median for CTP acquisition and processing alone was 11 minutes.⁴ However, there is a paucity of data demonstrating replication of fast CTP turnaround time in the real world experience. In this study we report the turnaround time of acute multi-modal computed tomography stroke imaging in two high volume stroke centers in Australasia.

Methods

A retrospective review of all cerebral CTP studies performed over a 3-month period from July to September 2019 at Christchurch Hospital, New Zealand and Box Hill Hospital, Melbourne, Australia. Departmental databases were interrogated for eligible cases. The data that support the findings of this study are available from the corresponding author upon reasonable request.

The healthcare setting and acute stroke workflow in both hospital has been reported elsewhere.^{5, 6} Patients considered eligible for reperfusion therapy proceed to emergent multimodal CT imaging immediately after the non-contrast CT (NCCT) excluded cerebral hemorrhage or tumor. A large-bore intravenous cannula (21G or above) is placed after the NCCT whilst the patient is on the CT table if it was not inserted by the ambulance crew prior to arrival to emergency department. In Christchurch, most patients brought in by ambulance would have a large bore (18G or above) intravenous line inserted prior to hospital arrival.

Technical information of the imaging specification and workflow is provided in Supplemental 1. The start of CT was extracted from time stamp on CT planning scan (completed at start of NCCT). The following time intervals were calculated: Planning scan to NCCT, NCCT to CTP injection, CTP injection to CT angiogram (CTA) injection, CTA injection to availability of perfusion maps from MiStar (Apollo Medical Imaging, Melbourne, Australia). Given different level of staffing at different times of the day, three time intervals were pre-defined: 0800 to 1700, 1700 to 2200, and 2200 to 0800. Time metrics were also analyzed according to weekday vs weekends and public holidays. Statistical analysis was performed using STATA (Stata Statistical Software: Release 14. College Station, TX: StataCorp LP). Ethics approval was obtained from local institutional review boards and patient consent was not required as per local legislation.

Results

There were 252 code stroke CT studies during the 3-month study period with 42% of the cases from Christchurch and the remaining from Box Hill. The mean age of patients was 72 (SD 14.6) years old with 49% male with no difference between the two sites. Overall, at both sites, 60% of the cases were performed during daytime hours (8am to 5 pm). Code stroke activation time of day was significantly different with 71% of studies done during working hours at Christchurch compared to 52% in Box Hill (Table 1). The median turnaround time was 11 minutes (IQR 10–12) for Christchurch and 15 minutes (IQR 13–19) for Box Hill respectively, with 66% and 56% of patients achieving times less than the respective site medians. Except for the time taken from NCCT to CTP injection at Box Hill, which would include IV cannulation time for some patients, the IQRs for the different steps in the imaging workflow are low (Table 1). Thus, there is negligible time variability in completion of imaging workflow steps at both centers.

Table 1
Baseline Characteristics of the cohorts.

	Christchurch	Box Hill	Overall
Baseline Characteristics, n (%)			
Number of patients	105 (42)	147 (58)	252
Age, mean (SD)	70 (15)	73 (14)	72 (14.6)
Male	52 (50)	71 (48)	123 (49)
0801–1700 hours	74 (71)	77 (52)	151 (60)
1701–2200 hours	19 (18)	39 (27)	58 (23)
2201–0800 hours	12 (11)	31 (21)	43 (17)
Weekdays	79 (41)	113 (59)	192 (76)
Weekends or Public Holidays	26 (43)	34 (57)	60 (24)
Imaging Metrics, median (IQR) minutes			
CT planning scan to NCCT	2 (1–2)	1 (1–1)	1 (1–2)
NCCT to CTP injection	2 (1–3)	6 (4–10)	4 (2–7)
CTP injection to CTA injection	2 (2–2)	6 (5–6)	5 (2–6)
CTA injection to CTP output	5 (5–6)	1 (1–2)	2 (1–5)
Turnaround time	11 (10–12)	15 (13–19)	13 (11–16)
NCCT: Non-contrast CT, CTP: CT Perfusion, CTA: CT Angiogram			

Table 2
Number of cases by site, time of day, weekdays and weekend/public holidays

	Christchurch			Box Hill		
	Weekday	Weekend or Public Holiday	Total	Weekday	Weekend or Public Holiday	Total
0800–1700 hours	54	20	74	56	21	77
1700–2200 hours	15	4	19	33	6	39
2200–0800 hours	10	2	12	24	7	31
Total	79	26	105	113	34	147

The median turnaround times at both sites are the same for all hours of the day, ~ 11 minutes in Christchurch and 15 minutes in Box Hill with slightly wider IQR during non-working hours (Fig. 1). Turnaround times are slightly longer during weekends and public holidays, by 1–2 minutes, except for when the denominator was small, for example only 2 patients were scanned overnight during weekend/public holidays in Christchurch with a turnaround time of 9 and 24 minutes. At Box Hill the median was 1 minute longer on weekend and public holidays. The IQRs were generally wider for Box Hill across all hours of the day, and the number of outliers were proportional to the total number of cases at each site (Supplemental Table 1).

In Christchurch, 0.6 mm cerebral CTA data is reconstructed immediately after CTA acquisition. Our data suggest the median time would be ~ 6 minutes from CT planning scan to CTA arrival on patient archiving and communication system (PACS). At Box Hill, cerebral CTA is reconstructed from CTP raw data via a semi-automated process, with a median of ~ 7 minutes from CT planning scan to PACS.

Discussion

Using a contemporary sample of patients, we have demonstrated that multimodal imaging can be acquired and processed in a timely manner. The acute stroke imaging process must be efficient to maximize the benefit of reperfusion paradigms based on CTP. In the endovascular thrombectomy era, upfront CTA is critical for patient selection. This report provides real world acute stroke CT time metrics for the purpose of benchmarking – cerebral CTA should be available within 6 to 7 minutes of a NCCT and CTP an extra 5 to 8 minutes. Our data reflect the inherent differences in work processes (timing of IV cannulation) and imaging processes (cerebral CTA from CTP data compared to arch to vertex CTA) at the study hospitals, this makes our data more generalizable.

We have focused on the imaging turnaround time alone to address the concern that additional perfusion imaging adds significant time delays in hyperacute stroke workflow. Indeed, if multimodal CT is not routinely performed upfront for all hyper-acute stroke, the addition of CTA alone may significantly delay the treatment workflow for patients with emergent large vessel occlusion presented to primary stroke centers.⁷ As recent as 2013, the median upload time for CTP alone was 23 minutes in health systems comparable to ours.⁸ With advances in hardware, network bandwidth and automated CTP processing, our overall median turnaround time is similar to the median of ~ 12 minutes from NCCT to completion of CTP processing reported in the multicenter Australasian EXTEND trial program which uses CTP exclusively for patient selection.⁴ Our definition of turnaround time, which starts from the planning scan, means routine median time recorded at Christchurch is even slightly faster than attended in EXTEND.

Extra information carries a cost, but the delay is minimal for most patients as shown by our data over a three-month period. We acknowledge the limitations; we did not record potential reasons for delay in patients with longer turnaround time, which most likely are due to patient factors such as agitation or

difficult cannulation. Secondly, we only analyzed 3 months of data at each center but given the medians were consistent, additional cases are unlikely to change results. Thirdly, both our centers utilize automated perfusion processing, which may not be generally available and is likely to be faster than semi-automated processing using proprietary software.

Conclusion

Our results suggest stroke multimodal imaging turnaround time of 11 minutes is an acceptable benchmark.

List Of Abbreviations

CT computed tomography; CTP computed tomography perfusion; NCCT non contrast computed tomography; CTA computed tomography angiogram; PACS patient archiving and communication system

Declarations

Quality assurance ethics approval was granted by ethics review boards of Eastern Health and Canterbury District Health. Patient consent was not required as per local legislation.

Consent for publication:

not applicable

Availability of data and materials:

The datasets analyzed during the current study are not publicly available due to local ethics committee regulations but are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests

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Author contributions:

CS data collection and writing manuscript; JB data collection; ST technical description of stroke imaging process at Box Hill Hospital; PM technical description of stroke imaging process at Christchurch Hospital; TYW writing of manuscript and study adviser; PMCC writing of manuscript, STATA statistical analysis and study adviser

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Figures

Figure 1

Total duration of acute imaging workflow in minutes by time of day and weekdays versus weekend/public holiday

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementalfinaldraft130320.docx](#)