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Original Research Article

COMPUTED TOMOGRAPHY ANGIOGRAPHY IN ACUTE ISCHEMIC STROKE

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Abstract

Introduction: We sought to evaluate the impact of a Computed Tomographic Angiography (CTA) for All emergency stroke imaging protocol on outcome after large vessel occlusion (LVO). CT scanners are more widely available than MRI scanners and are often located in emergency departments of district, hospitals. Noncontrast CT (NCCT) excludes intracranial hemorrhage and tumor and detects early signs of infarction. Inclusion of arte- rial and parenchymal imaging with CT angiography (CTA) can rapidly provide useful information that may influence manage- ment and may indicate infarct size, location, and extent of ves- sel occlusion and collateral integrity, all of which can influence clinical outcome and recanalization in HIS

Materials and Methods: This study done at Dept of Radio Diagnosis, Integral Institute of medical sciences and research, Lucknow, U.P. also done at United Medicity Medical College & Hospital (Nov 2021 to June 2022) Performing CTA and noncontrast computed tomography together as an initial imaging study for all patients with acute ischemic stroke (AIS) presenting within 24hours of last known well, regardless of baseline National Institutes of Health Stroke Scale score. Previously, CTA was reserved for patients presenting within 6 hours with a National Institutes of Health Stroke Scale score ≥6.

Results and Observations: After protocol implementation, more AIS patients underwent CTA (91% versus 61%; P<0.001) and had CTA performed at the same time as the initial noncontrast computed tomography scan (78% versus 35%; P<0.001). Median time from emergency department arrival to CTA was also shorter (29 [interquartile range, 16–53] versus 43 [interquartile range, 29–112] minutes; P<0.001), more cases of LVO were detected (166 versus 96; 32% versus 25% of all AIS; P=0.014), and more mechanical thrombectomy

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procedures were performed (108 versus 68; 21% versus 18% of all AIS; P=0.196). Among LVO patients who presented within 6 hours of last known well, median time from last known well to mechanical thrombectomy was shorter (3.5 [interquartile range, 2.8–4.8] versus 4.1 [interquartile range, 3.3–5.6] hours; P=0.038), and more patients were discharged with a favorable outcome (Glasgow Outcome Scale 4–5, 53% versus 37%; P=0.029). The odds of having a favorable outcome after protocol implementation was not significant (odds ratio, 1.84 [95% CI, 0.98–3.45]; P=0.059) after controlling for age and baseline National Institutes of Health Stroke Scale score.

Conclusions: Performing CTA and noncontrast computed tomography together as an initial assessment for all AIS patients presenting within 24 hours of last known well improved LVO detection, increased the mechanical thrombectomy treatment population, hastened intervention, and was associated with a trend toward improved outcome among LVO patients presenting within 6 hours of symptom onset.

Key Words: Brain ischemia, humans, stroke ,tomography, X-ray computed

Introduction

Large vessel occlusion (LVO) is associated with high mortality and poor functional outcome in patients with acute ischemic stroke (AIS).[1,2] Mechanical thrombectomy (MT) is an essential treatment for LVO patients who pre- sent within 6 hours of symptom onset and in selected LVO patients presenting 6 to 24 after onset.[3] Because MT is a highly time-sensitive treatment,[4] time-efficient vascular im- aging to diagnose LVO is needed. Combined noncontrast computed tomography (NCCT) and computed tomographic angiography (CTA) have been championed as the new minimum standard for initial imaging of disabling stroke.[5] Patient selection criteria that impose arbi- trary limits on time from last known well (LKW) or baseline National Institutes of Health Stroke Scale (NIHSS) score may delay CTA and the diagnosis of LVO. This in turn may limit the proportion of potentially treatable patients or reduce the ef- fectiveness of MT when performed after an unnecessary delay. We recently implemented a CTA-for-All stroke imaging policy throughout the Henry Ford Health System, which called for combined NCCT and CTA as the initial imaging study for all potential stroke patients presenting within 24 hours of LKW, regardless of the baseline NIHSS score. In this retrospective analysis, we compared treatment processes and outcomes between AIS patients admitted 1 year before and after protocol implementation.CT scan- ners are more widely available than MRI scanners and are often located in emergency departments of district hospitals. Noncontrast CT (NCCT) excludes intracranial hemorrhage and tumor and detects early signs of infarction. Inclusion of arte- rial and parenchymal imaging with CT angiography (CTA) can rapidly provide useful information that may influence manage- ment and may indicate infarct size, location, and extent of ves- sel occlusion and collateral integrity, all of which can influence clinical outcome and recanalization in HIS

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Materials and Methods

This study done at Dept of Radio Diagnosis, Integral Institute of medical sciences and research, Lucknow. And also done at United Medicity Hospital and Medical College & Hospital (Nov 2021 to June 2022) performing CTA and noncontrast computed tomography together as an initial imaging study for all patients with acute ischemic stroke (AIS) presenting within 24 hours of last known well, regardless of baseline National Institutes of Health Stroke Scale score. Previously, CTA was reserved for patients presenting within hours with a National Institutes of Health Stroke Scale score ≥6. and serum creatinine levels were routinely checked be forehand.To evaluate the impact of the CTA protocol, we compared patient characteristics, care processes, and outcome at discharge among all patients with AIS presenting within 24 hours of LKW who were admitted to HFH adoption of the new CTA protocol. We also analyzed data relating to MT among all LVO patients, broken down by those arriving <6 hours or between 6 and 24 hours after LKW. Our computed tomography perfusion protocol, specific data that we collected, outcome measures, and the statistical analysis plan are provided in the were discharged from HFH with a verified discharge diagnosis of AIS. Of these, 388 were admitted 1 year before, and 515 patients 1 year after, implementation of the CTA-for-All stroke imaging protocol.

Results And Observation

There were no significant differences in demographics, co- morbid diseases, baseline ambulatory status, admission source, or baseline NIHSS score between the 2 treatment periods. Time from LKW to arrival at the first ED, first NCCT, and arrival at HFH was also similar (Table I in the online-only Data Supplement). After implementation of the new protocol (Table 1), more patients underwent CTA, the proportion who underwent CTA at the time of the initial NCCT more than doubled, median time from first ED arrival to CTA was sig- nificantly shorter, and more cases of LVO were detected (166 versus 96 patients; 32% versus 25% of all AIS; *P*=0.014). The number of patients treated with intravenous tPA and door-to- needle time did not change. The proportion of LVO patients receiving MT did not differ, although 40 more patients received MT in the year following the initiation of the protocol (Table 2). Patients with LVO after protocol implementation had lower NIHSS scores than those diagnosed before. Postprotocol LVO patients also had shorter intervals from first ED arrival to CTA and more frequently had CTA performed at the same time as the initial NCCT (Table 2).

Its several relatively small trials demonstrated that CTA had excellent correlation with digital subtraction angiography (DSA), magnetic resonance angiography, and transcranial Doppler ultrasound.[6–8] Using DSA as a reference standard, Lev et al[9] directly compared CTA and DSA findings in 224 vessel segments (divided into internal carotid artery [ICA], middle cerebral artery [M1 and M2-MCA], anterior cerebral artery [A1-ACA], posterior cerebral artery [P1 and P2-PCA], basilar artery [BA], and vertebral artery) in 44 patients with acute stroke. Sensitivity and specificity for the detection of large-vessel occlusion was 98.4% and 98.1%, respectively. More recently, Bash et al[10] assessed 672 vessel segments in 28 patients who

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underwent CTA and magnetic resonance angiography, using DSA as a reference standard. CTA had sensitivity and positive predictive value for occlu- sion of 100%, significantly better than magnetic resonance angiography (87% and 59%, respectively).[11] When maximum intensity projection images have been compared with CTA source images (CTA-SI) for identification of occlusion, the lat- ter seems slightly more sensitive.[12]

Table 1: Patients With Acute Ischemic Stroke Presenting Within 24 Hours

Characteristics	Before CTA Protocol Implementation (n=388)	After CTA Protocol Implementation (n=515)	P Value
CTA performed	235 (61)	466 (91)	<0.001*
Time from LKW to CTA, h	2.9 (1.5–7.6)	2.6 (1.2–7.5)	0.055
Time from the first ED arrival to CTA, min	43 (29–112)	29 (16–53)	<0.001*
CTA performed at the same time as initial NCCT	136 (35)	400 (78)	<0.001*
LVO diagnosis	96 (25)	166 (32)	0.014*
Patients treated with intravenous tPA	170 (44)	248 (48)	0.195
Time from LKW to tPA, min	141 (91–181)	130 (90–184)	0.815
Door-to-needle time, min	59 (44–78)	54 (41–74)	0.134

Data are n (%) or median (IQR). CTA indicates computed tomographic angiography; ED, emergency department; IQR, interquartile range; LKW, last known well; LVO, large vessel occlusion; NCCT, noncontrast computed tomography; and tPA, tissue-type plasminogen activator.

*Statistically significant at P<0.05.

Table 2: Patients with Large Vessel Occlusion

Characteristics	Before CTA Protocol Implementation	After CTA Protocol Implementation	P Value
All patients	n=96	n=166	
Initial NIHSS score	17 (9–22)	13 (7–21)	0.027*
Time from LKW to CTA, h	2.4 (1.3–4.1)	2.3 (1.1–5.9)	0.598
Time from the first ED arrival to CTA, min	37 (22–67)	21 (9–39)	<0.001*
CTA performed at the same time as initial NCCT	59 (62)	145 (87)	<0.001*
Treated with MT†	68 (71)	108 (65)	0.338
Presenting <6 h	n=80	n=119	
Initial NIHSS	17 (11–22)	14 (7–22)	0.058
Time from LKW to CTA, h	1.9 (1.2–3.2)	1.4 (0.8–2.6)	0.005*
Time from the first ED arrival to CTA, min	35 (21–64)	21 (7–37)	<0.001*
CTA performed at the same time as initial NCCT	46 (58)	105 (88)	<0.001*
Patients treated with MT	64 (80)	82 (69)	0.083
Time from LKW to MT initiation, h	4.1 (3.3–5.6)	3.5 (2.8–4.8)	0.038*
Time from the first ED arrival to MT initiation, h	2.6 (2.1–3.6)	2.4 (1.9–2.8)	0.016*
Time from the first ED arrival to HFH arrival, h†	2.3 (2.0–3.2)	2.0 (1.6–2.5)	0.002*

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Data are n (%) or median (IQR). CTA indicates computed tomographic angiography; ED, emergency department; HFH, Henry Ford Hospital; IQR, interquartile range; LKW, last known well; MT, mechanical thrombectomy; NCCT, noncontrast computed tomography; and NIHSS, National Institutes of Health Stroke Scale.
*Statistically significant at P<0.05.

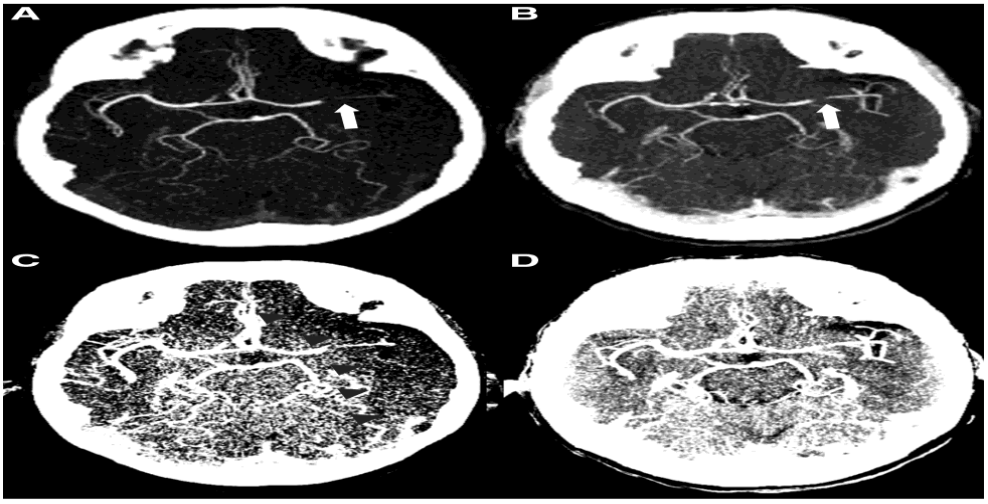

Figure 1: Early arterial (A and C) and delayed phase, 80 seconds after injection (B and D). Computed tomography angiograms demonstrating the difference in the appearance and length of thrombus depicted at different phases (A and B, white arrows). Additionally, images rewindowed to assess for ischemia (C and D) show that the early arterial imaging overestimates the degree of hypodensity (black arrowheads) relative to the delayed imaging.

Discussion

In this retrospective analysis, we sought to evaluate the impact of a system-wide stroke imaging protocol calling for routine CTA in addition to NCCT for all stroke patients presenting within 24 hours of LKW, regardless of baseline NIHSS. In the first year after protocol implementation, LVO detection increased from 25% to 32%, and the proportion of all AIS patients who underwent MT increased from 18% to 21%. Viewed another way, these data suggest that before implemen- tation of the CTA-for-All policy, up to one-quarter of all LVO cases were being missed. Among LVO patients presenting within 6 hours, the in- terval from LKW to arterial puncture decreased from 4.1 to 3.5hours, and the proportion of patients discharged with good outcome increased from 37% to 53%, although this relation- ship missed statistical significance after adjusting for age and baseline NIHSS scores. At the same time, the proportion of patients treated with tPA and the speed with which it was given did not change. These findings suggest that a uniform CTA-for-All imaging policy for stroke patients presenting within 24 hours is feasible and safe, improves LVO detection, speeds intervention, and can improve outcomes. The benefit appears to primarily affect patients presenting within 6 hours of symptom onset.The increase in favorable outcomes among LVO patients presenting within 6 hours of LKW after protocol implemen- tation was likely a consequence of lower baseline NIHSS scores in this group. Another contributing factor may have included faster thrombectomy because of earlier LVO detec- tion and improved

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interhospital transfer times after protocol implementation.Previously, CTA was reserved for patients presenting within 6 hours of symptom onset and a baseline NIHSS score ≥6. In the year after protocol implementation, we found that the proportion of patients who underwent CTA in addition to NCCT on admis- sion more than doubled, from 35% to 78%. At the same time, median door-to-CTA time fell from 43 to 29 minutes.Although the total number of patients receiving MT increased by 59% after protocol implementation, this was largely because of a 33% increase in overall AIS volume. Interestingly, the overall proportion of LVO patients treated with MT in the zero- to 6-hour window went down, from 80% to 69%, whereas both the total number and proportion in the 6- to 24-hour window went up. The decrease in the proportion of patients treated with MT in the zero- to 6-hour window is most likely explained by the fact that 18% of these patients had a baseline NIHSS of zero to 5. Although the benefit of MT in patients with an NIHSS score <6 is uncertain,[3] recent studies have reported better functional outcomes with thrombectomy in this subset.[13,14] This study has some important limitations. Unlike a pro- spective randomized trial, any before and after analysis is prone to unknown confounding variables that may explain observed differences in care dynamics or outcome. The large increase in AIS volume that we saw at HFH suggests that there were changes in referral patterns and stroke code acti- vation that occurred during the 2-year study period. Although we suspect that implementation of the CTA-for-All policy was the main cause of the improvement in the speed and sensitivity of LVO diagnosis, this remains speculative. The possible connection between our CTA imaging policy and the observed improvement in outcome among LVO patients presenting <6 hours remains even more tenuous. The Alberta Stroke Program Early CT Scores were unavailable in our data- base. Data on Alberta Stroke Program Early CT Scores would have helped us confirm that patients in the 2 treatment periods were comparable. We used the Glasgow Outcome Scale as our outcome measure at discharge, rather than more conventional metrics such as the modified Rankin Scale or NIHSS. We do not have data regarding the frequency of contrast-induced nephropathy. Finally, we did not evaluate cost effectiveness. The biggest strength of this study is that it reflects one health- care system's real-world experience with implementing a system-wide CTA-based stroke imaging protocol. Admittedly, however, this same strength has obvious limitations with re- gard to generalizability

Conclusion

It is evident that information gleaned from CTA images can be useful in prognosticating and decision-making in HIS. However, technique is the key to obtain reliable clinical infor- mation, and attention should be paid to this in setting up local imaging strategies. Combining vascular and parenchymal imaging findings may aid in selecting patients for, or exclud- ing patients from, more aggressive treatment options, with the aim of minimizing futile recanalization. Length of thrombus, site of occlusion, and size of core infarct may all be estimated using CTA, and these factors should be considered when tri- aging patients for intravenous or endovascular therapy. CT angiographic data are being included in endovascular stroke treatment trial design, and therefore, it will be interesting to see whether the findings of many of the published retrospective studies can be validated. What remains to

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be seen is whether patients presenting beyond the standard therapeutic time win- dows can be selected into recanalization therapy on the basis of imaging findings obtained using CTA. Specifically, a poten- tial avenue for research is whether good collateral status could be used as an inclusive marker for late thrombectomy.

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