JVIN | Journal of Vascular and Interventional Neurology

OFFICIAL JOURNAL OF ZEENAT QURESHI STROKE INSTITUTE

Neurovascular Imaging and Interventions for Stroke Management: A Systematic Review

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Abstract

Strokes present a significant global health challenge and remain a primary cause of death. Early detection and intervention are crucial for improved outcomes and prevention of post-stroke disability. Neuroimaging followed by neuro-intervention has proved to be of utmost importance in managing strokes. It is a relatively new and upcoming field, with advancements occurring as we speak. We reviewed 198 articles from reputable journals published between January 1st 2013, and January 1st 2023, focusing on eight selected papers for in-depth analysis. The analysis considered factors such as stroke type, treatment algorithms used, imaging, and interventions. This systematic review revealed that the current stroke-based diagnostic and treatment approaches face several open problems and issues regarding which imaging modality to use and the side effects of various interventions in real-life settings. Nevertheless, further exploration and research in neurovascular imaging, neuro-intervention, and stroke management are necessary to overcome these challenges and fully harness their potential to improve health outcomes for patients with cerebrovascular accidents.

INTRODUCTION AND BACKGROUND

Stroke or Cerebrovascular accident (CVA) is a highly debilitating condition characterized by sudden onset of symptoms and clinical signs. It is the second-leading cause of death and the third-leading cause of death and disability combined (expressed by disability-adjusted life years lost-DALY) in the world.[1] Every year, around 15 million people worldwide suffer from a stroke. About 5 million die out of these, and another 5 million are permanently disabled.[2] Approximately 12.2 million new strokes occur yearly, with one occurring as often as every 3 seconds.[1]

Stroke is defined as a condition wherein blood supply is disrupted to the brain, causing brain damage and loss of function. The two main categories are 1) Haemorrhagic, where blood leaks in the brain, and 2) Ischemic, caused by a clot in an artery.[3] CVAs can cause permanent damage, including partial paralysis and impairment in speech, comprehension, and memory. The disability depends on which part of the brain was affected and the duration for which blood supply was stopped.[3]

Strokes are multifactorial, and their causes include and are not restricted by elevated systolic blood pressure (SBP), high body mass index (BMI), high fasting glucose, smoking, high LDL cholesterol, and alcohol.[1] It is essential to know the signs of stroke as immediate emergency care can improve the outcome drastically. Strokes often present with facial drooping, arm weakness, slurred speech, and sometimes even vision changes and loss of balance.[3] The classification of CVAs includes ischemic stroke, hemorrhagic stroke, subarachnoid hemorrhage, cerebral venous thrombosis, and spinal cord stroke.[4]

It is essential to have standardized stroke protocols to prevent delays in acute stroke management and prevent neurologic and systemic complications. According to the American Stroke Association guidelines, there should be immediate transportation to the nearest stroke center after rapid identification of a stroke. In cases of acute ischemic stroke, after CT confirmation, Alteplase (IV r-tPA) is given within 4.5 hours of stroke onset (even if endovascular treatment is being considered), and this is associated with a higher chance (1.9 times) of having a favorable outcome. Mechanical thrombectomy is done for patients with large vessel occlusion within 6 hours of stroke onset, and this can help with improved early neurological recovery and improved functional outcome at 3 months.[5] After the patient is administered Alteplase, if the

Vol.14, No. 2, pp. 58-65, Published March, 2024.

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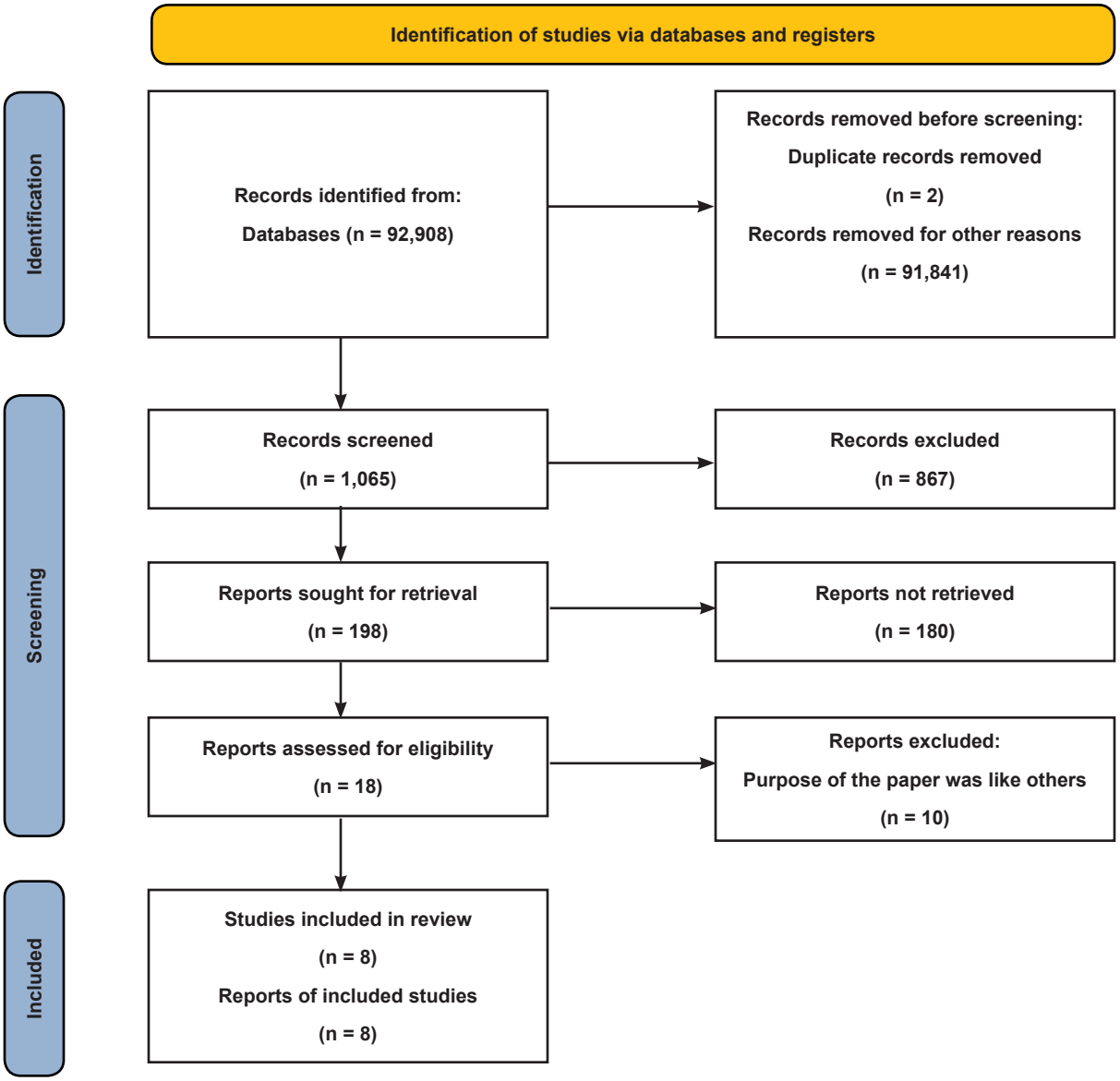

FIGURE 1: PRISMA flow diagram illustrating the search strategy and the study selection process for the systematic review.

cause of the stroke is due to the occlusion of a large cerebral artery in the anterior circulation, then endovascular therapy with a stent retriever is considered.[5]

The criteria for endovascular therapy include: under 6 hours of stroke onset, pre-stroke modified Rankin Score (mRs0-1), acute ischemic stroke receiving Alteplase (IV r-tPA) within 4.5 hours of onset, cause postulated due to occlusion of the internal carotid artery or proximal middle cerebral artery (M1), age- 18+ years, National Institutes of Health Stroke Scale (NIHSS) score of ≥6, Alberta Stroke Program Early Computed Tomography Score (ASPECTS) of ≥6.[5] Even though 4.5 hours is the recommended guideline, intra-arterial pharmacological thrombolysis can be considered up to 6 hours, and mechanical thrombectomy up to 8 hours from symptom onset in case of anterior circulation strokes, while a wider window of up to 12-24 hours is possible for posterior strokes.[6]

Neuro-endovascular surgery is a constantly growing field showing great potential in treating acute strokes. These mechanical thrombectomy devices not only allow an extension of the therapeutic time window but also can be used without adjuvant thrombolytic therapy, thus diminishing the risk of intracranial bleeding.[7]

Neuroimaging is an important modality that helps in decision-making in classifying and treating all kinds of strokes. Features seen range from parenchymal characteristics such as early ischemic changes, established infarct and tissue at risk (penumbra), and hemorrhage. We also see vessel pathology, which includes arterial and venous steno-occlusive diseases and vascular malformations. The vessel imaging also helps us assess collateral flow if there is a vessel occlusion.[8]

In a case suspected of stroke, computed tomography (CT) of the head is the first line imaging done. It helps identify the presence of hemorrhage, its severity, and its location. In cases without hemorrhage, it helps us administer thrombolytic therapy, thus decreasing the risk of further worsening any bleeding and thus giving appropriate treatment for ischemic strokes.[8]

Other neuroimaging used in strokes include CT angiography (CTA), which detects occlusion and dissection in extra-cranial and intra-cranial arteries; CT perfusion (CTP) imaging can help us see blood flow and study the characteristics of

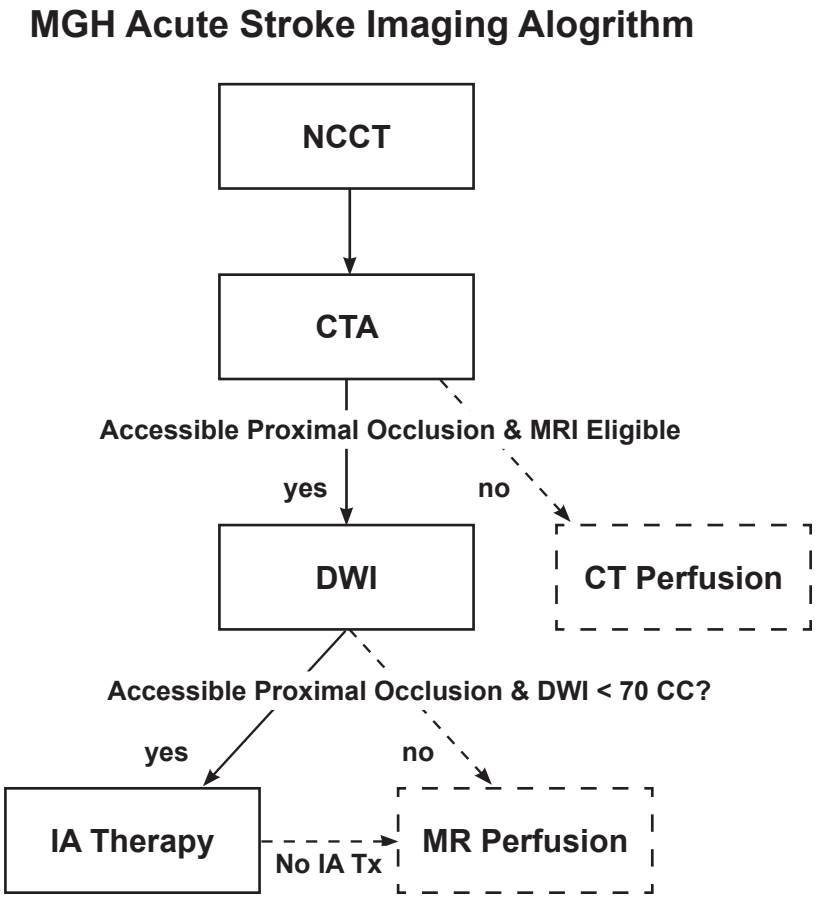

FIGURE 2: Massachusetts General Hospital acute stroke imaging algorithm for triage of patients with severe ischemic strokes caused by anterior circulation occlusions.

cerebral perfusion. CTA and CTP help us select patients for late window thrombectomy and rule out stroke mimics.[8]

MRI is an advanced neuroimaging tool wherein T1 and T2 sequences, diffusion (DWI), and perfusion (PWI) weighted imaging can detect early ischemia. MRI gradient recalled echo (GRE) could detect acute hemorrhage and is superior to CT for detecting chronic hemorrhage with a sensitivity of almost 100%.[8]

This systematic review evaluates available evidence concerning neuroimaging and neuro-interventions in stroke management, thus helping us know which imaging and intervention are suited in which cases, along with the advantages and disadvantages.

REVIEW

This review focuses on clinical studies concerned with neurovascular imaging and interventions in stroke management. We excluded animal studies and publications that only discussed the methodology of neurovascular imaging and interventions without presenting clinical data. The review follows the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[9] for 2020 in Figure 1, and it only uses data collected from published papers, eliminating the need for ethical approval.

Systematic Literature Search and Study Selection

We conducted a thorough search for relevant publications by using PubMed (including Medline) and Google Scholar. We searched for studies mentioned in clinical trials, meta-analyses, randomized controlled trials, and systematic reviews on PubMed. We reviewed the first ten pages on Google Scholar to find papers relevant to our topic. Nevertheless, we continued searching for additional studies that satisfied our inclusion criteria.

We had a list of abstracts that we independently reviewed for inclusion using specific criteria. The criteria included neurovascular imaging and interventions, focusing on stroke management, and a clearly described clinical cohort in the study.

Inclusion and Exclusion Criteria

We established specific criteria for including and excluding participants to achieve our study goals. Our Criteria can be summarized in Table 1.

Search Strategy

The population, intervention/condition, control/comparison, and outcome (PICO) criteria were utilized to conduct a thorough literature review. The search was conducted on databases such as PubMed (including MEDLINE) and Google Scholar Libraries, using relevant keywords, such as stroke, cerebrovascular accident, cerebral infarction, intervention, and imaging. The medical subject heading (MeSH) approach for PubMed (including MEDLINE) and Google Scholar, as detailed in Table 2, was employed to develop a comprehensive search strategy.

TABLE 1: Showing the criteria adopted during the literature search process.

	Inclusion Criteria	Exclusion Criteria
a	Human studies	Animal studies
b	From 2013 to 2023	Only methodological studies explaining neurovascular imaging and interventions
c	English texts	Non-English texts
d	Gender: All	
e	Age: >19 years	Age: <19 years
f	Free papers	Papers that need to be purchased
g		Studies involving clinical data other than neurovascular imaging and interventions

TABLE 2: Showing the search strategy, search engines used, and the number of results displayed.

Database	Search Strategy	Search results
PubMed (including MEDLINE)	stroke or cerebrovascular accident or cerebral infarction and intervention or imaging	1008
Google Scholar	stroke or cerebrovascular accident or cerebral infarction and intervention or imaging	91,900

TABLE 3: Showing quality appraisal tools used.
PRISMA: Preferred reporting items for systematic reviews and meta-analyses; SANRA: Scale for the assessment of non-systematic review articles.

Quality Appraisal Tools Used	Type of Studies
Cochrane Bias Tool Assessment	Randomized Control Trials
Newcastle-Ottawa Tool	Non-RCT and Observational Studies
PRISMA Checklist	Systematic Reviews
SANRA Checklist	Any Other Without Clear Method Section

TABLE 4: Summary of the results of the selected papers.

Author/Year	Country	Study design	Database used	Conclusion
Vagal A et al.[10]	USA, Canada	Clinical trial	Of 656 subjects enrolled in the Interventional Management of Stroke III trial, 90 received CTP and CTA, 216 received CTA (without CTP), and 342 received NCCT alone.	The use of CTA with or without CTP did not delay IV tPA thrombolysis or endovascular therapy compared with NCCT in the IMS III trial.
Roaldsen MB et al.[11]	Norway	Meta-analysis	Trials Registers of the Cochrane Stroke Group and Cochrane Vascular Group, CENTRAL (the Cochrane Library), MEDLINE, and Embase. They also used trial registers, screened reference lists, and contacted researchers.	Endovascular thrombectomy improves functional and neurological outcomes without increasing hemorrhage or death.
Nogueira RG et al.[12]	USA	Randomized controlled trial	Patients were enrolled from 25 North American centers. Patients with large-vessel intracranial occlusion AIS presenting with a National Institutes of Health Stroke Scale (NIHSS) score of at least 8 within 8 hours of onset underwent 1:1 randomization to 3-D stent retriever with aspiration or aspiration alone.	Non-inferiority of the 3-D stent retriever with aspiration compared to aspiration alone in AIS.
Jansen IGH[13]	Netherlands	Observational study	1488 patients from Multicentre Randomised Controlled Trial of Endovascular Treatment for Acute Ischaemic Stroke in the Netherlands (MR CLEAN) Registry who had received endovascular treatment, including stent retriever thrombectomy, aspiration, and all alternative methods for acute ischaemic stroke within 6.5 hours from onset of symptoms between March 2014 and June 2016.	In routine clinical practice, endovascular treatment for patients with acute ischaemic stroke is at least as effective and safe as in the setting of a randomized controlled trial.
Demchuk AM[14]	Canada, USA, Australia	Clinical trial	From the 656 subjects enrolled in the IMS III trial, 306 of them underwent baseline vascular imaging, including 292 who underwent CT angiography examinations, and 14 underwent MR angiography examinations.	Significant differences were identified between treatment arms for 24-hour recanalization in proximal occlusions; carotid T- or L-type and tandem ICA and M1 occlusions showed greater recanalization and a trend toward better outcomes with endovascular treatment. Vascular imaging should be mandated in future endovascular trials to identify such occlusions.
Albers GW[15]	USA	Randomized controlled trial	Across 38 centers in the United States, 182 patients were enrolled in the trial. After randomization, 92 were allocated to the to the endovascular-therapy group and 90 to the medical-therapy group.	Endovascular thrombectomy for ischemic stroke 6 to 16 hours after a last known well plus standard medical therapy resulted in better functional outcomes than standard medical therapy alone among patients with proximal middle cerebral artery or internal carotid artery occlusion.
Kamalian S[16]	USA	Review	Review of neuroimaging, patient selection, acute stroke management, and DAWN and DEFUSE 3 trial result analysis.	Neuroimaging is essential in assessing patients with suspected stroke, differentiating ischemic from hemorrhagic, identifying any stroke mimics, and guiding patient selection for available treatment options.
Furlan AJ[17]	USA	Editorial	Review of endovascular therapy in stroke management.	Comparison with the efficacy of various stroke trials.

Quality Appraisal

To ensure the reliability of our chosen papers, we utilized various quality assessment tools. We employed the PRISMA checklist and Cochrane bias tool assessment for randomized clinical trials for systematic reviews and meta-analyses. Non-randomized clinical trials were evaluated using the Newcastle-Ottawa tool scale. We assessed the quality of qualitative studies, as shown in Table 3, using the critical appraisal skills program (CASP) checklist. To ensure clarity in the classification, we utilized the scale for the assessment of narrative review articles (SANRA) to evaluate the article's quality.

RESULTS

After searching through selected databases, namely PubMed (including MEDLINE) and Google Scholar, we extracted 92,908 articles. We then carefully reviewed each paper and applied specific criteria, which led to the exclusion of 91,843 articles. From the remaining 1,065 papers, we chose not to utilize 867 of them due to unsatisfactory titles and abstracts. We closely examined the remaining 198 papers and excluded 190 more as their content did not meet our inclusion criteria. Finally, we conducted a thorough quality check on the remaining 8 papers, all meeting our criteria. These 8 articles are included in our final systematic review. Table 4 provides a detailed description of each.

DISCUSSION

Early detection (with neuro-imaging) and treatment (with IV r-tPA or endovascular therapy) are essential in improving survival and outcomes in patients presenting with acute stroke.

Recent advances in this field have resulted in a paradigm shift in how we approach imaging in neurology, specifically acute strokes. Recent advances in this field have resulted in a paradigm shift in our approach to acute stroke cases. The understanding of the concept "time is brain" has helped us understand that it is imperative that physicians use fast and reliable means when dealing with such time-sensitive scenarios.[18]

Neuroimaging has 4 critical roles in the assessment and diagnosis of acute ischemic stroke cases, namely:

(A) Excluding any acute intracranial hemorrhage is vital to help us, as IV-tPA is an absolute contraindication in these cases.

(B) Identification of a proximal large vessel occlusion (LVO) for administering intra-arterial thrombectomy (IAT) helps us account for most of the morbidity and mortality of strokes; in these cases, clot dissolution or retrieval with IV and intra-arterial thrombolysis helps restore normal blood flow to the brain.

(C) Estimating the volume of irreversible dead brain tissue (or infarction core) helps as large cores (with a threshold of 70mL) have a lower likelihood of an excellent clinical outcome and have an increased risk of intraparenchymal hemorrhage after successful reperfusion.

(D) Estimating the volume of potentially salvageable ischemic tissue is essential as the absence of it makes the risks of attempting reperfusion outweigh the benefits.[16]

The signs of an early infarct on non-contrast head CT (NCCT brain) are seen as loss of gray-white matter differentiation along the cortical ribbon (mainly in the insula) or lentiform nucleus, hyperdense vessel sign (indicating vessel embolus), effacement of the sulcus from edema.[16, 19]

Delayed-phase CTA images in acute stroke cases help in being confident that the observed collateral pattern reflects the true collateral circulation. It helps rule out an artifact of a delayed circulation time of contrast taking longer to reach the pial collateral circulation through a more circuitous pathway bypassing a proximal LVO, which also presents similarly.[16] Leptomeningeal collateral vasculature quality is a parameter of CTA that distinguishes patients most likely to benefit from IAT from those who are least likely to benefit.[20]

CTP is the mode of imaging used to determine cerebral blood flow (CBF) and cerebral blood volume (CBV), which helps in the measurement of the infarct core, and CBF and mean transit time (MTT), which is used for ischemic penumbra measurement.[16] Compared to a DWI reference standard, CTP is considered inferior in accuracy for assessing core infarct volume in a patient who is a potential candidate for IAT candidate; this is due to image noise and lack of standardization, leading to potential inaccuracy; there is also marked interscan variability in the quantification of perfusion parameter values as well as large measurement error in the estimation of infarct core volumes.[16]

MR (magnetic resonance) imaging's DWI (diffusion-weighted imaging) is highly sensitive, specific, and accurate in early detection and delineation of the infarct core. Ischemia causes restricted free water diffusion in the brain, resulting in marked hyperintense signal. It can often detect ischemia within minutes of onset compared to MRI's T1, T2, and FLAIR sequences, which are relatively insensitive in the first few hours post-ischemic stroke. The ADC (apparent diffusion coefficient) maps help distinguish a DWI-bright lesion as true restricted diffusion (i.e., DWI bright, T2 bright, and ADC dark) from T2 shine-through (i.e., DWI bright, T2 bright, and ADC bright).[19]

CTA is contraindicated in patients who cannot receive iodinated CT IV contrast material due to allergy or acute renal failure. Thus, an imaging modality called MR angiography is used. It is a valuable screening tool to detect any proximal LVO.[16]

A randomized open-label trial (DEFUSE 3) was conducted by Albers GW et al. across 38 US centers; it studied the outcome of patients with thrombectomy done 6 to 16 hours after last known well with selection done by perfusion imaging. The patients selected were those with proximal, middle cerebral artery, or internal carotid artery occlusion, infarct size of less than 70 ml, and a ratio of volume of ischemic tissue on perfusion imaging to infarct volume of 1.8 or more. They were then randomly assigned to either endovascular therapy

(thrombectomy) plus standard medical therapy (endovascular therapy group) or standard medical therapy alone (medical therapy group). The primary outcome was an ordinal score on the modified Rankin scale (range 0-no symptoms to 6-death, and the high scores indicate greater disability) at day 90 of the intervention.[15]

Analysis of the 182 patients was done, and it showed that endovascular therapy plus medical therapy, compared with medical therapy alone, was associated with a more favorable functional outcome on the modified Rankin scale at 90 days. The functionally independent patients were defined as a score on the modified Rankin scale of 0 to 2 at 90 days. It was 45% in the endovascular therapy group, compared to 17% in the medical therapy group. The 90-day mortality rate in the endovascular therapy arm was 14%, and in the medical therapy arm, it was 26%, with no significant difference in the frequency of symptomatic intracranial hemorrhage or adverse effects. The team concluded that endovascular thrombectomy for ischemic stroke at 6 to 16 hours, along with standard medical therapy, resulted in better functional outcomes than standard medical therapy alone.[15]

Demchuk AM et al. conducted a study wherein they used baseline CT angiography to analyze and study imaging and clinical endpoints in an Interventional Management of Stroke III cohort to identify patients who would benefit from endovascular stroke intervention. The study aimed to improve revascularization and clinical outcomes by comparing IV tPA with endovascular therapy with IV tPA alone in cases of moderate to severe acute ischemic stroke.

In this trial, the participants underwent a follow-up (after 24 hours) CT or MR angiography to evaluate recanalization rates in both the treatment arms. The study's primary endpoint was the 90-day dichotomized modified Rankin Scale (mRS) score. The secondary endpoints were 90-day mRS score distribution and 24-hour recanalization. The investigators reported the results: of 656 subjects, 306 (47%) underwent baseline CTA or MRA, and from these 306, 282 (92%) had arterial occlusions. At baseline CTA, proximal occlusions were noted in 220 participants.[14]

Post-intervention, it was noted that in patients with CTA proximal occlusions(n=220), there was no difference in the primary outcome in endovascular (41.3% [62 of 150]) vs. IV tPA (38% [27 of 70]). The relative risk was 1.07 [99% confidence interval: 0.67]; P = 0.70). The 24-hour recanalization rate was higher for endovascular treatment (n = 167; 84.3% [97 of 115] vs 56% [29 of 52] IV tPA; P < 0.001). Analysis for any occlusion at the baseline CTA did not demonstrate any significant differences between endovascular and IV tPA arms for the primary outcome (44.7% [85 of 190] vs 38% [35 of 92], P = 0.29). Carotid T- or L-type occlusion (terminal internal carotid artery [ICA] with M1 middle cerebral artery and/or A1 anterior cerebral artery involvement) or tandem (extra-cranial or intra-cranial) ICA and M1 occlusion subgroup also favored endovascular treatment over IV tPA alone for primary outcome (26% [12 of 46] vs 4% [one of 23], P = .047). The 90-day mortality was 17% [7 of 41] vs 16% [3 of 19], P > 0.99). The complete mRS distribution analysis was not significant (with P = 0.93).

They concluded that significant differences were found between both the treatment arms for 24-hour recanalization in proximal occlusions, carotid T- or L-type and tandem ICA and M1 occlusions showed greater recanalization and a trend towards better outcome with endovascular treatment.[14]

Using the Interventional Management (IMS) of Stroke III trial data, Vagal A. and their team explored and studied the effect of multimodal imaging (CT perfusion and/or CT angiography) versus non-contrast CT alone on time to treatment and outcomes.

The study involved a comparison of 3 groups:

1) participants with baseline CTP and CTA (CTP+CTA),
2) participants with baseline CTA without CTP (CTA), and
3) participants with non-contrast head CT alone. The aspects of the comparison included demographics, treatment time intervals, and clinical outcomes.

Out of the 656 subjects enrolled in the trial, 90 (13.7%) received CTP+CTA, 216 (32.9%) received CTA (without CTP), and 342 (52.1%) received NCCT alone. Median times for the CTP+CTA, CTA, and NCCT groups were: stroke onset to IV tPA (120.5 versus 117.5 versus 120 minutes; P .5762), IV tPA to groin puncture (77.5 versus 81 versus 91 minutes; P .0043), groin puncture to endovascular therapy starting (30 versus 38 versus 44 minutes; P = 0.0001), and endovascular therapy beginning to end (63 versus 46 versus 74 minutes; P <0.0001). Compared with NCCT, the CTA group had better outcomes in the endovascular arm (odds ratio of 2.12; 95% CI, 1.36 – 3.31; adjusted for age, NIHSS score, and time from onset to IV tPA). The CTP+CTA group did not have better outcomes when compared with the NCCT group.

The investigators from this study concluded that using CTA with or without CTP did not delay IV tPA or endovascular therapy compared with NCCT in the IMS III trial.[10]

The strength of this study lies in the fact that there was an analysis of time to treatment with 3 different imaging protocols, thus helping us compare the advantages and side effects. This study also has a control NCCT-alone group, which helps in accurate comparisons, something other recent endovascular stroke trials lack.[10]

Endovascular therapy first became popularized worldwide post 1991, after the results of the Prolyse in Acute Cerebral Thromboembolism (PROACT) II trial were published.[22]

The controversy of endovascular therapy is a constantly continuing debate that further came to light again in 2013 when the results of the Interventional Management of Stroke (IMS) III, Mechanical Retrieval and Recanalization of Stroke Clots Using Embolectomy (MR RESCUE), and Local versus Systemic Thrombolysis for Acute Ischemic Stroke (SYNTHESIS Expansion) clinical trials suggested that endovascular therapy was no more effective than IV tPA alone.[17]

Further studies in these fields, as seen in recent randomized clinical trials such as the Multicentre Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands (MR CLEAN) trial, Extending the Time for Thrombolysis in Emergency Deficits - Intra-Arterial (EXTEND-IA) trial, Endovascular Treatment for Small Core and Anterior Circulation Proximal Occlusion (ESCAPE)

trial, Solitaire with the Intention for Thrombectomy as Primary Endovascular Treatment (SWIFT PRIME) trial, and the Randomized Trial of Revascularization with Solitaire FR Device versus Best Medical Therapy in the Treatment of Acute Stroke Due to an Anterior Circulation Large Vessel Occlusion Presenting within Eight Hours of Symptom Onset (REVASCAT)— have shown that endovascular therapy is highly beneficial as compared with IV tPA alone in patients with occlusions of the intracranial internal carotid artery or middle cerebral artery up to 6 hours post the onset of the stroke.

Furlan AJ talked about three reasons for this drastic change in treatment approach:

1) State-of-the-art technology, such as stent-retriever devices, has helped in faster recanalization and better reperfusion outcomes than previous thrombectomy devices or IV-tPA.
2) Increasing awareness of the importance of time has helped us push for decreasing the time to intervention. In the SWIFT PRIME trial, an emergency department door–to–groin puncture time of 90 minutes was achieved.
3) Change in the neuroimaging criteria for selecting patients, for example, the demonstration of large-vessel occlusion, determination of the volume of irreversibly infarcted brain tissue, and penumbral mismatch help in diagnosis and thus prompt intervention. Thus, the statement "It's about time" with respect to endovascular therapy for stroke is apt for this time and age.[17]

In the newer thrombectomy devices, a novel 3-dimensional (3-D stent retriever was one such device being used. A study was done to analyze the treatment effects of individual mechanical thrombectomy devices in large-vessel acute ischemic stroke (AIS). It involved determining whether the novel 3-dimensional (3-D) stent retriever used in conjunction with an aspiration-based mechanical thrombectomy device (Penumbra System; Penumbra) is not inferior to aspiration-based thrombectomy alone in AIS. This was a randomized clinical trial wherein patients from 25 North American centers were enrolled with follow-up for 90 days. The criteria involved large-vessel intracranial occlusion AIS presenting with a NIHSS score of at least 8 within 8 hours of onset, they then were randomized to 1:1 between 3-D stent retrievers with aspiration or aspiration alone. The primary analyses were conducted in the intention-to-treat population.[12]

The primary effectiveness endpoint was the rate of a modified Thrombolysis in Cerebral Infarction (mTICI) grade of 2 to 3 with a 15% non-inferiority margin, and the primary safety endpoint was device and procedure-related serious adverse events at 24 hours.[12]

Out of the 8082 patients screened, 198 were enrolled in the study and randomized, and the median baseline NIHSS score was 18 with an interquartile range of 14.0-23.0.[12]

Out of the 94 patients in the 3-D stent retriever and aspiration group, 82 (87.2%) had an mTICI grade of 2 to 3 compared with 79 of 96 in the aspiration alone group (82.3%, difference of 4.9%; 90% CI, −3.6% to 13.5%). None of the other measures were significantly different between the 2 groups. Device-related severe adverse events were reported in 4 of 98 patients in the 3-D stent retriever with aspiration group (4.1%) vs. 5 of 100 patients in the aspiration-only group (5.0%); procedure-related severe adverse events, 10 of 98 (10.2%) vs 14 of 100 (14.0%). A 90-day modified Rankin Scale score of 0 to 2 was reported by 39 of 86 patients in the 3-D stent retriever with aspiration group (45.3%) vs. 44 of 96 patients in the aspiration-only group (45.8%).

Thus, the study provided class 1 evidence for the non-inferiority of the 3-D stent retriever with aspiration vs. aspiration alone in AIS.[12]

Jansen IGH et al. worked on an observational cohort (done across 16 centers in the Netherlands) to study and determine the outcomes and safety of endovascular treatment for acute ischemic stroke due to proximal intracranial vessel occlusion in the anterior circulation.

The study included 1488 people in the Multicentre Randomised Controlled Trial of Endovascular Treatment for Acute Ischaemic Stroke in the Netherlands (MR CLEAN) Registry who had received endovascular treatment, including stent retriever thrombectomy, aspiration, and any other alternative interventions within 6.5 hours from onset of symptoms.[13]

The results showed that endovascular treatment in routine clinical practice for patients in the MR CLEAN Registry is at least as effective and safe as in the MR CLEAN trial. Despite older age and comorbidities, a higher proportion of patients reached a good functional outcome after 90 days. A statistically significant shift was observed towards a better functional outcome in patients in the MR CLEAN Registry compared with the MR CLEAN trial intervention arm (adjusted odds ratio 1.30, 95% confidence interval 1.02 to 1.67) compared to the MR CLEAN trial control arm (1.85, 1.46 to 2.34). The reperfusion rate, with successful reperfusion defined as a score of 2B-3 on the extended thrombolysis in cerebral infarction score, was 58.7%, the same as in the MR CLEAN trial. The duration from the onset of stroke to the start of endovascular treatment and from the beginning of the stroke to successful reperfusion or last contrast bolus was one hour shorter for patients in the MR CLEAN Registry. Symptomatic intracranial hemorrhage occurred in 5.8% of patients in the MR CLEAN Registry compared to 7.7% in the MR CLEAN trial intervention arm and 6.4% in the MR CLEAN trial control arm.[13]

Roaldsen MB et al. did a meta-analysis to answer the age-old question of whether endovascular thrombectomy, intra-arterial interventions, or both, plus medical treatment, are superior to medical treatment alone in people with acute ischaemic stroke. They included 19 randomized control trials with a total of 3793 participants. Most participants had large artery occlusion in the anterior circulation and were treated within 6 hours of symptom onset with endovascular thrombectomy.[11]

The treatment increased the chance of achieving a good functional outcome, defined as a modified Rankin Scale score of 0 to 2; the risk ratio (RR) was calculated to be 1.50 (95% confidence interval (CI) of 1.37 to 1.63). Treatment also reduced the risk of death at the end of follow-up: RR 0.85 (95% CI of 0.75 to 0.97; 3793 participants) without increasing the risk of symptomatic intracranial hemorrhage, RR 1.46 (95% CI of 0.91 to 2.36) or by the end of follow-up RR was

1.05 (95% CI of 0.72 to 1.52). The neurological recovery with a National Institutes of Health Stroke Scale (NIHSS) score of 0 to 1 and degree of recanalization rates was better in the treatment group with RR 2.03 (95% CI of 0.21 to 3.40) and RR 8.25 (95% CI of 1.63 to 41.90) respectively.[11]

They concluded that treatment with endovascular thrombectomy can improve the patient's chance of survival and improved function without increasing the risk of bleeding in the brain or death, one of the most feared complications. They were unclear about the optimal window within which treatment is beneficial and whether treatment is effective in the posterior circulation of the brain. In short, in acute ischaemic stroke due to large artery occlusion in the anterior circulation, endovascular thrombectomy can increase the chance of survival with a good functional outcome without increasing the risk of intracerebral hemorrhage or death.[11]

CONCLUSION

With the advancement of technology and the medical field, it is safe to say that neuroimaging and neuro-intervention have come a long way since it was first introduced. Our research highlights the appropriate use of neuroimaging in stroke and the interventions to alleviate post-stroke sequelae. We have analyzed the appropriate benefits of these modes of imaging and intervention along with models to optimize their prognosis. The technological advancements in interventional neuroradiology aim to alleviate the burden on clinicians and support them in patient care. Although challenges still exist, encouraging results have been obtained from clinical trials. There is a need to develop standardized algorithms worldwide to guide timely interventions, ultimately saving lives and resources for patients with acute cerebrovascular accidents. More large-scale randomized control trials are necessary to establish these algorithmic models' diagnostic and prognostic benefits.

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