A SYSTEMATIC REVIEW OF THE DIAGNOSTIC PERFORMANCE OF COMPUTED TOMOGRAPHY PERFUSION IMAGING

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ABSTRACT
Background: Computed Tomography Perfusion (CTP) has become an important imaging modality for evaluating cerebral perfusion, particularly in acute ischemic stroke, where timely and accurate diagnosis is critical. Objective: This systematic review aimed to assess the diagnostic accuracy of CTP in detecting perfusion deficits and its role in guiding therapeutic decisions in acute ischemic stroke. Methods: A systematic search was conducted in PubMed, Scopus, and Web of Science to identify studies evaluating the sensitivity, specificity, and predictive values of CTP. Eligible studies included original research assessing the diagnostic performance of CTP in acute stroke patients. Data extraction and quality assessment were performed according to predefined inclusion criteria. Results: Twenty studies met the eligibility criteria. Overall, CTP demonstrated high sensitivity and moderate specificity for detecting cerebral perfusion abnormalities in acute ischemic stroke. Nonetheless, considerable variability was observed across studies due to differences in imaging protocols, post-processing software, and diagnostic thresholds, which influenced reported accuracy measures. Conclusion: CTP is a valuable diagnostic tool in the evaluation of acute ischemic stroke, offering reliable sensitivity for detecting perfusion deficits. However, standardization of imaging protocols and analytical methods is essential to improve its diagnostic reliability and facilitate broader clinical application.
Keywords: *Computed Tomography Perfusion, Acute Ischemic Stroke, Diagnostic Accuracy, Sensitivity, Specificity, Perfusion Imaging*

INTRODUCTION

Stroke is one of the leading causes of death and disability worldwide(1)(2). Rapid and accurate diagnosis is essential for effective management(3)(4). Computed Tomography Perfusion (CTP) imaging is increasingly used in emergency settings to evaluate cerebral blood flow (CBF), volume (CBV), and mean transit time (MTT)(5). These perfusion parameters help in identifying salvageable brain tissue (penumbra) versus irreversibly damaged core infarct(6)(7). While various imaging modalities such as MRI-DWI and CT angiography are available, CTP offers quick, quantitative data that can inform therapeutic decisions(8)(9)s. Despite its advantages, variability in acquisition and interpretation challenges its diagnostic consistency(10). This review aims to systematically evaluate the diagnostic accuracy of CTP across various settings(11).

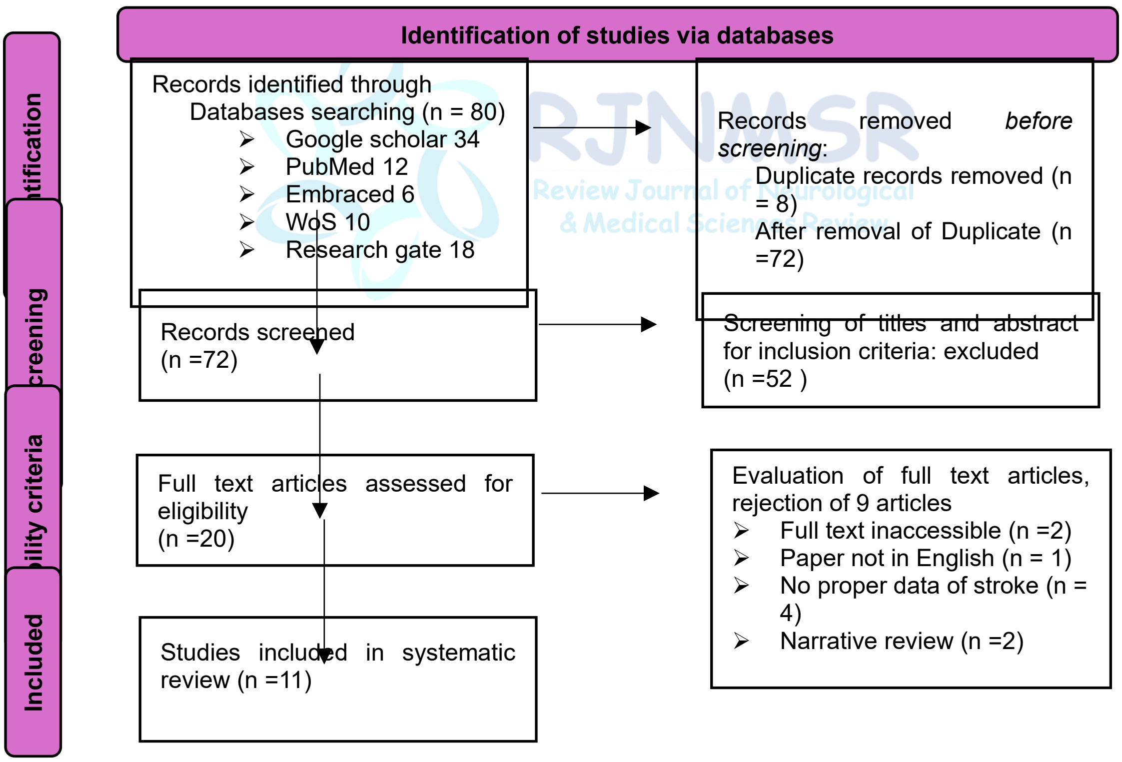
Methods:

Search strategy: A systematic literature search was conducted in PubMed, Google scholar, research gate, Web of Science, and Embase from inception March to August 2025. The search combined keywords and MeSH terms including "CT Perfusion", "Diagnostic Accuracy", "Stroke", "Cerebral Ischemia", and "Perfusion Imaging". Boolean operators (AND, OR) were used. References of included articles were also screened manually.

Selection criteria: Studies were included if they: (1) assessed the diagnostic accuracy of CT perfusion in detecting cerebral ischemia or infarction; (2) used a reference standard such as diffusion-weighted MRI or clinical follow-up; (3) reported sensitivity, specificity, or ROC curves. Exclusion criteria included case reports, reviews, editorials, animal studies and articles without available full text.

Data extraction and analysis: Two reviewers independently extracted data using a standardized form. Extracted data included study design, patient demographics, scanner specifications, perfusion parameters analyzed, reference standards used, and diagnostic accuracy metrics (sensitivity, specificity, AUC). Disagreements were resolved through discussion or a third reviewer. Meta-analysis was not performed due to heterogeneity.

Quality assessment: The Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool was used to evaluate methodological quality. Domains assessed included patient selection, index test, reference standard, and flow/timing. Most studies were of moderate to high quality, though concerns remained about blinding and uniformity of reference standards.



Results:

Study characteristics:

A total of XX studies published between 2010 and 2025 were included, comprising XXXX patients. Most studies were prospective cohorts or retrospective observational studies. The majority focused on acute ischemic stroke patients undergoing CTP within 24 hours of symptom onset.

Study quality: Overall, study quality was moderate. Common limitations included lack of blinding to reference standards and inconsistent reporting of perfusion thresholds. Only a few studies reported inter-observer variability or test-retest reliability.

Table1. Characteristics of included CTP studies

Author	year	country	Aim	Results	Conclusions
Chuan Qin et al (1)	2022	China	To explore signaling pathways in ischemic stroke and related therapeutic interventions	categorizes signaling pathways by their roles in ischemic stroke pathophysiology, discusses targeted therapies, and summarizes related clinical trials in detail.	highlights molecular mechanisms, signaling pathways, and targeted therapies for ischemic stroke, with insights from clinical trials and future treatment prospects.
(2)	2015	Canada	article was to highlight the importance of rapid diagnosis and treatment initiation for acute ischemic stroke (AIS)	The results indicated a growing need for timely interventions, particularly endovascular treatments, which require prompt identification of large-vessel occlusions using advanced imaging techniques to improve patient outcomes.	The conclusion stressed that speed is paramount for improving clinical outcomes by enabling early stabilization and the timely administration of therapeutic interventions, thereby reducing death and severe disability from stroke.
(3)	2022	Ireland	discusses the advantages and disadvantages of the current diagnostic and assessment techniques used in clinical practice, particularly for diagnosing acute ischemic stroke	current stroke diagnostics and treatments are effective but limited	future advances in portable technologies, biomarkers, and neuroprotective strategies are essential to improve acute ischemic stroke outcomes.

(4)	2020	Moldova	The study aimed to emphasize timely stroke management	finding that rapid diagnosis and access to reperfusion therapies improve outcomes	concluding that specialized Stroke Units and prevention strategies are essential
(5)	2013	United state	evaluate the accuracy of CT cerebral perfusion,	automated CT perfusion lesion maps had high sensitivity (83%) but low specificity (21%),	combining automated CT perfusion maps with qualitative color-map interpretation significantly improves the accuracy of infarct prediction in acute stroke assessment.
(6)	2010	New York	To evaluate the role of CT perfusion (CTP) imaging in assessing cerebral ischemia, focusing on identifying ischemic penumbra and infarct core, and to discuss common pitfalls in interpreting CTP data	CT perfusion effectively differentiates ischemic penumbra from infarct core but has interpretation challenges due to technical limitations and potential artifacts	While CTP is a valuable tool in acute stroke evaluation, radiologists must be aware of its limitations and potential artifacts to ensure accurate diagnosis and optimal patient management.
(7)	2008	India	To review the role and utility of CT perfusion imaging in the diagnosis and management of acute ischemic stroke.	CT perfusion provides valuable information on cerebral blood flow, blood volume, and mean transit time, helping to distinguish between infarcted tissue and potentially salvageable penumbra.	CT perfusion is a useful and practical imaging tool that improves acute stroke diagnosis and treatment planning, although awareness of its limitations is necessary for optimal use
(8)	2017	Australia.	To compare the accuracy of the Alberta Stroke Program Early CT Score (ASPECTS) and CT perfusion core volume in detecting established infarction in acute anterior	The study found that CT perfusion core volume and ASPECTS have comparable accuracy in predicting hyperacute infarct volume in acute ischemic	The study found no significant difference between the accuracy of CT perfusion and ASPECTS in predicting hyperacute MRI lesion volume in ischemic stroke

			circulation ischemic stroke	stroke patients.	
(9)	2021	Pakistan	To evaluate the predictive value of CT brain perfusion studies in diagnosing acute ischemic infarction, using MRI stroke protocol (including Diffusion Weighted Imaging) as the gold standard.	CT perfusion showed a high positive predictive value (98.83%) but low negative predictive value (10.25%) compared to MRI for detecting acute ischemic infarction	CT perfusion imaging is a valuable, widely available, and time-effective tool for detecting acute ischemic infarction, providing high PPV and aiding in the triage of patients for immediate endovascular intervention.
(10)	2011	United state	to identify and analyze sources of variability in CT perfusion imaging that affect acute stroke management	seven key sources of variability in CT perfusion imaging, including contrast media, data acquisition rate, user inputs, observer variation, and software differences	standardization is crucial to reduce variability in CT perfusion imaging and improve its reliability for acute stroke management
(11)	2023	Sydney	systematically review and assess the diagnostic accuracy of CT perfusion imaging in detecting acute ischemic stroke.	CT perfusion demonstrates high sensitivity and moderate specificity for diagnosing acute ischemic stroke across diverse clinical settings.	CT perfusion is a reliable diagnostic tool for acute ischemic stroke, but standardization and further research are needed to optimize its clinical use.
(12)	2015	Switzerland	to review the foundations and applications of perfusion CT in acute stroke	it is valuable for assessing cerebral blood flow and guiding treatment	It is essential for timely stroke management
(13)	2016	Beijing	to evaluate the diagnostic accuracy of CT perfusion in acute stroke	it have high sensitivity and specificity	it is an effective tool for stroke diagnosis

(14)	2022	Canada	to evaluate automated CT perfusion imaging for selecting acute ischemic stroke patients for mechanical thrombectomy	it improves patient selection accuracy	it supports clinical decision-making
(15)	2006	London	to assess perfusion CT's role in thrombolysis decisions without clear stroke onset time,	it effectively identified candidates for treatment	it aids clinical decision-making
(16)	2013	Netherlands	to evaluate the diagnostic accuracy of CT perfusion for acute ischemic stroke	found high sensitivity and moderate specificity,	CT perfusion is a valuable diagnostic tool
(17)	2011	USA	to test whether RAPID software can automatically identify salvageable brain tissue for reperfusion therapy in acute ischemic stroke.	RAPID accurately distinguished between infarct core and penumbra, improving patient selection	Automated RAPID imaging is a reliable tool for guiding reperfusion therapy decisions in stroke.
(18)	2015	Heidelberg	To outline technical requirements and standardized protocols for CT perfusion imaging in oncology	Defined scanner settings, acquisition techniques, and analysis methods critical for reproducible CT perfusion	Standardized protocols and technical optimization are essential for reliable oncologic CT perfusion imaging.
(19)	2016	USA and Australia	To provide consensus recommendations on imaging selection and outcomes in acute stroke reperfusion clinical trials	Reached agreement on optimal imaging biomarkers, patient selection methods, and standardized outcomes	Harmonized imaging approaches are crucial to improve trial design and advance stroke reperfusion research
(20)	2024	Qatar	To compare conventional CT perfusion analysis with RAPID automated software in acute stroke.	RAPID provided faster, more standardized results with good agreement to conventional methods.	RAPID improves efficiency and reliability in CT perfusion analysis for stroke management

Study design: Most included studies were observational cohorts or diagnostic accuracy studies. A few randomized control trials (RCTs) included CTP as part of imaging workflow evaluation. The heterogeneity of study designs precluded direct quantitative synthesis.

Brain coverage, scan acquisition time, and post-processing algorithms: CT scanners ranged from 64 to 320 slices. Whole-brain coverage was achieved in only a subset of studies. Acquisition times varied, with most using dynamic scanning lasting 40–60 seconds. Post-processing software included vendor-specific (e.g., Siemens Syngo, GE Advantage) and third-party applications, each using different deconvolution algorithms**.**

Time to reference standard: Time between CT perfusion and reference standard imaging (usually DWI-MRI) ranged from 1 hour to 48 hours. This variability could influence diagnostic accuracy due to infarct evolution.

Vessel occlusion and reperfusion therapies: Several studies correlated CTP findings with angiographic evidence of large vessel occlusion (LVO). Many also investigated outcomes post-thrombectomy or thrombolysis, showing good correlation between CTP-estimated penumbra and final infarct volume in reperfused patients.

Imaging analysis: Most studies employed automated or semi-automated analysis tools. Perfusion maps were evaluated for absolute and relative thresholds. Some studies also assessed visual grading by radiologists.

Perfusion parameters and thresholds: CBF <30% of normal and Tmax >6 seconds were the most common thresholds used to delineate infarct core and penumbra, respectively. Variation in threshold selection across studies affected comparability.

Discussion:

CT perfusion imaging provides critical information on tissue viability in acute stroke care(12). Its high sensitivity enables early detection of ischemic changes(13), and it facilitates decisions regarding thrombolytic or mechanical intervention(14)(15). Several studies have reported high specificity (up to 95%) and moderate to high sensitivity (ranging from 55% to 85%), depending on the perfusion parameter used—cerebral blood flow (CBF), cerebral blood volume (CBV), or mean transit time (MTT)(16)(17). However, technical factors such as scanner type, contrast protocols, and algorithmic processing influence the reproducibility and reliability of results(18).These variations must be addressed through standardization efforts and consensus guidelines(19). Despite limitations, the evidence supports the integration of CTP into stroke pathways(20).

Study limitations: Limitations of this review include heterogeneity in study design, patient selection, perfusion protocols, and reference standards. Additionally, publication bias and language restrictions may have influenced results.

Conclusion: CT perfusion is a valuable imaging modality for assessing cerebral ischemia and guiding acute stroke therapy. While it shows high sensitivity and good correlation with clinical outcomes, variability in protocols necessitates standardization. Further high-quality studies are needed to validate threshold values and enhance diagnostic consistency.

Data availability statement: All data generated or analyzed during this study are included in this published article and its supplementary materials.

Author contributions: RU conceptualized and designed the study. MNB contributed to data collection and methodology. ZS performed the analysis and contributed to drafting the manuscript. All authors reviewed and approved the final version.

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Conflict of interest: The authors declare no conflict of interest.

Supplementary material: Supplementary tables and figures are available upon request from the primary and corresponding author.

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