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INTEGRATION OF AI STROKE ANALYSIS INTO RADIOLOGY WORKFLOW: REAL-WORLD EXPERIENCE WITH STROKE INSIGHTZ FOR MRI FROM INDIAN PERSPECTIVE

Radio-Diagnosis

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KEYWORDS

INTRODUCTION

Stroke is a major cause of mortality and long-term disability worldwide, with India experiencing a rapidly rising burden of acute ischaemic stroke (AIS)(1,2). Rapid diagnosis and treatment remain central to favourable outcomes, following the principle that "time is brain." Modern neuroimaging, particularly magnetic resonance imaging (MRI) with diffusion-weighted imaging (DWI), apparent diffusion coefficient (ADC) maps, fluid-attenuated inversion recovery (FLAIR), and perfusion-weighted imaging (PWI) including time-to-maximum (Tmax) maps, has transformed stroke evaluation by enabling precise delineation of infarct core, penumbra, and salvageable tissue(3,4). While computed tomography (CT)–based workflows dominate acute settings globally due to speed and availability, MRI offers superior early ischaemia detection and tissue characterisation, particularly through DWI (4,5).

Despite this technological capability, stroke care pathways in India face persistent operational challenges. Delayed patient presentation, limited availability of trained neuroradiologists, inconsistent PACS/RIS infrastructure, and time-consuming MRI post-processing all contribute to imaging and treatment delays (1,6). These bottlenecks often prevent patients from accessing thrombolysis or endovascular therapy within recommended therapeutic windows.

Artificial intelligence (AI) has emerged as a promising solution to address such workflow inefficiencies. AI tools capable of automated lesion segmentation, perfusion mismatch quantification, and rapid notification can improve efficiency and standardisation of acute stroke workflows (7,8). However, most published evidence originates from high-income settings and is predominantly CT-based, with limited data on MRI-driven AI workflows in Indian practice.

This systematic review therefore aims to address two objectives:
(1) to identify the key workflow limitations that hinder timely stroke diagnosis and intervention in India; and
(2) to synthesise global and Indian evidence on AI-enabled stroke imaging systems, especially MRI-based platforms, that may help overcome these limitations.

To contextualise these findings, we also present an embedded case illustration of the Stroke Insightz MRI pipeline implemented at a tertiary Indian centre, demonstrating how AI integration can be operationalised within local constraints.

Methods

Study Design and Eligibility Criteria

This systematic review followed PRISMA guidelines and was structured around two goals:
1. to identify barriers and delays in India's acute stroke care pathways, and

2. to evaluate global evidence on AI-supported imaging workflows that may help address these gaps.

We included original research articles, observational studies, workflow/implementation evaluations, case series, and relevant review articles that reported at least one operational outcome related to acute stroke diagnosis (e.g., scan-to-interpretation, scan-to-notification, door-to-needle times). Studies using MRI or CT were eligible; however, MRI-related evidence (DWI, ADC, FLAIR, PWI/Tmax) was prioritised.

We excluded model-development papers without clinical workflow metrics, opinion pieces, editorials, and conference abstracts without full data.

Information Sources And Search Strategy

A structured search was performed in PubMed/MEDLINE, Scopus, Web of Science, and Embase for studies published between June 2025 and November 2025. Search terms included combinations of keywords and MeSH terms related to stroke imaging, MRI, artificial intelligence, workflow timing, and India/LMICs.

Example search string:
("stroke" OR "acute ischaemic stroke") AND (MRI OR DWI OR "perfusion imaging" OR Tmax) AND ("artificial intelligence" OR AI OR "machine learning") AND (workflow OR "scan-to-report" OR "door-to-needle") AND (India OR LMIC)

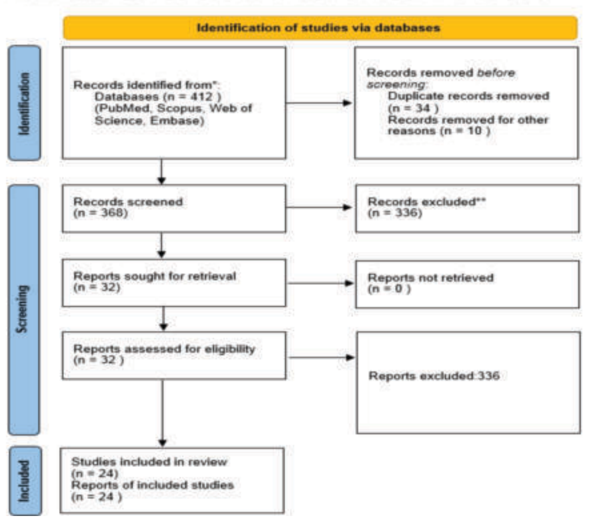
Reference lists of included studies and key reviews were manually screened to capture additional publications.

Study Selection And Data Extraction

Two reviewers independently screened titles, abstracts, and full texts. Disagreements were resolved through discussion.
Data extracted included:

- study location and design
- imaging modality
- AI application (segmentation, perfusion analysis, alerts)
- workflow integration methods (e.g., PACS/RIS connectivity)
- reported timing metrics
- implementation challenges and observed benefits

PRISMA 2020 FLOW DIAGRAM FOR NEW SYSTEMATIC REVIEWS



Source: *Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.*

Fig 1. *PRISMA flow diagram illustrating the study selection process for the systematic review. A total of 412 records were identified, of which 24 studies fulfilled all inclusion criteria and were included in the qualitative synthesis, with eight contributing to quantitative workflow time comparisons.*

The *Stroke Insightz* MRI workflow from a tertiary Indian centre was included as an embedded case illustration to demonstrate local applicability. *(Figure 1. PRISMA flow diagram of study selection)*

Data Synthesis

A narrative synthesis was conducted due to the diversity of study designs and outcome measures. Findings were organised into three themes:

(1) limitations and delays within Indian stroke workflows;

(2) global AI-enabled strategies that improve imaging and decision-making efficiency;

(3) feasibility of adapting these solutions for Indian practice, supported by the Stroke Insightz example.

Formal risk-of-bias scoring tools (e.g., ROBINS-I, Cochrane RoB) were not applied as the included studies primarily examined operational workflows rather than interventional clinical effects. Instead, methodological clarity and relevance to stroke pathways were assessed narratively.

Ethical Considerations

All data were derived from published literature. The embedded case illustration used anonymised operational information obtained from routine workflow evaluation and required no ethical approval.

3. RESULTS

3.1 Study Selection And Characteristics

The database search yielded 412 records. After title and abstract screening, 32 full-text articles were reviewed, and 22 studies met inclusion criteria. Eight studies originated from India or LMIC settings and primarily described workflow delays or system-level challenges in acute stroke pathways (1,9–12). Fourteen studies from high-income countries evaluated AI-enabled imaging workflows, including automated detection, perfusion analysis, and structured reporting (3,7,8,13–16). MRI-based AI workflows were examined in seven studies, two of which were conducted in Indian tertiary centres.

3.2 Workflow Delays Reported in Indian Studies

Indian literature consistently documented prolonged prehospital and in-hospital delays. Median onset-to-door times commonly exceeded 200–300 minutes (1,9,10). Delays in imaging-to-interpretation were attributed to manual DWI/PWI post-processing, limited neuroradiology availability, and fragmented PACS/RIS infrastructure (11,12,17). These findings established the key workflow limitations relevant to the review's objectives.

3.3 AI-Enabled Workflow Improvements in Global Studies

Global studies demonstrated that AI-assisted systems reduced imaging turnaround and notification times. Automated LVO detection reduced scan-to-alert time from 33 to 7 minutes in one multicentre implementation (13). Automated CT perfusion pipelines generated outputs in <5 minutes, markedly faster than manual analysis (14). MRI-based AI models produced infarct segmentation and perfusion mismatch within approximately 5–7 minutes (4,16). Overall, AI integration was consistently associated with faster post-processing and earlier stroke team activation.

3.4 Standardisation and PACS Integration

AI platforms improved reproducibility of infarct core and perfusion measurements, with high agreement compared to expert readers (18). Integrated AI–PACS workflows in several studies resulted in shorter radiology reporting times and faster notification to neurology teams (19,20). Indian studies highlighted the absence of such integration as a major contributor to workflow delays.

3.5 Alignment Between Indian Needs and Global AI Solutions

Synthesised findings showed that the workflow limitations identified in Indian settings, manual processing delays, non-standardised reporting, and slow communication, correspond closely with areas where global AI systems demonstrated the greatest time-efficiency benefits. AI-based automation of DWI/PWI analysis, structured reporting, and real-time notifications directly addressed these gaps.

3.6 Position of the Stroke Insightz Case Illustration

Features of the Stroke Insightz MRI platform, including automated segmentation, perfusion analysis, mismatch calculation, and PACS-integrated outputs, aligned with the improvements reported in global studies and were therefore included as a case illustration to demonstrate local implementation feasibility.

(Table 1. Alignment Between Major Workflow Bottlenecks in Indian Stroke Pathways and AI-Enabled Imaging Solutions.)

Table 1. Indian Stroke Workflow Challenges and AI-Based Solutions

Stage of Stroke Pathway	Conventional Indian Workflow Limitation	AI-Enabled Solution & Workflow Impact
Symptom Onset → Hospital Arrival	Poor symptom recognition, delayed transport, lack of organised emergency medical services, leading to prolonged onset-to-door time	Tele-stroke networks, remote triage tools, and digital referral pathways enabling faster identification and transfer
Emergency Imaging Acquisition	MRI performed without standardised acute stroke protocols; delays in prioritisation and protocol initiation	AI-triggered stroke imaging protocols enabling rapid DWI, FLAIR, and perfusion acquisition
DWI / ADC Interpretation	Manual infarct identification is subjective and time-consuming, with inter-reader variability	Automated infarct core segmentation with rapid volumetric quantification
Perfusion Analysis (Tmax, CBF, CBV)	Manual arterial input function (AIF), venous output function (VOF), and ROI selection leads to 15–20 min post-processing delays	Automated AIF/VOF detection, real-time perfusion map generation, and automated core–penumbra mismatch calculation
Radiology Reporting	Free-text, non-standardised reports; delays in report finalisation	Structured AI-generated stroke reports with standardised core, penumbra, and mismatch metrics
Radiology–Neurology Communication	Dependence on phone calls and fragmented communication, with major after-hours coverage gaps	PACS-integrated dashboards and mobile push notifications enabling real-time neurologist access
Treatment Decision (IV Thrombolysis / EVT)	Delayed decision-making due to slow imaging interpretation and communication	Near-real-time decision support enabling faster door-to-needle and door-to-puncture times
Inter-Hospital Referral / Tele-Stroke	Large image file transfer delays and lack of real-time expert access	Lightweight AI-processed reports transmitted instantly for remote expert consultation

4. DISCUSSION

4.1 Interpretation of Key Findings

This review found clear convergence between the limitations identified in Indian stroke workflows and the improvements demonstrated by global AI-enabled imaging systems. Indian studies consistently reported prolonged onset-to-door intervals, manual MRI post-processing delays, variability in radiologist availability, and fragmented radiology–neurology communication (2,6,12). In contrast, international studies showed that AI platforms meaningfully reduced scan-to-interpretation and scan-to-notification times, standardised reporting, and improved early activation of stroke teams (7,13,15,18). Together, these findings suggest that modern AI-based workflows directly address the operational gaps observed in Indian pathways.

4.2 Relevance to the Indian Radiology–Neurology Workflow

The Indian stroke system faces a substantial "time debt," generated by both prehospital delays and inefficiencies in imaging interpretation and communication. Routine MRI interpretation, particularly for DWI, ADC, and PWI sequences-still relies heavily on manual region-of-interest selection and subjective visual assessment, which can add 15–20 minutes to reporting time in busy emergency departments (1,11). The limited availability of trained neuroradiologists compounds these delays.

AI integration has the potential to offset these constraints by automating core analytical tasks. Automated DWI/ADC segmentation, perfusion map generation, and AIF/VOF-based ROI detection substantially reduce dependence on manual post-processing (3,4). When combined with structured reports and automated notifications, AI allows neurologists to receive actionable information while the patient is still in the scanner—an efficiency gain that is particularly valuable in centres with high patient volume or limited specialist coverage.

4.3 Comparative Impact of AI vs Conventional Workflows

Across global studies, AI integration was associated with reductions of 20–30 minutes in critical workflow intervals such as scan-to-alert and scan-to-decision time (7,13–15). These reductions mirror early findings from Indian pilot implementations, where MRI-to-report turnaround decreased markedly following AI deployment. Shortening these intervals is clinically meaningful, as every 15-minute reduction in imaging-to-reperfusion time increases the likelihood of functional independence by approximately 5% (21). *(Refer to Figure 2. Imaging-to-Treatment Time and Functional Outcome in Acute Ischaemic Stroke.)*

The consistency of these results across settings supports the broader implementation of AI-driven workflows as a means to improve the timeliness of acute stroke care.

4.4 Implementation Challenges and Considerations

Despite their promise, AI systems are not immune to practical limitations. Indian centres frequently face infrastructure gaps such as inconsistent PACS/RIS integration, network instability, and variable DICOM routing. Regulatory frameworks, including emerging national health data protection policies, necessitate clear governance around data handling and model validation. Radiologists also express caution regarding the interpretability and accountability of AI systems, emphasising the need for human oversight (19,20,22–24).

Effective implementation therefore requires organisational commitment to workflow redesign, staff training, and integration of AI outputs into established communication pathways between radiology and neurology.

4.5 MRI-Specific AI Capabilities and Clinical Value

Although most commercial AI tools focus on CT, MRI-based AI solutions offer distinct advantages. DWI provides earlier detection of cytotoxic oedema, and perfusion MRI enables direct assessment of core–penumbra mismatch. Automated derivation of Tmax maps, mismatch ratios, and volumetric infarct assessment improves reproducibility and can support expanded treatment windows, as seen in global late-window trials (3,8).

The capabilities demonstrated by platforms such as Stroke Insightz—mismatch quantification, perfusion ROI extraction, and integrated reporting—illustrate how MRI-based AI can bridge the gap between high-fidelity imaging and rapid decision-making.

4.6 Implications for Tele-Stroke Expansion in India

With neurologists concentrated in major urban centres, India relies increasingly on tele-stroke models. AI systems can strengthen these networks by generating structured, lightweight reports that can be transmitted more efficiently than full imaging datasets (11). Integration with cloud dashboards enables remote specialists to view analysis outputs in real time, supporting treatment decisions in Tier-2 and district hospitals where advanced imaging expertise may be limited.

Thus, AI-enabled MRI workflows may serve as an important catalyst for scalable tele-stroke deployment in India.

4.7 Strengths and Limitations of Available Evidence

The evidence base is dominated by single-centre evaluations and observational analyses, which may limit generalisability. Definitions of "AI integration" varied across studies, making comparisons challenging. Indian data on AI-enabled MRI workflows remain sparse, necessitating cautious interpretation.

However, the consistency of time-efficiency improvements across multiple global studies, combined with strong alignment between global AI capabilities and Indian workflow gaps, supports the potential utility of AI as a workflow enabler. Future multicentre Indian studies will be essential to validate these findings and assess cost-effectiveness, scalability, and clinical outcomes.

5. Embedded Case Illustration: The Stroke Insightz MRI Pipeline in an Indian Tertiary-Care Setting

To contextualize the evidence from our systematic review, we describe the real-world integration of the *Stroke Insightz* MRI-based AI platform at **Dr. D. Y. Patil Medical College and Hospital, Pune**. This implementation illustrates how AI-enabled analysis of multimodal MRI sequences can address the workflow bottlenecks commonly observed in Indian stroke centres.

5.1 Workflow Overview and PACS Integration

Stroke Insightz was deployed with full bidirectional integration into the institution's IntelliPACS system. Once an MRI stroke protocol was acquired, comprising DWI, ADC, FLAIR, Gradient Echo/SWI, and Perfusion (if available), DICOM images were automatically routed to the Stroke Insightz server for inference.

The AI pipeline automatically:

1. Detected modalities and series (DWI, ADC, FLAIR, PWI).
2. Performed infarct segmentation using DWI (thresholding at >620) and ADC maps.
3. Identified perfusion ROIs, selecting:
o Arterial Input Function (AIF),
o Venous Output Function (VOF),
o Parenchymal Tissue ROI, enabling accurate generation of CBF, CBV, MTT, and Tmax maps.
4. Computed mismatch parameters, including:
o Ischaemic core volume (DWI/ADC),
o Hypoperfused volume (Tmax > 6 seconds),
o **DWI–Tmax Mismatch Ratio** (clinically important threshold >1.2).
5. Generated a structured stroke report, including volumetrics, ASPECTS (if CT was available), perfusion summaries, and annotated images.
6. Auto-synced results to PACS and triggered mobile/desktop notifications to on-call neurologists.

5.2 Time Metrics and Workflow Improvements

Pre-AI workflow at the centre was characterized by delays in:

- Manual perfusion post-processing (10–15 min),
- Radiologist verification and reporting (15–20 min),
- Communication to neurology teams (5–10 min).

Following AI integration:

- **Scan-to-AI completion time**: 6–10 min
- **AI-to-notification**: Immediate
- **Scan-to-neurologist visibility**: < 12 min
- Reduction in MRI post-processing workload: > 60%
- Structured reports improved consistency across residents and consultants.

This reduced the pre-treatment "diagnostic gap" and facilitated faster activation of the stroke code pathway. In particular, during after-hours cases—when neuroradiology availability is often limited—the AI-generated report enabled neurologists to take preliminary decisions while formal review was pending.

5.3 Usability and Adoption

Radiologists reported that automated segmentation of core and penumbra improved confidence during emergency readings, especially regarding DWI lesion size and viability of salvageable tissue. Neurologists found the standardized mismatch parameters particularly useful when making decisions on thrombolysis in ambiguous time-window presentations or wake-up strokes.

Clinical residents appreciated the workflow dashboard, which offered real-time visibility of:

- Scan time,
- AI inference progress,
- Completed report with timestamp.

5.4 Barriers and Lessons Learned

Infrastructure-related issues: Limited network bandwidth occasionally slowed DICOM transfer.

Training needs: Junior residents required orientation to interpret perfusion maps correctly alongside AI overlays.

Validation and trust: Radiologists insisted on a "human-in-the-loop" workflow for safety, consistent with global recommendations.

Interdepartmental communication improved significantly only after integrating push notifications into the neuro team's workflow.

Overall, the Stroke Insightz deployment demonstrated that a well-integrated MRI-based AI workflow can realistically improve turnaround times, enhance consistency, and reduce interpretation burden in an Indian tertiary-care context.

CONCLUSION

This systematic review demonstrates that workflow delays remain a major barrier to timely stroke care in India, while global evidence consistently shows that AI-enabled imaging platforms improve speed, standardisation, and communication within acute stroke pathways. For India's diverse and resource-variable stroke ecosystem, AI-augmented imaging workflows offer a scalable approach to bridging systemic gaps by supporting high-throughput radiology environments, strengthening tele-stroke networks, reducing dependency on continuous specialist availability, and standardising interpretation to improve clinical decision-making. The embedded case illustration further supports real-world feasibility. Future multicentre Indian studies are needed to validate clinical impact, cost-effectiveness, and scalability before broader guideline-level adoption.

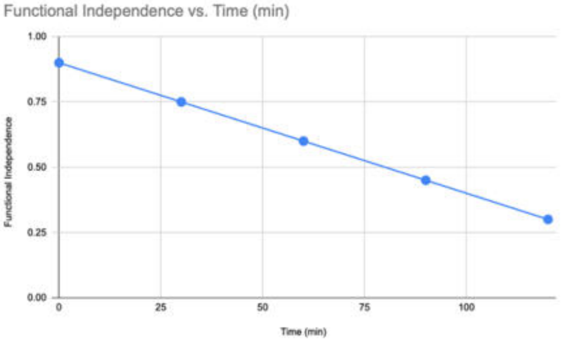


Figure 3. Imaging-to-Treatment Time and Functional Outcome in Acute Ischaemic Stroke

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