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A Team-Based Stroke Practitioner–Led Workflow Achieves Comparable Outcomes to Neurohospitalist-Led Care in Acute Ischemic Stroke: A Real-World Study

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Highlights

What are the main findings?

- Stroke practitioner workflow matched neurohospitalist outcomes in AIS.
- Higher DNT <60 min rates achieved with multidisciplinary model.

What are the implications of the main findings?

- ICU transfer rates significantly reduced with team-based workflow.
- Efficient stroke care possible with limited specialist availability.

Abstract

Background/Objectives: Acute ischemic stroke (AIS) care depends on rapid, coordinated workflows. This study compared two real-world in-hospital stroke models—a neurohospitalist-led model and a stroke practitioner–led multidisciplinary model—in terms of time metrics, radiological outcomes, and 3-month clinical outcomes in patients undergoing reperfusion therapy. **Methods**: This retrospective, single-center cohort study evaluated patients across two sequential workflow periods. In the practitioner-led model, trained non-neurologist clinicians coordinated care with a stroke nurse under neurologist supervision. Time metrics included door-to-needle time (DNT) and door-to-puncture time (DPT). Clinical outcomes included intensive care unit (ICU) transfer and 3-month functional outcomes assessed by the modified Rankin Scale (mRS). **Results**: A total of 573 patients were included (284 neurohospitalist-led, 289 practitioner-led). Baseline NIHSS scores were similar between groups. The proportion achieving DNT <60 minutes was significantly higher in the practitioner-led period (74.0% vs. 52.5%, p<0.001), while mean DNT and DPT were comparable. Early radiological outcomes at 24 hours were similar between groups. ICU transfer rates were significantly lower in the practitioner-led period (17.6% vs. 28.2%, p=0.002). Three-month mRS outcomes did not differ significantly. **Conclusions**: A structured, practitioner-led multidisciplinary workflow was as safe and efficient as a neurohospitalist-led model. Improved adherence to DNT targets and reduced ICU transfers highlight the importance of system-level organization in optimizing AIS care.

Keywords: acute ischemic stroke; stroke workflow; door-to-needle time; multidisciplinary care; stroke systems; reperfusion therapy

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1. Introduction

Acute ischemic stroke (AIS) remains a major cause of mortality and disability worldwide and continues to impose a substantial clinical and organizational burden on health systems. In the Turkish context, stroke is also a major vascular health problem, and recent work from Türkiye has further emphasized the importance of structured stroke-related assessment and early complication management in local clinical practice [1]. Contemporary AIS management is fundamentally based on rapid recognition, urgent imaging, timely reperfusion, and coordinated in-hospital care, as reflected in current guideline recommendations that support organized stroke systems of care across prehospital and hospital settings [2].

The therapeutic benefit of reperfusion therapy in AIS is highly time dependent. Pooled analyses and meta-analyses of alteplase trials have consistently shown that earlier intravenous thrombolysis (IVT) is associated with greater functional benefit, whereas treatment delays diminish efficacy and may worsen overall outcomes [3–5]. Likewise, advances in endovascular thrombectomy (EVT) have expanded treatment opportunities for selected patients with large vessel occlusion (LVO), including those treated in extended windows when supported by advanced imaging-based selection, reinforcing the need for streamlined and responsive stroke workflows throughout the acute care pathway [6].

Because treatment benefit is tightly linked to speed, optimization of stroke workflow has become a central objective of modern stroke centers. Large quality-improvement initiatives such as Target: Stroke demonstrated that reducing door-to-needle time (DNT) at scale is feasible and is associated with better clinical outcomes, including lower in-hospital mortality and reduced symptomatic intracranial hemorrhage [7,8]. Subsequent studies have further shown that specific operational strategies—including direct transport to computed tomography, rapid registration, scanner-based alteplase administration, pre-notification systems, and structured team activation—can substantially shorten treatment times in routine clinical practice [9–11].

Importantly, workflow improvement in stroke care is not limited to physician-led decision-making alone but depends on a multidisciplinary and system-oriented approach. Lean redesign models, collaborative hospital interventions, and structured team-based protocols have all been associated with shorter time-to-thrombolysis and, in some settings, improved functional outcomes [12–15]. More recent evidence also suggests that nursing-driven and protocolized stroke care models can improve selected time-sensitive workflow metrics, even if gains in thrombolysis timing are not universal, underscoring the importance of clearly defined responsibilities and standardized coordination across the entire stroke pathway [16].

Despite these advances, the most effective real-world configuration of acute stroke teams may vary across institutions depending on patient volume, staffing constraints, available expertise, and local organizational structure, particularly in developing stroke systems. In particular, there remains limited real-world evidence on how evolving organizational models—from traditional neurohospitalist-led systems to structured multidisciplinary models led by stroke practitioners (hospitalist general practitioners) in coordination with specialized stroke nurses under neurologist supervision—affect time metrics and clinical outcomes within the same institutional setting. Therefore, this study aimed to compare two sequential real-world stroke workflow periods at a single comprehensive stroke center—a neurohospitalist-led period and a stroke practitioner–led period—with respect to time metrics and 3-month clinical outcomes in patients with AIS.

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2. Materials and Methods

2.1. Study Design

This retrospective, single-center cohort study was conducted at the Istinye University Liv Hospital Bahçeşehir Comprehensive Stroke Center between January 2020 and December 2024. Although the analysis was retrospective, all stroke cases were prospectively, systematically, and consecutively recorded within the continuously maintained Istinye Stroke Registry, which operates as a high-quality, standardized data capture system integrated into routine clinical practice. This structured and consistently audited registry enabled precise delineation of workflow periods based on the natural evolution of the stroke center rather than predefined interventional phases. The Stroke Workflow Periods were not conceived as a traditional prospectively staged trial; rather, they emerged organically from a unifying institutional philosophy aimed at improving time-sensitive AIS performance metrics while preserving safety, and scalability. Each period therefore represents real-world organizational adjustments developed in alignment with this overarching philosophy.

2.2. Participants

A total of 705 patients were screened, of whom 132 were excluded due to prior stroke history, resulting in a final cohort of 573 patients (Figure 1). Eligible participants were adults aged ≥18 years presenting with AIS and undergoing reperfusion therapy, including IVT, EVT, or both. Patients were consecutively included from the institutional stroke registry. Patients with a prior history of stroke were excluded.

2.3. Istinye Stroke Registry

All AIS patients managed by the stroke team were entered prospectively and consecutively into the Istinye Stroke Registry. The registry includes demographic, clinical, radiologic, time-metric, treatment, and functional outcome data, enabling retrospective data analyses.

2.4. Rationale for Defining Stroke Workflow Periods

The stroke management workflow at the Istinye University Comprehensive Stroke Center, as in advanced stroke systems worldwide, is fundamentally shaped by the need to optimize highly time-sensitive processes. Importantly, this workflow functions as a continuously remodeled system, rather than a fixed operational structure. Remodeling efforts are undertaken to improve the management of time-critical intervals, refine team coordination, and strengthen the system's overall reliability. Each remodeling cycle aims to enhance key performance metrics—such as DNT and door-to-puncture time (DPT)—while preserving patient safety and maintaining high standards of care quality. Accordingly, the workflow periods presented in this study do not represent predetermined experimental phases. Instead, they reflect sequential remodeling stages in the natural evolution of our institutional stroke workflow. Each stage incorporates data-driven adjustments, lessons learned from prior configurations, and targeted strategies to accelerate treatment readiness without compromising safety.

2.5. Stroke Workflow Periods

Two sequential workflow periods were defined based on the natural evolution of the institutional stroke care system (Figure 2).

1. Neurohospitalist-Led Period

During this period, a Neurocode system composed of a stroke neurologist and a dedicated stroke nurse performed real-time evaluation, diagnosis, treatment decision-making, and operational coordination of all AIS cases. Early workflow support included structured hospital-wide Neurocode alerts and a fast-track patient transport pathway enabling prioritized transfer to imaging.

2. Stroke Practitioner–Led Period

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In this period, an advanced team-based workflow model was implemented in response to increasing patient volume and resource constraints. Specially trained non-neurologist clinicians were incorporated into the Neurocode team as stroke practitioners, enabling rapid front-line evaluation and workflow coordination. A stroke practitioner and a dedicated Neurocode nurse jointly managed patient flow, while a remotely available supervising stroke neurologist provided oversight and confirmed treatment decisions when required. Pre-imaging and imaging assessments were standardized across both periods.

2.6. Data Collection and Variables

Extracted variables included demographics, clinical characteristics (National Institutes of Health Stroke Scale [NIHSS], vascular risk factors), imaging data (LVO presence). Time metrics included last known well time, wake-up stroke status, DNT, and DPT. Radiologic outcomes included hemorrhagic transformation, parenchymal hematoma, and remote hemorrhage, with symptomatic intracranial hemorrhage defined according to the Safe Implementation of Treatments in Stroke–Monitoring Study (SITS-MOST) criteria [17].

The primary outcome was the proportion of patients achieving DNT <60 minutes. Secondary outcomes included DPT, Intensive care unit (ICU) transfer, radiological outcomes, and 3-month functional outcomes (mRS).

For secondary analyses, the mRS at 3 months was further categorized into three clinically meaningful groups: no disability (mRS 0–2), disability present (mRS 3–5), and death (mRS 6). This categorization was used to facilitate comparison of functional outcomes between workflow models.

2.7. Potential Sources of Bias

Potential sources of bias included differences in baseline characteristics between workflow periods, inclusion of patients during daytime hours when neurologists were available in both periods, and possible contamination due to neurologist consultation in the stroke practitioner–led model.

2.8. Statistical Analysis

Statistical analyses were performed using Wistats v3.0 (WisdomEra Corp., Istanbul, Turkey), which operates on the Python programming language and utilizes statistical and machine learning libraries including SciPy v1.2.3, scikit-learn v0.24.0, and statsmodels v0.9.0 (https://wistats.wisdomera.io, accessed on 18 May 2026). Data distribution was evaluated using skewness and kurtosis statistics, while the Shapiro–Wilk test was applied to assess normality. Selection of statistical tests for comparative analyses was based on data distribution characteristics.

Comparative analyses were conducted between the neurohospitalist-led and stroke practitioner–led periods across predefined variable groups, including demographic variables (age, sex), clinical characteristics (NIHSS, vascular risk factors), imaging findings, presence and subtype of LVO, workflow time metrics (last known well time, DNT, DPT), radiological outcomes (hemorrhagic transformation, infarct expansion, edema, and recanalization).

Comparisons between categorical variables were conducted using Chi-square or Fisher's Exact tests. Analyses involving numerical variables were performed using Independent Samples t-test or Mann–Whitney U test for two-group comparisons, and One-way ANOVA or Kruskal–Wallis tests where appropriate. Time metrics were analyzed both as continuous and categorical variables. All statistical tests were two-tailed, and p values < 0.05 were considered statistically significant.

No formal sample size calculation was performed, as all eligible patients within the study period were included.

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2.9. Handling of Missing Data

Missing data were not imputed. All analyses were conducted using an available-case (complete-case) approach, whereby each variable was analyzed based on non-missing observations. Accordingly, the number of observations may vary across analyses.

3. Results

3.1. Baseline Characteristics of the Study Population

A total of 573 patients with AIS were included in the study, of whom 284 (49.6%) were managed during the neurohospitalist-led period and 289 (50.4%) during the stroke practitioner–led period (Table 1). The overall mean age was 68.79 ± 13.77 years, and 45.7% of the cohort were female. The mean baseline NIHSS score was 11.91 ± 6.45, indicating a moderate stroke severity profile.

The distribution of cases across years reflected a temporal transition in workflow organization, with earlier years dominated by the neurohospitalist-led model and later years by the stroke practitioner–led model. Additional baseline characteristics, including admission day, duty period, treatment type, and time metrics, are summarized in Table 1.

3.2. Comparison of Clinical Characteristics Between Workflow Periods

Baseline stroke severity, as assessed by NIHSS, was comparable between the two periods (12.09 ± 6.35 vs. 11.72 ± 6.55, p=0.486). However, patients managed during the stroke practitioner–led period were significantly older than those in the neurohospitalist-led period (70.73 ± 13.06 vs. 66.82 ± 14.20 years, p=0.002) (Table 2).

The last known well time was significantly shorter in the stroke practitioner–led period (217.71 ± 250.07 vs. 292.79 ± 236.22 minutes, p<0.001). In addition, wake-up strokes were more frequent in the stroke practitioner–led period (5.1% vs. 1.5%, p=0.029).

Treatment strategies differed significantly between the two periods (p<0.001), with a higher proportion of IVT in the stroke practitioner–led period (73.4% vs. 48.0%), whereas EVT was more commonly performed during the neurohospitalist-led period (27.1% vs. 7.3%). Combined IVT+EVT treatment rates were relatively similar (Figure 3A).

Significant differences were also observed in admission timing variables. The distribution of admission days varied between periods (p<0.001), as did duty periods (p=0.005), suggesting potential differences in workflow dynamics and staffing patterns (Figure 3B and Figure 3C).

Despite these differences, LVO rates were comparable between groups (76.4% vs. 71.5%, p=0.108).

3.3. Time Metrics and Workflow Performance

Key time metrics were largely similar between the two workflow models. DNT did not differ significantly between periods (46.01 ± 24.18 vs. 46.84 ± 29.80 minutes, p=0.963). However, when analyzed categorically, a significantly higher proportion of patients achieved DNT <60 minutes in the stroke practitioner–led period (74.0% vs. 52.5%, p<0.001) (Figure 4).

DPT was also comparable between groups (108.22 ± 45.71 vs. 124.36 ± 149.46 minutes, p=0.704).

3.4. Early Radiological Outcomes

Early radiological outcomes at 24 hours were similar between the two workflow periods (Table 3). There were no significant differences in infarct expansion (p=0.451), hemorrhagic transformation patterns (p=0.982), remote infarction (p=0.746), or brain edema (p=0.330).

Recanalization rates showed no statistically significant difference between groups (p=0.087), although numerically higher recanalization was observed in the neurohospitalist-led period.

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3.5. Clinical Outcomes

Clinical outcomes were largely comparable between the two models. Three-month functional outcomes, as measured by the mRS, did not differ significantly between groups (p=0.208) (Table 3, Figure 5). Similarly, when categorized into disability groups, no significant differences were observed (p=0.976).

However, ICU transfer rates were significantly lower in the stroke practitioner–led period compared to the neurohospitalist-led period (17.6% vs. 28.2%, p=0.002), suggesting a potential advantage in early clinical stabilization or patient management..

4. Discussion

In this study, we evaluated the impact of two sequential real-world stroke workflow models—a neurohospitalist-led model and a stroke practitioner–led multidisciplinary model—on time metrics, safety, and clinical outcomes in patients with AIS. The most important findings can be summarized as follows: (i) although mean DNT and DPT were similar between groups, (ii) the proportion of patients achieving DNT <60 minutes was significantly higher in the stroke practitioner–led period, (iii) ICU transfer rates were significantly lower in the stroke practitioner–led period, and (iv) 3-month functional outcomes (mRS) were comparable between groups. Taken together, these findings suggest that a structured, multidisciplinary workflow led by stroke practitioners is at least as efficient and safe as a traditional neurohospitalist-led model.

Time-dependent benefit remains the cornerstone of AIS care, as consistently demonstrated in pooled analyses and meta-analyses showing that earlier IVT leads to better outcomes and reduced mortality [3,4]. In our study, although mean DNT did not differ significantly, the proportion of patients treated within the guideline-recommended 60-minute window increased substantially in the stroke practitioner–led period (74.0%). This finding aligns with large-scale quality improvement initiatives such as Target: Stroke, where increasing the proportion of patients treated within 60 minutes has been associated with improved outcomes, including reduced mortality [8,18]. Our results therefore support the concept that categorical performance metrics (e.g., DNT <60 minutes) may be more sensitive indicators of workflow improvement than mean time values alone.

The observed improvement in rapid treatment delivery is consistent with prior studies emphasizing the importance of structured protocols and multidisciplinary coordination. Strategies such as direct transfer to imaging, pre-notification systems, and standardized stroke code activation have been shown to significantly reduce treatment delays [9,10]. Similarly, meta-analytic data indicate that organizational interventions and comprehensive stroke pathways can substantially increase IVT utilization and improve adherence to time targets [19]. The workflow model implemented in our center incorporates many of these elements, including rapid activation, parallel processing, and clearly defined team roles, which likely contributed to the observed improvements.

Despite these advantages in early workflow performance, 3-month functional outcomes were similar between groups. This finding may reflect the influence of baseline differences between periods, including older age in the stroke practitioner–led group, as well as differences in stroke characteristics and recanalization patterns. Previous studies have shown that while workflow optimization can reduce early complications and mortality, long-term functional outcomes are also shaped by factors such as infarct size, collateral circulation, and post-acute care processes [20]. Therefore, the absence of a difference in long-term outcomes does not diminish the clinical importance of improved early efficiency and reduced ICU utilization.

The integration of a multidisciplinary stroke team led by trained stroke practitioners represents an important organizational adaptation, particularly in healthcare systems where neurologist availability is limited. Expanding team roles and distributing responsibilities may enhance system resilience, scalability, and responsiveness to increasing patient volumes. Prior studies have demonstrated that protocol-driven and team-based stroke care models can improve efficiency even

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in resource-constrained environments [21]. In this context, our findings suggest that such models may provide a viable and sustainable alternative to exclusively neurologist-led systems.

Several limitations should be acknowledged. First, this was a single-center, retrospective analysis, which may limit generalizability. Second, although patients were prospectively recorded, unmeasured confounders and temporal changes in clinical practice may have influenced outcomes. Third, the study design does not allow causal inference regarding specific components of the workflow, and the relative contribution of each intervention within the workflow model could not be isolated. Fourth, a potential source of bias is that patients admitted during daytime hours—when a neurologist was actively involved in both workflow periods—were included in the analysis, which may have attenuated differences between groups. In addition, differences in baseline comorbidities between periods may have contributed to outcome variability and represent a source of residual confounding. Furthermore, during the stroke practitioner–led period, consultation with a neurologist was available when necessary, and treatment decisions could be made collaboratively; this may have introduced a contamination effect, further reducing observable differences between workflow models. Finally, long-term outcomes beyond 3 months and detailed process-level metrics (e.g., prehospital delays) were not evaluated. Future studies stratifying patients according to duty periods, adjusting for comorbidity burden, and minimizing cross-model interactions are warranted to reduce bias and provide a more precise assessment of workflow-related effects.

Future research should focus on multicenter validation of structured multidisciplinary stroke workflow models, with particular emphasis on identifying the most impactful components. Integration of advanced decision-support tools, automated alert systems, and real-time performance monitoring may further enhance workflow efficiency and consistency.

5. Conclusions

A structured, multidisciplinary workflow led by stroke practitioners was at least as efficient and safe as a neurohospitalist-led model. It was associated with improved adherence to DNT targets, increased use of IVT, and significantly reduced ICU transfer rates, despite a higher baseline risk profile. While long-term functional outcomes (3-month mRS) remained comparable between groups, these findings underscore the critical role of system-level organization and multidisciplinary coordination in optimizing AIS care. Importantly, this model represents a scalable and resource-efficient approach for improving stroke care delivery, particularly in settings with limited specialist availability and in developing stroke systems.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Istinye University (protocol code: 24-272, date of approval: November 22, 2024).

Informed Consent Statement: Due to the retrospective nature of the study and the use of fully anonymized data, the requirement for informed consent was waived by the Institutional Review Board.

Data Availability Statement: The datasets generated and/or analysed during the current study are available in the Dataset Sharing Platform of Istinye University repository, [https://dataset.istinye.edu.tr/dataset?did=70, accessed on 18 May 2026]

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AIS	Acute ischemic stroke
ED	Emergency department
CT	Computed tomography
CTA	Computed tomography angiography
IVT	Intravenous thrombolysis
EVT	Endovascular treatment
NIHSS	National Institutes of Health Stroke Scale
DNT	Door-to-needle time
DPT	Door-to-puncture time
ICU	Intensive care unit
mRS	Modified Rankin Scale
LVO	Large vessel occlusion

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