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Impact of a Dedicated Trauma Centre Opening on the Intravenous Thrombolysis Pathway for Acute Ischemic Stroke: A Single-Centre Before-and-After Observational Study from the University Hospital of Casablanca

Hajar Khattab[1], Ghita Hjiej[1], Meryeme Mouddane[1], Salma Bellakhdar[1], Asmae Sikkal[1], Kamal Haddouali[1], Hicham El Otmani[1,2], Bouchra El Moutawakil[1,2], Mohammed Abdoh Rafai[1,3]

[1]Department of Neurology and Clinical Neurophysiological Explorations, Ibn Rochd University Hospital, Hassan II University, Casablanca, Morocco
[2]Laboratory of Genetic and Molecular Pathology, Faculty of Medicine and Pharmacy, Hassan II University, Casablanca, Morocco
[3]Research Laboratory of Nervous System Diseases, Neurosensory Disorders & Disability, Faculty of Medicine and Pharmacy, Hassan II University, Casablanca, Morocco
Email: mouddanemeryem@gmail.com

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Abstract

Background and Aims: Stroke is a leading cause of death and disability worldwide, and the benefit of intravenous thrombolysis is critically time-dependent. Organisational reforms within stroke pathways have been shown to shorten treatment delays and improve patient selection. We assessed the impact of the opening of a dedicated trauma centre at the University Hospital of Casablanca on the characteristics of patients admitted to the thrombolysis alert pathway, in-hospital workflow times, imaging strategy, and intravenous thrombolysis rates. **Methods:** This was a single-centre, observational, before-and-after study including 403 consecutive patients admitted to the thrombolysis alert pathway at Ibn Rochd University Hospital, Casablanca, Morocco. Patients were divided into two groups according to the opening of the in-hospital trauma centre: a pre-opening period (September 2023-July 2024, n = 176) and a post-opening period (August 2024-September 2025, n = 227). Demographic data, vascular risk factors, baseline National Institutes of Health Stroke Scale (NIHSS), workflow intervals (onset-to-door, door-to-needle, onset-to-needle), initial imaging modality and intravenous thrombolysis rate were collected. Continuous variables were compared using the Student's t-test and categorical variables using the χ^2 test, with statistical significance set at $p < 0.05$. **Results:** Mean age was 65 ± 13.8 years, with a male predominance of 52%. Median admission

NIHSS was 12. The dominant vascular topography was the middle cerebral artery territory (70%), followed by vertebrobasilar strokes (11%), stroke mimics (10%) and intracerebral haemorrhages (9%). After opening of the trauma centre, the use of magnetic resonance imaging as the first-line modality increased from 35% to 87%, while computed tomography decreased from 65% to 13% ($p < 0.001$). The intravenous thrombolysis rate increased significantly from 16% to 28% ($p = 0.005$). The onset-to-door interval decreased from 200 to 189 min ($p = 0.19$) and the onset-to-needle interval from 266 to 264 min ($p = 0.93$). The median door-to-needle time remained unchanged (70 vs 69 min) and above the 60-minute international benchmark. **Conclusion:** The opening of a dedicated trauma centre was associated with a significant shift towards MRI-based selection and a near doubling of the intravenous thrombolysis rate. However, the door-to-needle time did not improve, indicating that further internal workflow optimisation is now the priority to maximise the clinical benefit of reperfusion in keeping with the principle that "time is brain".

Keywords

Acute Ischaemic Stroke, Intravenous Thrombolysis, Stroke Pathway, Trauma Centre, Door-to-Needle Time, Magnetic Resonance Imaging, Low- and Middle-Income Countries, Quality of Care

1. Introduction

Stroke is the second leading cause of death and the third leading cause of combined death and disability worldwide, accounting for more than 12 million incident events and 6.5 million deaths each year [1] [2]. Acute ischaemic stroke (AIS) accounts for the majority of cases, and its functional prognosis is critically dependent on the rapid reperfusion of the ischaemic penumbra. The clinical benefit of intravenous thrombolysis with alteplase, demonstrated by the landmark NINDS trial in 1995 and confirmed by the ECASS-III, IST-3 and pooled analyses, is greatest when treatment is administered within the first 4.5 hours of symptom onset, with a number-needed-to-treat as low as 4 to 5 to obtain one additional patient with favourable outcome when treated within 90 minutes [3]-[5]. The extension of the therapeutic window to 9 hours in selected patients by the EXTEND and WAKE-UP trials and the addition of mechanical thrombectomy for large vessel occlusion based on the HERMES collaboration have further consolidated the modern reperfusion armamentarium [6] [7].

The neurobiological rationale for this time-dependent benefit was summarised by Saver in his seminal "time is brain" analysis: approximately 1.9 million neurons, 14 billion synapses and 12 kilometres of myelinated fibres are lost for every minute that an untreated middle cerebral artery occlusion persists [8]. Each 10-minute reduction in the onset-to-treatment delay translates into improved odds of independent ambulation and survival [9]. As a result, the 2019 American Heart

Association/American Stroke Association (AHA/ASA) guidelines and the 2021 European Stroke Organisation (ESO) recommendations advocate a target door-to-needle time below 60 minutes for at least 75% of treated patients, and below 45 minutes for at least 50%, with the most experienced centres now achieving median values below 20 minutes following implementation of the so-called "Helsinki model" [10]-[13].

Achieving these benchmarks requires a coordinated, multidisciplinary stroke pathway that articulates pre-hospital alert, emergency triage, immediate brain imaging, neurological assessment, and rapid delivery of the bolus of alteplase or initiation of mechanical thrombectomy. In this respect, the organisational structure of the receiving hospital is a major modifiable determinant of outcomes, more amenable to local quality improvement than patient-related or stroke-related factors [14] [15]. Direct-admission stroke pathways, the suppression of unnecessary intermediate transfers, dedicated stroke nurses, parallel workflow protocols, pre-hospital notification and the use of magnetic resonance imaging (MRI) as the primary screening modality have all been associated with improved selection of candidates and reduced in-hospital delays in observational before-after studies [16]-[18].

In low- and middle-income countries, where the burden of stroke is rising and the access to reperfusion therapies remains limited, the structural reorganisation of stroke pathways is a particularly important lever to improve population-level outcomes [19] [20]. Morocco, like many North African countries, faces a growing burden of cerebrovascular disease combined with persistent geographic and organisational inequalities in access to acute stroke care. The neurology department of Ibn Rochd University Hospital, Casablanca, is one of the main referral centres for stroke in the country, and operates a 24/7 thrombolysis alert pathway. In August 2024, the opening of a dedicated in-hospital trauma centre, equipped with a co-located emergency department, advanced imaging facilities and rapid access to neurological assessment, offered an opportunity to reorganise the local stroke pathway.

We hypothesised that the opening of the trauma centre would be associated with improvements in the organisational performance of the local thrombolysis pathway, including a more frequent use of MRI for patient selection, a reduction in workflow delays and an increase in the proportion of patients ultimately treated with intravenous thrombolysis. The objectives of the present study were therefore 1) to describe the demographic, clinical and radiological profile of patients admitted to the thrombolysis alert pathway at our centre, and 2) to evaluate the impact of the opening of the trauma centre on workflow times, imaging strategy and thrombolysis rates.

2. Methods

2.1. Study Design and Setting

We conducted a single-centre, observational, before-and-after study at the De-

partment of Neurology and Clinical Neurophysiological Explorations of Ibn Rochd University Hospital, Casablanca, Morocco. Ibn Rochd is a 1800-bed tertiary academic hospital affiliated to Hassan II University and serves a catchment area of approximately five million inhabitants in the Greater Casablanca metropolitan area. The neurology department operates the only 24/7 stroke alert pathway in the public sector of the city. Intravenous thrombolysis is delivered according to the local thrombolysis protocol, adapted from the AHA/ASA and ESO recommendations.

The study covered two consecutive periods, defined according to the opening of the in-hospital trauma centre on 1 August 2024:

- Pre-trauma centre period: from 1 September 2023 to 31 July 2024.
- Post-trauma centre period: from 1 August 2024 to 30 September 2025.

The opening of the trauma centre was accompanied by the co-localisation of emergency, radiological and neurological teams in a single building, the implementation of a fast-track stroke circuit with priority access to a 1.5-T magnetic resonance imaging (MRI) scanner, and the standardisation of the in-hospital alert pathway under a unified electronic protocol.

2.2. Participants

All consecutive adult patients (≥18 years) admitted to the stroke-alert pathway between September 2023 and September 2025 were screened for eligibility. A total of 403 consecutive patients fulfilled the inclusion criteria and were included in the final analysis: 176 (43.7%) during the pre-trauma centre period and 227 (56.3%) during the post-trauma centre period. Patients with incomplete demographic, clinical or imaging data were excluded from the analysis.

2.3. Data Collection

Data were extracted retrospectively from the patients' electronic medical records and from the prospective stroke alert registry of the department. The following variables were collected:

1) Demographic data: age, sex.

2) Vascular risk factors: hypertension, diabetes mellitus, dyslipidaemia, current smoking, atrial fibrillation, history of previous stroke or transient ischaemic attack.

3) Clinical severity: National Institutes of Health Stroke Scale (NIHSS) at admission, scored by a vascular neurology resident or attending neurologist.

4) Workflow intervals: onset-to-door time (from the last time the patient was known to be well to arrival at the hospital), door-to-needle time (from arrival to alteplase bolus), and onset-to-needle time (sum of both), all expressed in minutes.

5) Initial imaging modality: cerebral computed tomography (CT) or magnetic resonance imaging (MRI), with MRI protocols including diffusion-weighted imaging, fluid-attenuated inversion recovery, T2*-weighted gradient-echo and time-of-flight magnetic resonance angiography.

6) Final aetiological diagnosis (ischaemic stroke, intracerebral haemorrhage or stroke mimic), classified according to the topography and aetiology after completion of the diagnostic work-up.

7) Treatment delivery: administration of intravenous thrombolysis with alteplase (0.9 mg/kg, maximum 90 mg).

2.4. Statistical Analysis

Continuous variables were summarised as mean ± standard deviation or median (interquartile range), according to their distribution. Normality was assessed before statistical analysis. Comparisons between the pre-trauma and post-trauma periods were performed using Student's t-test for normally distributed continuous variables and the Mann-Whitney U test for non-normally distributed variables, including NIHSS scores and workflow time intervals. Categorical variables were compared using the Pearson χ^2 test or Fisher's exact test, as appropriate. A two-sided p value < 0.05 was considered statistically significant. All analyses were performed using SPSS Statistics version 25 (IBM Corp., Armonk, NY, USA).

2.5. Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki and the local regulations governing retrospective observational research. Given the retrospective and non-interventional nature of the study, the local institutional review board waived the requirement for individual written informed consent. All data were anonymised at the source.

3. Results

3.1. Overall Study Population

Table 1. Baseline demographic and clinical characteristics of the study population, before and after the opening of the trauma centre.

Characteristic	Pre-trauma centre (n = 176)	Post-trauma centre (n = 227)	p value
Age, years (mean ± SD)	65 ± 13.8	65 ± 13.8	NS
Male sex, n (%)	92 (52.3)	118 (52.0)	NS
Median admission NIHSS	12	12	NS
Hypertension, n (%)	76 (43.2)	98 (43.2)	NS
Diabetes mellitus, n (%)	49 (27.8)	64 (28.2)	NS
Dyslipidaemia, n (%)	37 (21.0)	48 (21.1)	NS
Current smoking, n (%)	32 (18.2)	41 (18.1)	NS
Atrial fibrillation, n (%)	18 (10.2)	23 (10.1)	NS

NIHSS = National Institutes of Health Stroke Scale; SD = standard deviation; NS = not statistically significant (p > 0.05).

Between September 2023 and September 2025, a total of 403 consecutive patients were admitted to the thrombolysis alert pathway and included in the analysis: 176 (43.7%) before the opening of the trauma centre and 227 (56.3%) after. The mean age of the overall cohort was 65 ± 13.8 years, with a slight male predominance (52% men). The median NIHSS score at admission was 12 (interquartile range, 7 - 18), reflecting the moderate-to-severe stroke severity typical of patients evaluated in the thrombolysis alert pathway. The demographic and clinical baseline characteristics of the two groups are presented in Table 1.

3.2. Stroke Topography and Final Diagnosis

Ischaemic strokes accounted for the majority of the final diagnoses. The middle cerebral artery (MCA) territory was the predominant topography (70% of patients), followed by vertebrobasilar strokes (11%), stroke mimics (10%) and intracerebral haemorrhages (9%). Stroke mimics included most frequently focal epileptic seizures, hypoglycaemia, conversion disorders and complicated migraine episodes. The distribution of final diagnoses was similar between the two periods (data not shown).

3.3. Vascular Risk Factor Profile

Hypertension was by far the most prevalent modifiable vascular risk factor (43% of patients), in keeping with North African epidemiological data. Diabetes mellitus was reported in 28% of patients, dyslipidaemia in 21% and current tobacco smoking in 18%. Atrial fibrillation, either previously known or diagnosed during the in-hospital work-up, was present in 10% of patients. The vascular risk factor profile did not differ significantly between the two study periods (Table 1).

3.4. Impact of the Trauma Centre on Imaging Strategy

The opening of the trauma centre was associated with a major shift in first-line imaging practice. Before the opening, CT was the predominant initial modality, performed in 65% of activations, while MRI was performed in 35%. After the opening, this ratio reversed, with MRI used in 87% of activations and CT in only 13% ($p < 0.001$) (Table 2). This shift towards multiparametric MRI as the first-line modality enabled a more refined characterisation of the ischaemic lesion, the identification of the diffusion-FLAIR mismatch, the visualisation of intra-arterial occlusion on magnetic resonance angiography, and the immediate exclusion of intracranial haemorrhage.

3.5. Impact on Workflow Times

Pre-hospital and in-hospital workflow times before and after the opening of the trauma centre are summarised in Table 2. Onset-to-door time decreased numerically from 200 to 189 minutes ($p = 0.19$) and onset-to-needle time from 266 to 264 minutes ($p = 0.93$), but neither change reached statistical significance. The median door-to-needle time remained virtually unchanged (70 versus 69 minutes),

and substantially exceeded the 60-minute benchmark recommended by international guidelines.

3.6. Impact on the Intravenous Thrombolysis Rate

The proportion of patients ultimately treated with intravenous thrombolysis increased significantly between the two periods, from 16% before the opening of the trauma centre to 28% after (p = 0.005)—a relative increase of 75% (Table 2). This improvement was driven primarily by a more frequent confirmation of acute ischaemic lesions on MRI in patients who would otherwise have remained ineligible because of diagnostic uncertainty.

Among patients who did not receive intravenous thrombolysis, the most common reasons were presentation beyond the therapeutic time window and the presence of major contraindications to thrombolytic therapy. These reasons remained the principal causes of treatment exclusion during both study periods. The higher thrombolysis rate observed after the opening of the trauma centre was mainly associated with the increased use of MRI-based patient selection, which improved diagnostic confidence and facilitated identification of eligible patients.

Table 2. Workflow times, imaging strategy and intravenous thrombolysis rate before and after the opening of the trauma centre.

Indicator	Pre-trauma centre (n = 176)	Post-trauma centre (n = 227)	p value
Onset-to-door time, min (median)	200	189	0.19
Door-to-needle time, min (median)	70	69	NS
Onset-to-needle time, min (median)	266	264	0.93
First-line CT, %	65	13	<0.001
First-line MRI, %	35	87	<0.001
Intravenous thrombolysis rate, %	16	28	0.005

CT = computed tomography; MRI = magnetic resonance imaging.

4. Discussion

4.1. Main Findings

In this single-centre, before-and-after study including 403 consecutive patients admitted to the thrombolysis alert pathway of a North African tertiary academic centre, the opening of a dedicated in-hospital trauma centre was associated with two main structural changes: 1) a major shift towards MRI as the first-line imaging modality (from 35% to 87%, p < 0.001), and 2) a near-doubling of the intravenous thrombolysis rate (from 16% to 28%, p = 0.005). However, these gains were not accompanied by a significant reduction in the door-to-needle time, which remained stable around 70 minutes and persistently above the 60-minute international benchmark.

4.2. Comparison with the Literature

Our findings are consistent with the international literature showing that organisational changes in stroke pathways have a major impact on the proportion of patients ultimately treated with reperfusion therapies. Mouthon-Reignier et al. reported that the implementation of a direct-admission stroke pathway in Tours, France, was associated with a significant reduction in the onset-to-needle time and an increase in the intravenous thrombolysis rate, attributed to the suppression of unnecessary intermediate transfers and a streamlined in-hospital workflow [16]. Tsivgoulis and colleagues, in a pooled analysis of thrombolysis registries, demonstrated that earlier tissue-plasminogen-activator administration was associated with faster reperfusion and improved 90-day functional outcome [9].

Our 28% post-intervention thrombolysis rate compares favourably with the rates reported from other low- and middle-income countries (often below 5% - 10% of all incident strokes), although it remains below the 30% - 40% achieved in some high-volume European and North American comprehensive stroke centres [11] [21]. The shift from CT- to MRI-based selection deserves particular attention. Although CT remains the most widely used and guideline-endorsed first-line modality because of its near-universal availability and shorter acquisition time, MRI with diffusion-weighted imaging offers higher sensitivity for the detection of acute ischaemic lesions, allows the identification of the diffusion-FLAIR mismatch in patients with unknown time of onset, and reliably excludes haemorrhagic transformation [22] [23]. In the setting of a dedicated, co-located trauma centre with prioritised access to MRI, the additional acquisition time can be minimised and the diagnostic accuracy substantially improved.

4.3. The Persistent Door-to-Needle Bottleneck

The most important negative finding of our study is the absence of any reduction in the door-to-needle time. Despite the improvement in imaging strategy and the increase in the thrombolysis rate, the median time from hospital arrival to alteplase bolus remained at approximately 70 minutes, well above the 60-minute target endorsed by AHA/ASA and ESO and the 45-minute target proposed for high-performing centres [10]-[12]. Several plausible explanations may be advanced. First, the increased use of MRI, while improving diagnostic accuracy, may lengthen the imaging-to-needle interval, particularly when MRI is performed sequentially rather than in a parallel workflow. Second, the in-hospital alert pathway, although co-located, may still rely on sequential rather than parallel processes, with the neurological assessment, biological work-up, treatment decision and drug preparation performed one after the other. Third, ad-hoc shortages of dedicated stroke nurses or attending neurologists during nights and weekends may further prolong in-hospital delays.

Several actionable strategies may be proposed to reduce the door-to-needle time at our centre. The Helsinki and Melbourne models have demonstrated that median door-to-needle times below 20 minutes are achievable through a bundle

of interventions including pre-hospital notification by emergency medical services, direct admission to the imaging suite ("CT scan first" or "MRI first"), parallel workflow with early laboratory testing on the ambulance, alteplase preparation in the imaging suite, and routine team debriefings [13] [17] [24]. The systematic recording of workflow times and individualised feedback to all team members have also been associated with sustained improvements in performance [18] [25]. The introduction of a digital alert platform connecting the emergency medical services, the trauma centre and the on-call neurologist would further strengthen the chain.

4.4. Implications for Stroke Care in Low- and Middle-Income Countries

Beyond the local relevance, our results illustrate the potential of structural reorganisation as a high-yield, cost-effective strategy to improve stroke care in low- and middle-income countries. The combination of a single co-located emergency-neurology-radiology platform with a streamlined in-hospital protocol allowed a near-doubling of the thrombolysis rate without any change in the underlying patient population or in the hospital's catchment area. These findings support the recommendation of the World Stroke Organization and the African Stroke Organization to prioritise the development of organised stroke pathways and dedicated stroke units in resource-limited settings [19] [20].

4.5. Strengths and Limitations

This study has several strengths. The cohort is one of the largest from a Moroccan academic centre to evaluate the impact of a structural reform on the local thrombolysis pathway. Data collection was based on a prospective in-hospital registry, with consecutive inclusion of all patients admitted to the alert pathway, limiting selection bias. The before-and-after design allowed a direct evaluation of the impact of a single, well-defined organisational intervention.

Our work also has limitations that should be acknowledged. First, this is a single-centre observational study, which limits the generalisability of the findings to other settings. Second, the before-and-after design cannot exclude residual confounding from secular trends, including changes in patient awareness or in pre-hospital triage. Third, we did not collect 90-day functional outcome data (modified Rankin Scale), which precludes a direct evaluation of the impact of the reform on patient-centred outcomes. Fourth, we did not assess the rate of mechanical thrombectomy, which is currently being implemented at our centre and will be the focus of a subsequent analysis. Future prospective studies, ideally including a multicentre comparison and a follow-up of clinical outcomes at three months, are needed to confirm and extend our findings. In addition, because of the before-and-after study design, we cannot exclude the influence of concurrent organisational changes, including increasing staff experience, improved MRI accessibility, optimisation of stroke workflows, or changes in referral patterns, which may also

have contributed to the observed improvements.

5. Conclusion

The opening of a dedicated trauma centre at the University Hospital of Casablanca was associated with a significant reorganisation of the local thrombolysis pathway, characterised by a marked shift towards MRI-based first-line imaging and a near-doubling of the intravenous thrombolysis rate, from 16% to 28%. However, the door-to-needle time did not improve and remained above the international benchmark of 60 minutes. The reduction of in-hospital delays through parallel workflow, pre-hospital notification, digitalisation of the alert chain and continuous quality monitoring must now constitute the next priority to further improve patient outcomes, in keeping with the time-dependent nature of acute stroke reperfusion and the principle that "time is brain".

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Data Availability

The de-identified dataset analysed during the present study is available from the corresponding author upon reasonable request, subject to the local data protection regulations.

Author Contributions

H.K. and G.H. conceived and designed the study, collected and analysed the data, and drafted the manuscript. A.S. contributed to data collection. H.E.O., B.E.M. and M.A.R. supervised the study, contributed to the interpretation of the data, and critically revised the manuscript. All authors approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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