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Article

Real-World Analysis of Stroke Care: Thrombolysis and Thrombectomy in a Regional Stroke Unit in Germany

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Abstract: Objectives: Stroke is a leading cause of disability worldwide, requiring timely intervention with intravenous thrombolysis (IVT) or endovascular thrombectomy (EVT). This study evaluates real-world stroke management in a regional stroke unit, focusing on IVT administration and EVT transfer logistics. Design: A sub-analysis was performed using prospectively collected data from an observational study. Setting: This study took place at a regional, non-university stroke unit in Germany, serving approximately 253,000 inhabitants. Participants: A total of 2436 patients were admitted for suspected stroke between May 2019 and June 2021. Outcome Measures: Outcome measures included IVT administration rates, reasons for IVT non-administration, and EVT transfer logistics for acute ischemic stroke (AIS) patients. Results: Of 952 stroke cases, 14.8% received IVT, with a mean door-to-needle time (DNT) of 41 ± 36 min. The most common reasons for IVT non-administration were unclear or elapsed symptom onset (51.8%), anticoagulation (7.9%), resolving symptoms (18.4%), and intracranial hemorrhage (7.1%). EVT transfers occurred in 6.7% of AIS patients, with a mean door-in-door-out (DIDO) time of 81 ± 36 min. Conclusions: This study highlights the low IVT rate, primarily due to delayed hospital presentation, and the limited number of EVT transfers. The prolonged DIDO times emphasize the urgent need for streamlined transfer protocols to optimize stroke care delivery.

Keywords: stroke; intravenous thrombolysis; endovascular thrombectomy; emergency medical services; interhospital transfer

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1. Introduction

Stroke is one of the most critical medical emergencies worldwide, and its effective management remains a cornerstone of modern healthcare systems. Acute ischemic stroke (AIS), the most common subtype, is characterized by the sudden occlusion of cerebral vessels, leading to potentially irreversible neuronal damage. The mantra "time is brain" succinctly captures the urgency required in stroke care, where every minute can mean the loss of millions of neurons [1–3].

Stroke care systems worldwide are continuously evolving, with increasing emphasis on early recognition and rapid intervention to minimize neuronal damage and long-term disability. Over the past two decades, two major treatment modalities have revolutionized AIS management: intravenous thrombolysis (IVT) and endovascular thrombectomy (EVT).

IVT, which utilizes recombinant tissue plasminogen activator (rtPA) to dissolve thrombi, is widely accessible and can be administered in most stroke units (SU). EVT, on the other hand, requires specialized centers with the capability to perform mechanical thrombectomy and is actually reserved for patients with large-vessel occlusion (LVO). While EVT significantly improves outcomes for eligible patients, its application remains limited to a subset of AIS cases [4,5].

The complexity of managing stroke patients lies not only in selecting the appropriate therapy but also in the logistical challenges associated with prehospital and hospital-based care. Prehospital triage is unable to differentiate between ischemic and hemorrhagic strokes, as imaging is essential for making accurate treatment decisions, except in cases involving mobile stroke units (MSUs) [6]. While IVT can be initiated at the regional SU level, EVT requires rapid transfer to a thrombectomy-capable center. This "drip-and-ship" strategy has shown promise but introduces delays that may negatively impact outcomes, particularly when interhospital transfers are involved [7,8].

Moreover, IVT is not applicable for every stroke patient. Several factors, including unclear symptom onset or a prolonged time window, and contraindications such as anticoagulation, frequently exclude patients from receiving thrombolytic therapy.

In the German healthcare context, regional stroke units often serve as the first point of contact for suspected stroke cases. These facilities are pivotal for initiating IVT and determining the need for transfer to a thrombectomy center. However, real-world data on the proportion of patients receiving IVT or requiring EVT and the reasons for exclusion remain sparse. In contrast to many studies conducted at university hospitals or specialized stroke centers, this study focuses on a non-university, regional stroke unit. By doing so, it addresses a real-world evidence gap concerning the delivery of reperfusion therapies and transfer logistics in decentralized healthcare settings, which are often underrepresented in clinical trials. This information is vital for optimizing both prehospital triage and intrahospital care pathways to ensure the best possible outcomes for stroke patients. To get this missing data we performed a sub-analysis of a trial investigating a new stroke detection tool [9]. These challenges underscore the importance of analyzing real-world data from typical regional stroke units. By assessing actual patient characteristics, treatment decisions, and transfer processes, we aim to identify areas for improvement and support the development of more effective, evidence-based care strategies that reflect everyday practice rather than idealized clinical settings.

Aims

The primary aim of this study is to determine the real proportion of the application of IVT and the reasons for non-administration of IVT. Furthermore, this study aims to determine the real proportion of patients with large vessel occlusion and the possibility for EVT. Secondary aims are the determination of relevant process times like door-to-needle and door-in-door-out times.

2. Methods

2.1. Study Design and Setting

This sub-analysis of prospectively collected data analyzed real-world stroke care in a regional stroke unit located in the Lahn-Dill district in central Hesse, Germany, which has a population of approximately 253,000 inhabitants. The geographic structure of the Lahn-Dill district includes a combination of urban centers and rural areas, which may influence access times to specialized stroke care. Although individual transport times were not systematically recorded in this study, variation is to be expected due to geographic distance, EMS availability, and traffic conditions. This variability may impact the proportion

of patients arriving within the therapeutic time window for acute interventions. The stroke unit is part of a general hospital offering emergency care, internal medicine, and radiology, but does not provide neurosurgical or interventional neuroradiological services on-site. The facility serves as a primary stroke unit with standard diagnostic and treatment capabilities but does not perform EVT. Patients requiring EVT are transferred to a nearby thrombectomy-capable center. This organizational structure reflects the standard stroke care model in many regions of Germany, where regional stroke units are integrated into larger stroke networks to ensure timely access to mechanical thrombectomy.

In the Lahn-Dill district, emergency medical services (EMSs) are centrally coordinated and operate 24/7. Ambulance crews typically consist of paramedics and, when indicated, an emergency physician. Patients with suspected stroke are usually transported to the nearest stroke unit, based on predefined regional routing protocols. Allocation decisions are supported by a digital system for real-time capacity monitoring (IVENA eHealth, Frankfurt, Germany), although availability and geographic factors may influence final destination choice.

Advanced imaging techniques such as perfusion or mismatch imaging (CT or MRI) were not available at the stroke unit during the study period and therefore were not performed. This limited the ability to identify patients who might still have been eligible for IVT or EVT beyond standard time windows. The stroke unit included in this study treats approximately 600 stroke patients annually and follows standardized treatment pathways based on national protocols, ensuring consistency in patient management. The medical team was composed of board-certified neurologists, stroke-trained nursing staff, and rotating residents. Daily interdisciplinary meetings were held to discuss complex cases and transfer decisions. Although no dedicated stroke coordinator was employed during the study period, clinical oversight was provided by the attending senior physician. These structural conditions mirror those of many mid-sized regional hospitals across Germany, enhancing the external validity of our observations. The study period spanned from May 2019 to June 2021.

2.2. Patient Population

All patients admitted to the stroke unit under suspicion of stroke, including AIS, transient ischemic attack (TIA), or intracranial hemorrhage, during the study period were included. No minimum age or severity threshold was applied during inclusion, which ensured a representative and comprehensive sample. This inclusive strategy reflects typical clinical conditions and allows for the evaluation of a broad range of stroke presentations. Patients with mild symptoms, atypical presentations, or uncertain diagnoses were also considered, as this mirrors the real-world complexity faced by emergency departments and stroke units in everyday practice. By including all patients admitted under suspicion of stroke, regardless of final diagnosis, the study captures valuable information about diagnostic processes and care pathways, even in non-stroke cases.

2.3. Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and approved by the institutional review board of the Justus-Liebig-University Giessen, Germany (Approval No. AZ 215/18, 18 January 2019). Informed consent was waived because there were no study-related changes in the care of patients, and data were collected independently of this study. All data were stored on secure institutional servers with restricted access, and no identifying personal information was included in the analysis. The ethical approval covered all aspects of data access, processing, and anonymization. As the study involved a secondary analysis of pre-existing clinical documentation, the risk to partici-

pants was deemed negligible. Ethical oversight was maintained throughout the project in accordance with local institutional policies and the principles set forth by the Declaration of Helsinki and applicable data protection laws.

2.4. Data Collection

Data were collected retrospectively from prospectively collected patient records of the FAST4D-Trial and included patient demographics such as age and sex, the mode of admission (e.g., emergency medical services or self-presentation), and final diagnoses, including acute AIS, TIA, and intracranial hemorrhage [9]. Data collection was conducted by trained medical staff and reviewed for consistency. All relevant information was extracted using standardized documentation forms, in line with the hospital's quality management protocols. Information regarding the administration of IVT, including reasons for not receiving IVT, as well as transfers to thrombectomy-capable centers for EVT and overlaps between prior IVT administration and EVT transfers among AIS patients, was documented. Reasons for not receiving IVT were categorized based on an unclear or exceeded symptom onset time window (exceeding 4.5 h after onset), anticoagulation therapy, mild or resolving symptoms, other medical contraindications (e.g., active bleeding, recent major surgery, and intracranial tumors), or no documented reason. All contraindications were based on national stroke guidelines valid during the study period. The quality of documentation was assessed through random cross-checks by two independent reviewers. Discrepancies were resolved by consensus, ensuring a high level of data accuracy. All information was anonymized prior to analysis. This study relied on digital medical records and standardized stroke care forms used across all departments involved in acute stroke care, further supporting data consistency.

2.5. Definitions and Procedures

AIS was diagnosed based on clinical presentation and imaging (CT/MRI) findings.

At presentation, all patients routinely underwent non-contrast cranial CT and CT angiography (CTA) as the standard neuroimaging protocol. If the initial CT did not provide a definitive diagnosis, cranial MRI (cMRI) was usually performed on the following day or within the subsequent days. Radiological imaging was available 24/7, with a radiology resident present in-house during night shifts and a board-certified radiologist accessible on call, capable of reviewing images remotely. Although the hospital did not have a dedicated neuroradiology department, neurologists were available on-site around the clock.

IVT was administered according to national and international guidelines in effect during the study period. EVT referrals followed the "drip-and-ship" model, with patients transferred promptly to the nearest thrombectomy-capable center. Advanced perfusion imaging was not performed in the participating stroke unit during the study period, as these capabilities were not available at the time. The use of imaging was guided by internal protocols, and all scans were interpreted by experienced clinicians. Whenever necessary, imaging results were discussed in interdisciplinary rounds to support therapeutic decision-making. To ensure comparability with other studies, terminology and definitions followed the standards set by national stroke guidelines. The categorization of IVT contraindications, imaging protocols, and timing metrics were aligned with those used in quality assurance frameworks, which allows for benchmarking and future replication in similar healthcare settings.

The key process times analyzed were the door-to-needle time (DNT), representing the interval between the patient's arrival in the emergency room and the initiation of IVT, and the door-in-door-out time (DIDO), which measures the time from the patient's arrival in the emergency room to the commencement of transfer to a thrombectomy-capable center.

2.6. Statistical Analysis

Descriptive statistics were used to summarize the data. Continuous variables were reported as mean ± standard deviation (SD) or as number and percentage, depending on data distribution. Categorical variables were presented as frequencies and percentages. Missing data were handled using complete case analysis, without imputation. As more than 95% of data points were complete, we considered the remaining missing values to have a negligible impact on the overall results. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 25 (IBM Corporation, New York, NY, USA). The decision to use descriptive statistics was based on the observational and exploratory nature of the study. Since no predefined hypotheses or interventions were tested, the aim was to generate a clear overview of real-world treatment patterns and process times. This approach aligns with the goals of quality assurance and health services research, where the focus lies on transparency, completeness, and practical relevance rather than on inferential statistical testing. Due to the exploratory nature of this sub-analysis, no formal sample size calculation was performed. The entire dataset available from the original FAST4D trial was used to maximize statistical power and descriptive completeness. As this was not a hypothesis-driven study, no correction for multiple testing was applied. The primary objective remained the generation of real-world insight into current treatment patterns and hospital logistics in the context of acute stroke care.

3. Results

A total of 2436 patients were admitted to the stroke unit under suspicion of stroke during the study period. Of these, 1394 (57.2%) were diagnosed with a confirmed cerebrovascular event, including acute ischemic stroke (AIS), transient ischemic attack (TIA), or intracranial hemorrhage (ICH). Among the confirmed stroke patients, 749 (53.7%) were female, and the mean age was 73 ± 15 years. AIS was diagnosed in 952 patients (68.3%), TIA in 343 patients (24.6%), and ICH in 99 patients (7.1%) (Table 1).

Table 1. Patient characteristics.

Variable	Value
Total patients	2436
Mean age (years)	73 ± 15
Female sex (n/%)	749/53.7%
Cerebrovascular event (n)	1394
-Acute ischemic stroke (n/%)	952/68.3%
-Transient ischemic attack (n/%)	343/24.6%
-Intracranial hemorrhage (n/%)	99/7.1%

Overview of demographic and clinical characteristics of the study population. Values are presented as mean ± standard deviation (SD) or percentage (%).

Figure 1 provides a visual summary of the study population, confirmed strokes, and patients receiving IVT.

Of the 952 patients with AIS, 141/952 (14.8%) received intravenous thrombolysis (IVT) with a median door-to-needle time of 41 ± 36 min (Figure 1). IVT could not be administered in 494/952 (51.8%) due to unclear or exceeded symptom onset time windows, in 76/952 (7.9%) because they were on anticoagulation therapy, in 175/952 (18.4%) due to mild or resolving symptoms, and in 52/952 (5.4%) due to other medical contraindications for IVT. In 14/952 (1.4%) cases, no specific reason for exclusion was documented (Table 2).

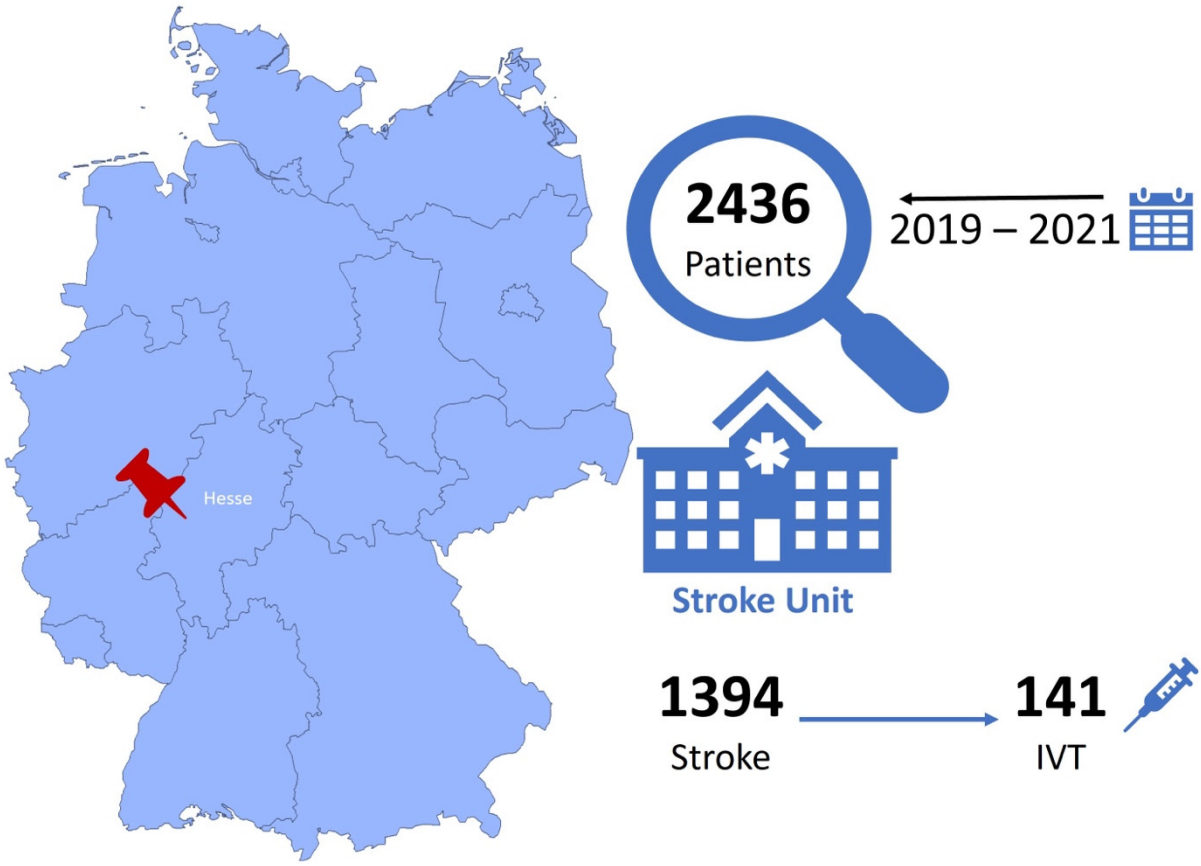

Figure 1. Overview of the study population from 2019 to 2021 in a regional stroke unit in Hesse, Germany. Of 2436 patients admitted with suspected stroke, 1394 were diagnosed with a cerebrovascular event, and 141 received intravenous thrombolysis (IVT).

Table 2. IVT administration and exclusions.

Parameter	Value
IVT administered (n/%)	141/14.8%
No IVT (n/%)	811/85.2%
Reason for no IVT (n/%)	
-Elapsed or unclear time window	494/51.8%
-Anticoagulation therapy	76/7.9%
-Resolving symptoms	175/18.4%
-Other contraindications	52/5.4%
-No documented reason	14/1.4%
Mean door-to-needle time (minutes)	41.2 ± 36

Overview of intravenous thrombolysis (IVT) administration rates and reasons for exclusion in AIS patients. IVT = intravenous thrombolysis; AIS = acute ischemic stroke. Values are presented as percentages (%) or mean ± standard deviation (SD).

Endovascular thrombectomy (EVT) was indicated for 63 out of 952 (6.7%) patients. All of them were transferred to a thrombectomy-capable center (Figure 2). Half of them (33/63 (51.6%)) received IVT prior to transfer. The median DIDO time was 81 ± 36 min (Table 3).

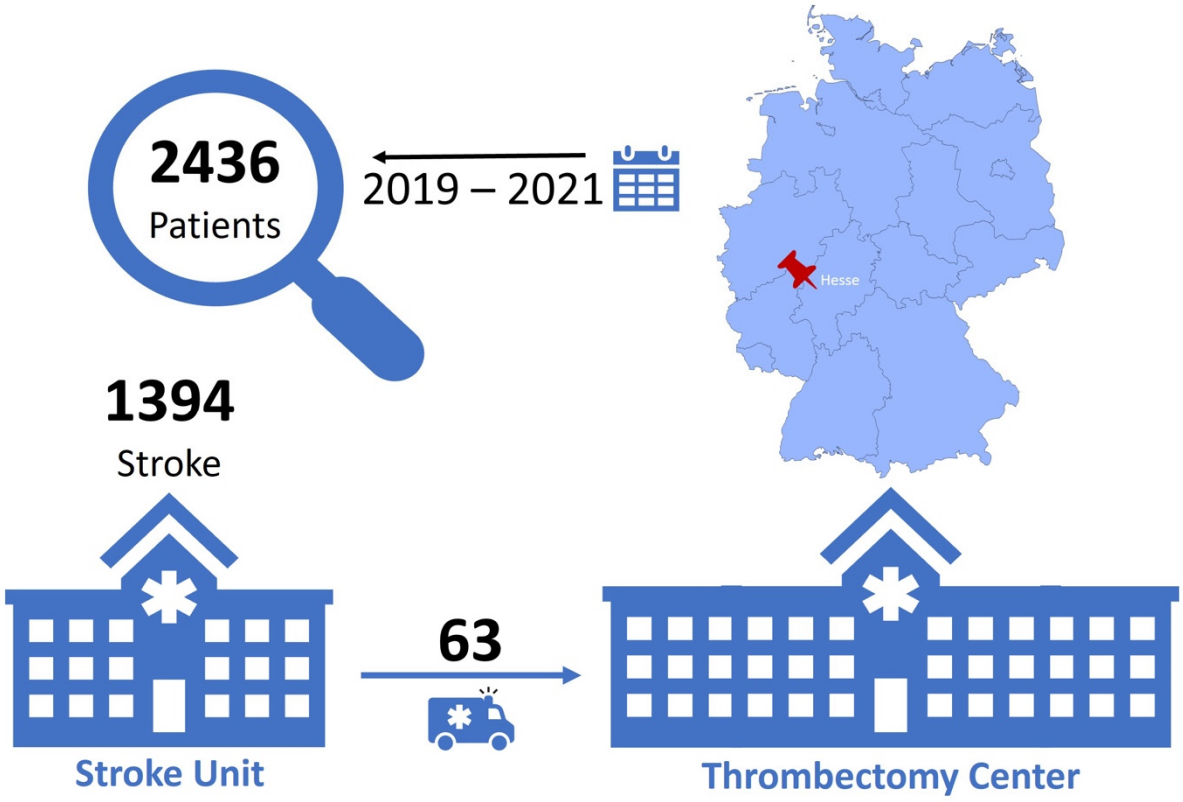

Figure 2. Number of patients with an indication for endovascular thrombectomy (EVT) and interhospital transfer to a thrombectomy-capable center.

Table 3. EVT transfers and process times.

Parameter	Value
EVT transfers (n/%)	63/6.7%
IVT prior to transfer (n/%)	33/51.6%
Mean door-in-door-out time (minutes)	81 ± 36

Overview of endovascular thrombectomy (EVT) transfers, prior IVT administration, and process times. EVT = endovascular thrombectomy; IVT = intravenous thrombolysis. Values are presented as percentages (%) or mean ± standard deviation (SD).

Figure 2 shows the total number of patients with an EVT indication who were transferred to a thrombectomy-capable center.

4. Discussion

This study provides a real-world analysis of intravenous thrombolysis (IVT) utilization and endovascular thrombectomy (EVT) referral processes in a regional stroke unit that operates outside of a university setting. Such real-world evaluations are essential to understand the gap between guideline recommendations and actual clinical practice. In contrast to controlled clinical trials, observational data from everyday healthcare environments reflect the true variability and limitations inherent in stroke care delivery. This includes resource constraints, varying staff experience levels, and regional differences in infrastructure. Therefore, this study contributes to the growing body of literature emphasizing the importance of context-specific evaluations when planning systemic improvements. Although no clinical outcome data were collected, this was not due to a methodological flaw but rather reflects the pragmatic nature of the data source, which was initially designed to evaluate prehospital stroke recognition tools. Furthermore, the use of observational data from daily clinical

practice strengthens the external validity of our findings. It allows for a more nuanced understanding of how stroke protocols are applied in non-academic, resource-limited settings. As such, the findings offer valuable insights into logistical barriers, treatment eligibility, and system-level challenges that are often underrepresented in controlled studies but highly relevant for health services planning in similar regional settings.

Approximately one in seven patients with acute ischemic stroke (AIS) received IVT, while only a small subset required EVT following interhospital transfer. The low IVT rate was primarily due to delayed hospital presentation, highlighting the need for improved public awareness and early stroke recognition. At the same time, the small proportion of EVT candidates questions the generalizability of direct transport to thrombectomy centers for all suspected stroke patients in comparable regional settings.

The mean age of the patients in this study was 73 $\pm$ 15 years, with an almost equal distribution between males and females (49% male vs. 51% female). This demographic distribution is consistent with data from other studies on cerebrovascular events [10–12].

When comparing the types of strokes in the analyzed cohort, 68% of stroke patients had cerebral ischemia, approximately 25% had a transient ischemic attack (TIA), and 7% experienced intracranial hemorrhage (ICH). These findings align with data from the German Federal Statistical Office for 2017, which reported that among 370,000 stroke patients, 61% were diagnosed with cerebral ischemia, approximately 29% with TIA, and 7% with ICB, while 2% suffered from subarachnoid hemorrhage (SAH) [10]. Consequently, the patient cohort in this study can be considered representative of the general population of stroke patients in Germany, making the results generalizable. The stroke unit in this study treats approximately 600 stroke patients per year, which corresponds to the typical caseload of a regional stroke unit in Germany [13].

In this study, 146 of 952 patients with AIS (14.8%) underwent IVT. This rate was slightly below the national average of 16.3%, but it still fell within the wide regional variability range reported in 2019 (2.9% to 32.0%) [12]. The mean DNT was 41 min, which was well below the maximum 60 min threshold required for certification as a stroke unit [14]. However, this duration remains longer than optimal, considering the urgency of treatment for acute ischemic stroke. It is estimated that approximately 1.9 million neurons are irreversibly lost per minute in cases of middle cerebral artery occlusion [1,3]. Therefore, further reductions in DNT are essential to improve patient outcomes and minimize the extent of ischemic damage.

Among all patients with AIS, 811 did not receive IVT, with the most common reason being an unclear or elapsed symptom onset (48%). These findings highlight a pressing need to improve public education on recognizing stroke symptoms early and seeking immediate medical attention. An additional 38% of patients were excluded from IVT due to resolving symptoms at presentation. However, resolving symptoms should no longer be considered a definitive exclusion criterion, as these patients may still be at risk of significant ischemic events [5,15]. Oral anticoagulation was the reason for IVT exclusion in 10% of cases, which remains an increasing challenge in stroke care. However, recent advancements allow for the measurement of anticoagulant levels, enabling the safe administration of thrombolysis in patients with low anticoagulant activity [16–19]. These developments suggest the potential need to revisit current practices and explore the broader integration of such diagnostic capabilities into clinical workflows; however, this was not demonstrated in the present study.

In this study, only 6.7% of AIS patients were transferred for MT due to LVO, aligning with averages reported in other studies [12,20,21]. The mean DIDO time was 81 min, comparable to a recent retrospective analysis from the Hessian Stroke Registry, which reported a median DIDO time of 92 min (interquartile range: 69–110) [4]. A detailed analysis

of all in-clinic treatment and decision-making steps—such as time to imaging, imaging to transfer decision, transfer decision to thrombectomy center confirmation, and confirmation to patient transport—would have been valuable but was not recorded in detail. In addition to optimizing DIDO times, another potential strategy could be the direct transport of all patients with severe stroke syndromes to a thrombectomy center (mothership model). While this approach could further reduce delays, additional studies are needed to evaluate its feasibility, clinical impact, and potential benefits before widespread implementation. However, consistent with prior findings from the stroke registry, the coordination and execution of patient transport to a receiving MT center remain key delaying factors [4]. The findings of this study support the drip-and-ship model as a viable and effective approach for EVT, provided that process times are optimized and standardized. In addition, the role of structural factors such as staff availability, shift handovers, and diagnostic turnaround times should be considered when analyzing in-hospital process durations. Even with standardized pathways, variability in team composition or delays in imaging interpretation may affect overall door-to-needle or door-in-door-out times. These elements, while not quantifiable in the present dataset, represent important real-world conditions that are often overlooked in protocol-driven evaluations. Future observational studies could benefit from systematically documenting such factors. Although the mothership model could theoretically reduce delays, its practical implementation may result in inefficiencies due to the small proportion of patients ultimately requiring EVT. Improved coordination between stroke units and thrombectomy centers, along with the integration of digital systems for real-time capacity monitoring, could help mitigate these delays. Well-structured in-hospital processes are crucial to reducing the time from patient arrival in the emergency department to therapy initiation, ultimately improving outcomes. Additionally, in-hospital training programs could enhance these workflows, as demonstrated in a prospective, multicenter interventional study [22,23].

5. Strengths and Limitations

A major strength of this study is that data collection was not primarily focused on process times, thereby minimizing the risk of observer bias. Studies explicitly targeting process times often introduce bias by optimizing workflows during the study period, leading to results that may not accurately reflect real-world conditions. Additionally, the study was conducted in a non-university, community-based stroke unit, which is representative of many regional centers that are often underrepresented in clinical trials. This enhances the generalizability of the findings to similar healthcare settings.

This study also has several limitations. First, it was based on data from a single regional stroke unit, which may not capture the full variability of stroke care across different healthcare systems and geographic regions. Second, no clinical outcome data were collected, as this sub-analysis focused on organizational process variables based on existing records from the FAST4D study. The original study design did not include structured outcome documentation, and retrospective outcome assessment was not feasible due to ethical and logistical constraints. While this limits the ability to draw conclusions about the clinical consequences of treatment delays, our findings nonetheless highlight key process-related bottlenecks that warrant further investigation. Third, the study did not include a detailed breakdown of individual time intervals within the treatment process, such as time from imaging to decision-making and from decision to patient transfer.

Furthermore, although DIDO times were calculated, the study did not include a detailed breakdown of the individual in-hospital intervals contributing to DIDO, such as time to initial imaging, decision-making, and transfer initiation. This limits the ability to identify specific in-hospital sources of delay and should be addressed in future research.

Despite these limitations, our data highlight significant challenges in stroke recognition, in-hospital workflows, and interhospital transfers, all of which require further investigation to develop effective solutions. We fully acknowledge that including outcome data would have strengthened the clinical relevance of our analysis and plan to address this in future prospective studies.

Furthermore, important clinical details such as stroke severity scores (e.g., NIHSS), imaging-based ASPECTS scores, stroke etiology, and vascular risk factors were not systematically documented and could therefore not be included in the analysis. This reflects common practice in regional, non-university stroke units in Germany, where structured imaging scores such as ASPECTS are not routinely assessed.

In addition, our analysis did not include subgroup comparisons based on age, sex, or comorbidities. This decision was made due to the descriptive nature of the study and the lack of standardized documentation for relevant covariates. Although such analyses could provide further insight into differences in care pathways or treatment eligibility, they were beyond the scope of this real-world assessment. Future studies with prospective data collection could address these questions in more detail and explore the impact of demographic or clinical factors on stroke management and outcomes.

Future research should focus on prospective data collection including clinical outcomes and evaluate targeted interventions to further reduce treatment delays. Additionally, patient-centered outcome measures could complement process metrics in assessing the quality of stroke care. Another relevant limitation to consider is that the study did not explore the impact of external factors such as weather conditions, traffic delays, or emergency service availability on transfer times. These variables, while outside the hospital's control, may still contribute significantly to the variability in DIDO times. Incorporating such contextual data into future research may help to further disentangle avoidable delays from system-inherent limitations and thereby enhance the specificity of proposed solutions.

6. Conclusions

This study highlights the low rate of IVT, primarily due to delayed hospital presentation, which remains the main barrier to treatment eligibility. Additionally, only a small proportion of patients were eligible for EVT, and among these, prolonged DIDO times were observed during interhospital transfers. These findings emphasize the importance of raising public awareness to promote early stroke recognition and timely hospital presentation. Furthermore, streamlined logistics, better coordination between stroke units and thrombectomy centers, and in-hospital training programs are essential to optimize stroke care and improve patient outcomes. In summary, our findings confirm the critical importance of early hospital arrival and rapid process execution for successful stroke treatment. Ensuring sufficient resources, standardized pathways, and strong network coordination must remain top priorities. Future prospective studies should build on these insights to test the effectiveness of specific workflow interventions in similar regional settings and further expand the evidence base for stroke care beyond academic centers.

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Informed Consent Statement: Informed consent was waived due to the observational design of the study, as no study-specific interventions were performed, and all data were collected anonymously. Patient confidentiality was strictly maintained throughout the study, and no personally identifiable information was included in the dataset.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author/s.

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

Abbreviations

AIS	Acute ischemic stroke
CT	Computed tomography
DIDO	Door-in-door-out
DNT	Door-to-needle time
EVT	Endovascular thrombectomy
ICH	Intracranial hemorrhage
IVT	Intravenous thrombolysis
LVO	Large vessel occlusion
MRI	Magnetic resonance imaging
MT	Mechanical thrombectomy
rtPA	Recombinant tissue plasminogen activator
SAB	Subarachnoid hemorrhage
SU	Stroke unit
TIA	Transient ischemic attack

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