Review



# Streamlining Acute Stroke Processes and Data Collection: A Narrative Review

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# Streamlining Acute Stroke Processes and Data Collection: A Narrative Review

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**Abstract: Background:** Acute ischemic stroke treatment has been thoroughly studied to identify strategies to reduce treatment times. However, many centers still do not meet the benchmark time metrics. Additionally, smaller centers often face longer treatment times, yet studies focus primarily on larger, more advanced centers. **Objectives:** The aim of this study is to analyze existing literature to understand the strategies implemented in primary and comprehensive stroke centers to reduce their treatment times, and categorize the studies based on methods used to improve their processes **Results:** Three main categories of improvements were identified in the literature: 1) standardization of processes, 2) resource management, and 3) data collection. Both primary and comprehensive stroke centers were able to reduce treatment times through standardization of processes. However, challenges such as variations in resources between hospitals and difficulties in integrating data collection software into workflow were highlighted. Additionally, many strategies to optimize resource management and data collection were conducted in comprehensive stroke centers, which can benefit primary stroke centers. **Conclusions:** Many existing strategies to improve treatment times are viable for both primary and comprehensive stroke centers. However, while data collection is recognized as crucial for process improvement, challenges persist in integrating data collection methods into clinical workflow. Proposed solutions include the development of easy-to-use software tailored to clinician needs.

**Keywords:** Acute stroke; workflow standardization; resource management; data collection; clinical workflow; primary stroke centers; comprehensive stroke centers

## 1. INTRODUCTION

Stroke is one of the leading causes of death and disability globally [1]. Ischemic stroke accounts for approximately 85% of all strokes and is treatable with two methods: thrombolysis [2,3] and endovascular thrombectomy (EVT) [4,5]. Both treatment are highly time dependent; as approximately 1.9 million neurons die in the brain every minute a stroke goes untreated [6]. Thrombolysis and EVT must be provided within 4.5 hours and up to 24 hours from symptom onset, respectively. Both treatments are more effective the earlier they are administered [7,8].

Benchmark times have been in place for hospitals to administer thrombolysis and EVT within a median 30 minutes and 60 minutes of hospital arrival [9,10]; these measures are called door-to-needle time (DNT) and door-to-groin-puncture time (DGPT), respectively. Studies have identified strategies to reduce DNT and found out that a DNT of 20 minutes was achievable [11]. Additional studies have identified and evaluated the effects of individual strategies to improve stroke processes of care [12–14], primarily focusing on DNT. These studies highlighted the importance of organized practice and continuous improvement.

Rural and community hospitals are typically primary stroke centers (PSCs) capable of thrombolysis treatment, and urban teaching centers called comprehensive stroke centers (CSCs) capable of both thrombolysis and EVT. Despite the proposed strategies to improve DNT, many

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centers still do not meet the median benchmark time of 30 minutes [15]. PSCs often face longer treatment times, at the same time, most studies focusing on DNT are conducted in CSCs [16,17].

This narrative review aims to compare strategies implemented in PSCs and CSCs to review barriers different centers face towards optimizing and monitoring their stroke treatment processes. It also aims to review how centers improved their DNTs and categorize the strategies implemented in PSCs and CSCs.

## 2. SEARCH STRATEGY

The review was conducted using PubMed to identify studies improving acute stroke treatment. Keywords used included: "acute stroke", "process", "workflow", (door-to or door to). The words "rehabilitation" and "transfer" were excluded from the search to focus on interventions that were applicable to the in-hospital workflow of both PSCs and CSCs. Articles included were: 1.) published in peer-reviewed journals; 2.) written in English; 3.) published after 2010; 4.) provided a set of interventions implemented either in a single-center, or across multiple centers.

## 3. CATEGORIZED STRATEGIES

The literature identified three main categories of improvement strategies in different centers. The first was standardization of processes. This concerned how centers organized stroke care and implemented clinical practice guidelines to optimize their stroke care pathway. The second was resource management, which involved how the dedicated stroke teams distributed tasks between their members to deliver care effectively. Finally, data collection focused on how centers gathered and used data to either guide improvements or provide feedback to influence change. Table 1 shows included articles and their focus areas.

**Table 1.** Focus Areas of Included Articles.

| Authors | Article Focus | | | |
|---|---|---|---|---|
| | Hospital Focus (PSC, CSC, both) | Standardization of Processes | Resource Management | Data Collection |
| **Ernst et al. (2022)** | CSC | Yes | No | No |
| **Prabhakaran et al. (2015)** | Both | No | Yes | No |
| **Bohmann et al. (2021)** | CSC | Yes | No | No |
| **Aghaebrahim et al. (2019)** | CSC | Yes | Yes | No |
| **Andrew et al. (2017)** | Both | No | No | Yes |
| **Hill et al. (2020)** | CSC | Yes | No | No |
| **Liberman et al. (2022)** | Both | Yes | No | No |
| **Willems et al. (2019)** | CSC | Yes | Yes | No |
| **Park et al. (2021)** | PSC | Yes | Yes | No |
| **Zhang et al. (2023)** | CSC | No | No | Yes |
| **Zuckerman et al. (2016)** | CSC | Yes | Yes | No |
| **Ford et al. (2012)** | CSC | Yes | Yes | No |
| **Kamal et al. (2017)** | CSC | Yes | No | No |
| **Gutiérrez-Zúñiga et al. (2022)** | CSC | Yes | No | Yes |
| **Busby et al. (2015)** | CSC | Yes | No | No |
| **Hennebry et al. (2021)** | PSC | No | Yes | No |
| **Burnett et al. (2014)** | CSC | Yes | No | Yes |
| **Van Schaik et al. (2014)** | PSC | Yes | No | No |
| **McGrath et al. (2018)** | PSC | Yes | Yes | No |
| **Jauch et al. (2018)** | PSC | Yes | No | Yes |
| **Mohedano et al. (2017)** | CSC | Yes | No | No |
| **Rubin et al. (2015)** | CSC | Yes | Yes | Yes |
| **Olson et al. (2011)** | Both | Yes | No | No |
| **Prior et al. (2016)** | PSC | No | Yes | No |

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|---|---|---|---|---|
| **Wong et al. (2023)** | PSC | Yes | Yes | No |
| **Kamal et al. (2019)** | PSC | Yes | No | Yes |
| **Kircher et al. (2016)** | CSC | No | Yes | No |
| **Santana Baskar et al. (2020)** | Both | Yes | Yes | No |
| **Tahtali et al. (2017)** | Both | Yes | Yes | No |
| **Bulmer et al. (2021)** | Both | Yes | Yes | No |

### *3.1. STANDARDIZATION OF PROCESSES*

The most frequently implemented strategies in single centers involved standardizing workflow processes. Implementation of standardization discussed four main methods to reduce treatment times: task completion pre-arrival, streamlining workflow, facilitating communication and parallel task flow.

Task completion pre-arrival was identified as a key factor in reducing treatment times by allowing the stroke team to prepare before the patient arrival to the hospital. If pre-notification occurs, further steps including pre-registering patients, paramedics putting IV lines, pre-ordering lab tests and CT scan can be completed. This was reinforced by centers (both a CSC and a PSC) describing the lack of pre-registration capabilities in their hospitals electronic systems as a limitation that kept their interventions from reducing DNTs further [18,19]. In addition, Mohedano et al. (2017) identified how often pre-arrival tasks were not completed and what caused the failures [20].

Streamlining workflow was completed by modifying centers' existing protocols. Often, modifying the protocols would require a multidisciplinary team to meet and agree on the planned changes to the process. Frequently identified strategies to streamline the process included direct to CT (or Emergency Department (ED) 'pit stop' evaluations), ensuring the stroke team is involved in treatment, beginning the thrombolysis treatment discussion as soon as imaging ends and speeding up the thrombolysis treatment by preparing and administering the drug in the imaging area. Regardless of PSC or CSC, many centers implemented the described strategies. Kamal et al. (2017) identified the frequency and time saved from iteratively implementing rapid registration, CT and thrombolysis administration practices, showing mean time reductions ranging from 7 minutes to 19 minutes [21]. Kamal et al. (2019) and Hennebry et al. (2022) implemented interventions to reduce DNT in different PSCs to 30 minutes and 35 minutes, respectively [22,23]. Three studies from different center types (2 CSCs and 1 PSC) did not discuss initiating thrombolysis in the imaging area [19,24,25], however, comfort with administering thrombolysis in the scanner increased with simulation training [26].

Facilitating communication was an improvement strategy that primarily relied on simple methods of providing information to multiple people at once. Zuckermann et al. (2016), Hennebry et al. (2022) and Hill et al. (2020) modified their communication systems to alert all stakeholders simultaneously, rather than individually, and identified this strategy as a key factor in reducing their DNTs [23,25,27]. This not only applies to pre-notification, but also intra-departmental communication, as one study applied the use of a "mass alert" to notify the ED staff when the EVT decision was made [27].

Parallel task flow was a strategy implemented in both PSCs and CSCs. However, CSCs often had larger stroke teams, including in-house neurologists, residents, fellows, and stroke nurses. The use of a stroke nurse aided in setup and administration of thrombolysis in the CT scanner or imaging area in some CSCs [28]. Additional studies included the ED social worker and pharmacist, but this was less common and exclusive to CSCs [19,29,30]. When modifying protocols, centers would assign roles and responsibilities to each member of the stroke team, providing each member with clarity of their roles. In PSCs, the smaller stroke teams meant tasks such as patient history review, clinical assessments and contacting family members were the responsibility of the nurse or physician [23].

### *3.2. RESOURCE MANAGEMENT*

One of the challenges discussed about PSCs is the lack of resources, primarily in terms of staff, equipment, and training [16,31]. Common strategies have been discussed to improve these

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challenges, including the use of telestroke [32–34]. However, variability in neurology contact time can impact the effectiveness of telestroke implementation [35]. Besides telestroke, other strategies can be used to aid PSCs in maximizing resource efficiency.

Resource management problems occur when there is an inadequate stroke team size or staff specialization. In PSCs, typically the roles involved in stroke treatment are less specialized. Some PSCs have neurology teams in-house, while others rely on telestroke. Bulmer et al. (2021) interviewed rural and urban clinicians and found rural clinicians often rely on telestroke consultations for treatment decisions, and there could be delays contacting the neurologist [36]. Prabhakaran et al. (2015) compared an academic and community hospital and found the community hospital faced unique challenges with ED overcrowding [37]. Liberman et al. (2023) identified the most critical failures that occurred in PSCs and CSCs were due to providers lacking experience in assessing patients or ED busyness resulting in missed paramedic reports [38). While studies have discussed the lack of staff contributing to challenges in stroke treatment, Wong et al. (2023) reviewed stroke treatments in their PSC and found the number of staff present did not impact the team journey time [39].

Along with modifying protocols, PSCs without neurologists accommodated their lack of specialized teams by relying on decision support references. The references would be used to aid in the process that relies on algorithms to determine the decisions the clinician would have to take. This included determination for thrombolysis and EVT referral, exclusion from advanced imaging, and calculating scores like ASPECTS. However, Hennebry et al. (2022) discussed including a video guide for staff education and training in future process improvement initiatives [23]. The decision support references were only described as an intervention implemented in PSCs without in-house neurology teams [18,23].

Finally, a strategy that can aid in resource management is the use of simulation training to improve staff experience. Willems et al (2019) explain the importance of non-technical skills such as communication as necessary skills to develop for stroke treatment, and regular simulation training can aid in reducing treatment times [40]. While the two studies discussing simulation training focused on CSCs, Tahtali et al. (2017) explained how to setup a stroke team simulation and how it can be applied to different centers [41].

Despite challenges associated with fewer resources in PSCs, existing strategies can be implemented to address the lack of specialization or potential unfamiliarity with stroke processes including the regular use of telestroke, decision support tools, and simulation training.

### *3.3. DATA COLLECTION*

The final set of strategies used to facilitate improvements was the collection and use of data gathered in the process. There were two aspects of data collection reviewed: how the data was collected and how it was used. Studies have identified and implemented data feedback as an improvement strategy towards DNT [15,20,23,42]. However, data feedback was less discussed than the aforementioned topics, often used as a temporary tool to identify areas of improvement.

Jauch et al. (2018) evaluated the treatment times in a set of thrombolysis centers called the "stroke belt" and used retrospective electronic medical record (EMR) reviews to determine each hospital's DNT. The data from the chart review was leveraged by comparing clinicians anticipated DNTs with their actual DNTs, highlighting their actual DNTs were much longer [43]. This study relied on education and data feedback to motivate clinicians to improve their DNTs, and their rates of patients receiving thrombolysis within 60 minutes increased from 22.2% to 67.3% [43].

Multiple studies discussed prospective (or-real time) data collection and feedback methods. A simple real-time data feedback mechanism was implemented by Burnett et al. (2014) using a group text system [44]. Through regular real-time feedback after each stroke treatment, documenting the DNTs and reviewing cases that were longer than 60 minutes, the intervention reduced the centers DNT from 82 minutes to 56 minutes. Despite the simplicity, the prompt data feedback was beneficial to motivate change.

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One of the studies focused on real-time data collection used sensors in key locations (ED, imaging, angiosuite) to collect time metrics throughout the treatment process. Zhang et al. (2023) combined EMR information and sensor data to identify when delays were occurring and relay feedback to the stroke team [45]. The benchmark times improved significantly after the intervention, but this intervention was only implemented in a large CSC that had a specialist abstracting the data to the medical charts.

One of the approaches to facilitate prospective data collection was through mobile software. Three studies focused on the use of mobile applications that aimed to aid in treatment processes while facilitating documentation. The studies focused on three different applications: Pulsara's "Stop Stroke" [46], The Mayo Clinic Acute Stroke Evaluation tool [47], and JOIN [48]. Each software served similar functions and provided aids to assist clinicians. Each software provided a combination of communication tools, reference aids and timestamp capabilities. There were key differences in the software's features. Pulsara's "Stop Stroke" used the phones notifications system to update the stroke team on tasks completed [46]; the Mayo clinic Acute Stroke Evaluation software provided an automatic text feature to contact the on-call neurologist if the center used telestroke [47]; and JOIN linked to imaging software to automatic updates on imaging results [48]. Each study found the software's helped reduce treatment times. However, there were reported issues from each study concerning either data completeness [46,47], interference with workflow [48], or low user satisfaction [48].

## 4. DISCUSSION

Many improvement strategies have been implemented in the stroke treatment process across PSCs and CSCs. Despite limitations in resources, some PSCs can reduce their treatment times significantly using similar strategies in CSCs. However, due to the smaller stroke team sizes and less specialized staff, PSCs without neurologists have implemented additional aids such as referral guides and regular feedback to improve performance [18,23]. While barriers such as costs and technology systems can prevent implementation of certain improvements, many interventions were cost neutral.

While standardization of tasks has been thoroughly reviewed and implemented in stroke process improvement, resource management strategies were less discussed. Telestroke is often seen as the primary method to improve PSC performance through neurologist consultations, but reference guides and simulation training are less discussed. Simulation training was shown to be valuable in improving communication and confidence in staff in CSCs [26,40]. With evolving technology, simulation training can become more accessible through technology such as virtual reality [49]. However, an important aspect highlighted in the studies includes communication among the stroke team, so group simulation training should not be ignored.

Data collection and monitoring was also discussed in fewer studies, despite its recognized value in improving treatment processes. Prompt feedback was shown to reduce treatment times and improve motivation in the centers. Studies in PSCs relied on retrospective data collection that required the dedicated quality improvement intervention team to complete. Existing tools were tested to aid in prospective data collection, but they suffered from issues either due to missing data, intensive requirement of resources or interference with workflow. Studies discussing mobile application use found users were missing key data, or they were not satisfied with the software [45–48].

This review study was limited to various aspects. First, topics including improvement strategies in transferring patients from PSCs to CSCs and user experience analyses in acute care settings could be further reviewed to identify other applications. Additionally, this review analyzed the current treatment process in three different aspects. However, stroke treatment process in both centers can be affected in other aspects as well, such as comfort level of treating and hospital culture.

## 5. CONCLUSIONS

There are many accepted strategies to reduce DNT by standardizing stroke processes. Streamlining workflow, completing tasks before the patient arrives, simplifying communication, and

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completing tasks in parallel are well established strategies that both PSCs and CSCs can utilize to improve their processes. While PSCs face unique challenges concerning their resource availability, multiple centers have effectively reduced their DNT through task standardization and use of tools like telestroke. However, existing strategies such as decision support tools, and simulation training have shown to be effective in CSCs and are understudied in PSCs. Furthermore, data feedback, while shown to be an effective method to reduce treatment times, have few dedicated strategies in place to effectively collect and relay in PSCs and many CSCs. Thus, these existing strategies about resource management and data collection should be implemented in PSCs to improve their processes.

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

## ABBREVIATIONS

ASPECTS – Alberta Stroke Program Early CT Score
CT - Computed Tomography
CSC – Comprehensive Stroke Center
DGPT – Door-to-Groin Puncture Time
DNT – Door-to-Needle Time
ED – Emergency Department
EMR – Electronic Medical Record
EVT – Endovascular Thrombectomy
PSC – Primary Stroke Center

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