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Video Consultation in Prehospital Stroke Care: Results From a Pilot Feasibility Study

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ABSTRACT

Introduction: Timely prehospital stroke assessment and accurate triage are essential for improving patient outcomes, especially for those eligible for thrombectomy due to large vessel occlusion (LVO). This pilot study explores the feasibility of video consultations between ambulance nurses (ANs) and stroke neurologists to enhance decision-making in the prehospital stroke care pathway.

Methods: A prospective observational cohort study was conducted over 12 months. Patients with suspected stroke were assigned to either video-assisted ambulances ($n = 19$) or standard ambulances ($n = 44$). The primary outcome was direct transport to the comprehensive stroke center (CSC). Secondary outcomes included prehospital time intervals and time to stroke treatment. Statistical analyses were performed using Mann–Whitney U and Fisher's exact tests, with $p < 0.05$ considered significant.

Results: Patients in the video group had significantly longer transport times to the hospital (median 31 min vs. 17 min, $p < 0.05$), reflecting geographic differences. However, total prehospital time and time to treatment did not differ significantly. A higher proportion of video group patients were transported directly to the CSC (9/19 [47%] vs. 13/44 [30%], $p = 0.25$). No patients in the video group required secondary transport, whereas 5/44 (11%) in the nonvideo group did. Thrombectomy rates were similar between groups (4/19 [21%] vs. 10/44 [23%], $p = 1.00$). However, among patients who underwent thrombectomy, a higher proportion in the video group were transported directly to the CSC, without requiring secondary transfer.

Conclusion: Video consultations between ANs and neurologists may be feasible in terms of clinical workflow. The primary outcome, direct transport to the CSC, was higher in the video group, indicating potentially improved triage accuracy, and importantly, the intervention did not prolong on-scene time. Video support may reduce delays associated with secondary transport. Although the sample size limits statistical power, these initial findings warrant further investigation through larger studies to evaluate the impact of video support on clinical outcomes.

1. Introduction

Stroke is a leading cause of death and long-term disability worldwide. Each year, more than 12.2 million stroke cases are reported globally [1], and in Sweden, approximately 25,000 patients are affected annually [2].

Time is a crucial factor in stroke treatment and outcome. Early recognition of stroke is correlated with shorter time intervals to diagnostic imaging and treatment initiation. Failure to recognize a stroke, on the other hand, is associated with an increased risk of mortality [3]. However many patients arrive too late for optimal treatment, where prehospital delays account for a large proportion of the time loss [4].

The early stroke care pathway includes the time from symptom onset to diagnosis and treatment initiation. A substantial part of this delay occurs during the prehospital phase where the healthcare system is actively involved. Prehospital system delay includes the time from first contact with healthcare to diagnostic and treatment and is influenced by factors such as time on scene, transport decisions, and distances to appropriate care [5, 6]. Since more than 70% of all stroke patients in Sweden are transported by ambulance, the prehospital phase is critical for ensuring timely and appropriate care [6].

Ambulance nurses (ANs) play a critical role in this process, as they are responsible for the initial assessment and identification of stroke [3]. Structured assessment tools such as the modified National Institutes of Health Stroke Scale (mNIHSS) are used to support clinical evaluation in the prehospital setting [7, 8]. Accurate identification of stroke by the AN has been associated with shorter time to appropriate care and improved patient outcome [3, 9]. However, prehospital stroke assessment remains challenging, particularly when determining the most appropriate level of care and transport destination in time-critical situations [10].

In recent years, telemedicine solutions, including video consultation, have been introduced to support decision-making in the prehospital setting. Studies have shown that real-time video and audio communication may improve the accuracy and speed of remote assessment compared to audio-only assessment [11, 12]. Video consultation has also been reported to enhance patient safety and improve collaboration between ANs and neurologists [13, 14]. Furthermore, remote neurological assessment via video has shown to be comparable to in-person evaluation in certain settings [15, 16].

Several studies have demonstrated that technical solutions for video-supported assessment in prehospital care are available and feasible [17, 18]. Despite these promising findings, there is limited evidence on how video consultation is implemented and used in routine prehospital stroke care, particularly regarding its impact on clinical workflow, decision-making, and transport strategies in real clinical settings [19].

The aim of this study was to investigate the feasibility of video consultation between ANs and neurologists in clinical prehospital stroke care, focusing on its impact on clinical workflow, transport decisions, and prehospital time intervals.

2 | Materials and Methods

This pilot study is part of a larger project conducted in western Sweden, video support in the prehospital stroke chain (ViPHS), where video consultation was implemented and tested in the prehospital stroke chain. The ViPHS project began with a simulation study [20, 21] which forms the basis for this small sample clinical study. Based on the experiences from these, a larger clinical study involving video consultation is being planned.

2.1 | Study Design

This study employed a quantitative prospective cohort design with cohort selection and lasted 12 months, from March 1, 2019, to February 29, 2020. Patients who met the predefined inclusion criteria during the study period were identified and divided into two groups. The study followed the recommended STROBE guidelines for observational studies [22] (see File S1). The primary outcome was direct transport to the comprehensive stroke center (CSC). Direct transport to the CSC was used as a proxy for clinical decision-making in the prehospital workflow. Secondary outcomes included time intervals and time to stroke treatment. Artificial intelligence (AI) tools (ChatGPT) were used for language editing of parts of the manuscript. AI has not been used for any form of data analysis or manuscript writing.

2.2 | Participant and Setting

The ambulance services in the region are organized into five hospital administrations, each with a varying number of ambulance districts and ambulances. There are seven local hospitals that offer thrombolysis treatment, including one CSC that provides thrombectomy. This project involved three ambulances from one of the regional hospital administrations, along with the neurologists on call at the CSC. The control group consisted of the remaining ambulances within the same regional hospital administrations.

In Sweden, a legislative change in 2005 introduced a requirement that at least one licensed healthcare professional authorized to administer medication must be present in each ambulance. Consequently, all ambulances are now staffed with at least one registered nurse (RN). This nurse can also have a specialized education in ambulance care obtaining the protected title of specialist AN. In the district where this study was conducted, most of the EMS personnel are ANs.

All EMS personnel are required to follow and make decisions based on regional and national treatment guidelines [23, 24]. The evolution of ambulance care has allowed ANs to play a more active role in decision-making determining the most appropriate level of care and the transport destination, primarily based on the severity of the patient' symptoms, rather than automatically transporting all patients to the nearest ED [25]. Transport to the hospital, when preferred, is typically to the nearest ED. However, if the AN suspects that the patient is suffering from a stroke/TIA (transient ischemic attack), ACS (acute coronary syndrome), or a hip fracture, the decision may be to refer the patient directly to a specialized care unit, via a so-called fast-track [25]. The decision-making process may require evaluation, consultation, or approval from a specialized physician, usually remotely. Clinical protocols mandate telephone consultation when stroke is suspected [26]. According to regional clinical guidelines, when an AN identifies a patient as a suspected stroke case, they first conduct an assessment using the airway, breathing, circulation, disability, and exposure (ABCDE) algorithm. The patient is then examined using the modified NIHSS scale [8]. If the mNIHSS score is 2 points or higher and transport time to the CSC exceeds 45 min, the AN must contact the local hospital for an initial assessment and CT. If the CT reveals a large vessel occlusion (LVO) and the patient is considered a candidate for thrombectomy, a secondary ambulance transport to the CSC is required [27, 28].

The ViPHS ambulances were equipped with three cameras to provide the neurologist on call with live images of the patient: side, close-up view, and fisheye [21] (Figure 1).

When the ambulance requests a consultation with a stroke neurologist (via the ambulance's standard mobile phone), the neurologist can initiate a live video from the ambulance through a tablet. The video stream enhances the already familiar audio consultation procedure. Through the tablet, the neurologist can view all three cameras, select one for detailed information, and zoom in or out, allowing for as precise a remote consultation as possible. The neurologist controls the cameras, switching between views and adjusting zoom as needed. The AN has a local screen displaying the same camera views as the neurologist's screen to facilitate mutual consultation, such as adjusting the patient's position for better visibility. Technical and logistical aspects of the video consultation system are detailed in a previous publication [21]. When the stroke neurologist begins the video examination, they use the full NIHSS scale rather than the modified version used by the AN.

If a patient was initially transported directly to the CSC, the presence of an LVO was confirmed by neurovascular imaging and the stroke team's final diagnosis at the CSC. In instances where detailed LVO confirmation was not systematically recorded in our dataset, the performance of an endovascular thrombectomy was used as a surrogate indicator that an LVO had been present (since thrombectomy is only undertaken when an LVO is confirmed).

2.3 | Population

The physician participating in this study was the regional stroke consultant, available on weekdays during office hours (8 AM to 4 PM). Typically, this physician is stationed at the CSC during these hours. The CSC performed 242 thrombectomies in 2021, representing approximately 9% of all stroke patients in the region that year.

The intervention group consisted of patients who met the inclusion criteria and were transported by a video-equipped ambulance. The control group included patients meeting the same inclusion criteria in the same ambulance district but were transported by an ambulance without video equipment. The control ambulances were not always stationed at the same locations as the video-equipped ambulances but were generally located closer to both the local and CSC. Ambulance dispatch followed the Swedish proximity principle for Priority 1 emergency calls, meaning that the closest available ambulance was assigned to each case according to national regulations. As a result, allocation to either the video or nonvideo group was determined by ambulance availability and location rather than patient characteristics.

To be included in the study, patients had to meet the following criteria:

1. Known stroke symptom onset within a maximum of 4 h.
2. mNIHSS score of 6 points or higher.
3. No altered consciousness (15–14p in Glasgow Coma Scale).

In the district studied, the CSC is located on the outer edge of the region, significantly impacting transport times. The three ambulances equipped with video technology (the ViPHS ambulances) were stationed at the periphery of the district, leading to longer transport distances to both the local hospital and the CSC. This geographical factor distinguishes the innovation group from the control group, which has shorter distances to both the local and CSC. The prehospital time intervals used in the study are defined in Table 1.

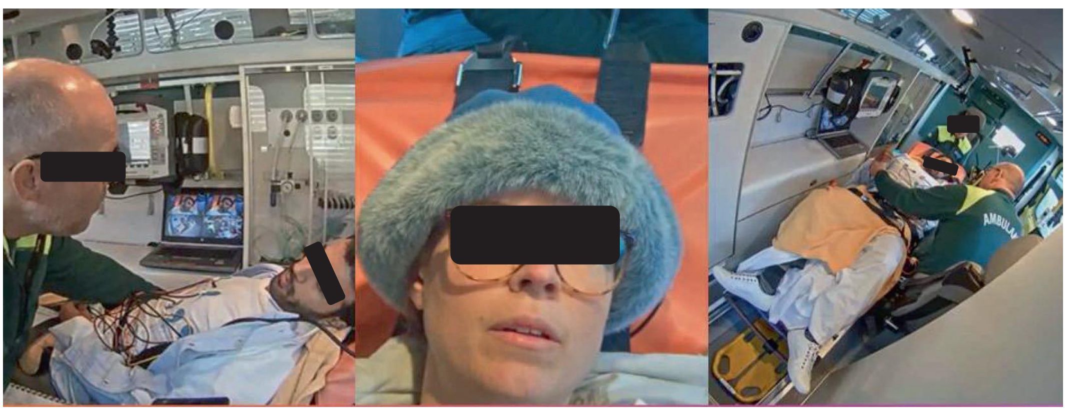

FIGURE 1 | The neurologist's view (pictures from a previous simulation study).

TABLE 1 | Prehospital time intervals.

Time interval	Explanation
Time to patient	From dispatch to ambulance arrival at the patient's location
Time on scene	From arrival at patient to loading into the ambulance
Time to hospital	From patient loaded to hospital arrival
Total prehospital time	Sum of the above times
Time from dispatch to CT	From dispatch to first radiology image
Time from dispatch to thrombolysis	From dispatch to medication administration
Time from dispatch to thrombectomy	From dispatch to arterial puncture

TABLE 2 | Demographic and vital parameters.

Median (IQR)	Video ambulance ($N = 19$)	Nonvideo ambulance ($N = 44$)	Missing data
Gender (male/female)	11/4	29/15	4
Age (years)	83 (74–87)	83 (64–82)	4
First hospital NIHSS	10.0 (6.0–14.0)	10.0 (7.5–19.5)	15[a]

[a]The missing data regarding the first hospital NIHSS is not truly missing; rather, absence in the records is typically due to the suspicion of stroke being dismissed upon the patient's arrival at the hospital.

2.4 | Data Collection

Data for the study were obtained from ambulance and hospital records. The primary data collection was conducted by one individual familiar with the electronic health record system. Another person then conducted a second data extraction to verify the data. As this was a pilot study with no previous data available to calculate statistical power, the study proceeded over a predetermined period.

2.5 | Data Analysis

The study had a small population, and the data were nonnormally distributed. Continuous variables were presented as median and range, while categorical data were presented as counts (*N*) and percentages (%). The Mann–Whitney test was used for comparisons between groups for continuous variables, and Fisher's exact test was used for categorical variables. A p value of < 0.05 was considered significant for all tests. The analyses were performed using IBM SPSS Statistics Version 28.

2.6 | Ethical Considerations

The study received approval from the Regional Ethics Review Board in Gothenburg (Ref. No. 2018-06-18). No informed consent was obtained from the patients included in the study as this requirement was waived by the same Regional Ethics Review Board. Images in this manuscript are from previous recorded simulations with neurologists as figurants, and ANsto demonstrate camera angles. Both verbal and written consent have been obtained from the individuals as shown in Figure 1.

During the study, regular procedures were followed, with the only difference being that consultation was conducted via video rather than by phone, which is the standard practice. ANs were given instructions regarding video consultation. They were informed to abort the consultation if the patient reached 6 points on the mNIHSS and to continue the examination in the ambulance while connecting to the video. If they experienced connection issues, they were instructed to move the vehicle and attempt reconnection. If the video still did not function satisfactorily, they were to return to their normal routine. Additionally, healthcare records were monitored monthly to detect delays, and if significant delays were observed, the study would be aborted. No video streams were stored. Data were pseudoanonymized, and a codebook containing personal information was kept on a secure server separate from the dataset.

3 | Results

3.1 | Study Population Demographics and Vital Parameters

The study included 63 patients (19 in the intervention group and 44 in the control group). The two groups were comparable in terms of age, gender, vital parameters recorded in the ambulance, and the first hospital NIHSS score (Table 2). The missing data regarding age and gender were most likely due to nonidentification in the prehospital setting and lack of linkage to in-hospital records.

3.2 | Prehospital Times, Time to Examinations, and Stroke Treatment Times at the Hospital

Time to hospital and total prehospital time were significantly longer in the video group, reflecting the video ambulances' peripheral stationing within the region. However, there was no significant difference in on-scene time between the two groups, nor in the time from ambulance assignment to stroke treatment (thrombolysis and thrombectomy). Importantly, the use of video consultation was not associated with any delay in intravenous thrombolysis. Among patients who received thrombolytic treatment, dispatch-to-needle times were similar in the video and nonvideo group (median 89 vs. 94 min, $p = 1.00$). This indicates that video-supported assessment did not prolong the time to thrombolysis, irrespective of whether patients were transported to a local hospital or directly to the CSC.

3.3 | Stroke Patient Destination and Final Treatment

A higher, nonsignificant proportion of patients in the video group were transported directly to the CSC, and none required secondary transport from a local hospital. Thrombectomy rates were similar between groups, but more patients in the video group received thrombectomy following direct transport to CSC (Table 3).

4 | Discussion

4.1 | Interpretation of Findings

This pilot study shows that video consultations between ANs and neurologists may be feasible in terms of clinical workflow and may support prehospital decision-making without prolonging on-scene time, although technical performance and adherence could not be fully evaluated.

Although a higher proportion of video group patients were transported directly to the CSC (47% vs. 30% in controls), this difference was not statistically significant ($p = 0.25$) and should be interpreted with caution given the small sample size. This observation may suggest improved prehospital triage decisions with video support but cannot be considered conclusive evidence of better LVO triage accuracy. Furthermore, some patients transported directly to the CSC did not undergo thrombectomy; in these cases, initial field suspicion of LVO was not confirmed by subsequent imaging or clinical assessment, or patients were ultimately found ineligible for thrombectomy (e.g., due to rapid clinical improvement or other contraindications). Such outcomes underscore the inherent uncertainty in prehospital stroke triage and the importance of balancing rapid access to endovascular care with the risk of overtriage.

The longer transport time was primarily due to geographical differences, as these ambulances were stationed in peripheral areas. This is also reflected in the longer time to CT (Table 4). However, despite these delays, the time from ambulance assignment to treatment was similar between groups. Given the small sample size, these findings should be interpreted with caution but may suggest that factors such as improved coordination or in-hospital preparedness could have contributed to maintaining similar treatment times. Since every minute counts in stroke management, even minor improvements in the care pathway may have a meaningful impact on patient outcomes.

In both groups, a subset of patients was transported directly to the CSC but did not undergo thrombectomy. This likely reflects the inherent uncertainty in prehospital stroke assessment, where some patients may initially be suspected of having an LVO but are later found not to be candidates for thrombectomy. Possible reasons include clinical factors (e.g., patient condition or unexpected contraindications) or limitations in information available to the remote neurologist. This highlights the challenge of balancing rapid access to thrombectomy with the risk of over triage.

As the intervention included both video consultation and a more comprehensive neurological assessment by a remote neurologist using the full NIHSS, the relative contribution of each component to the observed findings cannot be fully distinguished. However, video consultation is a prerequisite for enabling this type of remote neurological assessment and reflects real-world clinical practice, where it supports more informed decision-making in the prehospital setting. Notably, the European Stroke Organization's consensus states that additional travel time for thrombectomy candidates may extend by as much as 30–45 min [29]. In our study, four out of nine patients who were directly transported to the CSC in the video group proceeded to thrombectomy, suggesting a tendency towards higher diagnostic precision in triage with video support, although the sample size is too small for firm conclusions. Although the sample size limits definitive conclusions, other studies have shown that secondary transfers from a local hospital to a CSC typically take over 100 min [30, 31]. One study found that even when the distance was as short as 15 miles, over 100 min was saved when patients were transported directly to a thrombectomy center [31]. None of the patients in the video group required secondary transport, which may suggest that video consultation supports more appropriate initial triage and reduces unnecessary transfers. Similar approaches to prehospital video-supported stroke triage have been explored in other settings—for example, a mixed-method service evaluation in the United Kingdom demonstrated that

TABLE 3 | Patient destinations and treatment.

Variable *N* (%)	Video ambulance	Nonvideo ambulance	Missing data	*p*value
Local hospital ED ($N = 8$)	2 (11)	6 (14)	0	1.00
Local hospital CT lab ($N = 33$)	8 (42)	25 (57)	0	0.41
CSC direct ($N = 22$)	9 (47)	13 (30)	0	0.25
CSC secondary ($N = 5$)	0 (0)	5 (11)	0	0.31
Thrombolysis ($N = 18$)	6 (32)	12 (27)	0	0.77
Thrombectomy ($N = 14$)	4 (21)	10 (23)	0	1.00
Thrombectomy direct ($N = 10$)	4 (21)	6 (14)	0	0.46

TABLE 4 | Prehospital time, examinations, and treatment.

Time (min), median (IQR)	Video ambulance	Nonvideo ambulance	Missing data	*p* value
Time to patient	11.0 (7–15)	8 (5–14)	1	0.30
Time on scene	31 (24–42)	31 (22–35)	2	0.41
Time to hospital	31 (16–43)	17 (7–35)	3	0.04[a]
Total prehospital time	71 (61–96)	57 (48–74)	3	0.02[a]
Time from ambulance assignment to CT-brain ($N = 51$)	78 (69–93)	66 (57–88)		0.07
Time from ambulance assignment to thrombolysis ($N = 9$)	89 (86–89)	94 (78–94)		1.00
Time from ambulance assignment to thrombectomy ($N = 14$)	140 (119–264)	148 (118–192)		0.94

Abbreviations: CT, computed tomography; IQR, interquartile range; *N*, number of patients (for that time interval).
[a]A statistically significant difference between groups (Mann–Whitney *U* test), comparing medians.

such systems are feasible and acceptable, while also highlighting remaining knowledge gaps regarding clinical outcomes and implementation [32].

Earlier studies indicate that time on scene tends to be longer when using video-supported consultation in cases of suspected stroke. Despite this, video consultation is regarded as a valuable instrument to get the patient to the right level of care quickly, because the time lost due to secondary transfer is significantly greater than the potential time loss during video consultation [21]. This study, however, indicates that time on scene was comparable between the two groups, suggesting that video consultation may not take longer than current telephone consultation, even with the initial unfamiliarity of the technology.

This study represents an initial step in a stepwise implementation and evaluation of the intervention, conducted on a limited scale and during office hours. Based on findings from this pilot study, we have expanded the intervention to more ambulances and extended coverage to on-call hours and are evaluating user experience and acceptability through qualitative methods.

4.2 | Limitations

This was a prospective observational cohort study with a small sample size. Due to the study design and limited statistical power, we cannot establish causal relationships between the intervention and outcomes.

Although ambulances were assigned based on emergency call priority, potential biases include variations in EMS personnel training, patient severity, and other unmeasured confounders affecting prehospital and in-hospital stroke management (such as differences in local CT routines). Geographical factors emerged as an important confounder in this study. Because the video-equipped ambulances were stationed in more peripheral areas, their transport distances (and times) to the hospital were longer on average than those of standard ambulances. We explicitly acknowledge that these geographic differences likely influenced prehospital time intervals and may have diluted some potential time-saving benefits of the video intervention. This factor is now highlighted as a limitation, since it could have biased our comparisons of transport and treatment times independently of the video consultation's effect.

Another limitation is that the use of video consultation was not systematically documented, including how often it was successfully used or whether any technical issues occurred. Although no technical problems were reported by ANs during the study period, the absence of systematic documentation limits the assessment of adherence and technical performance. It is also unknown to what extent video consultation was used in all eligible cases. Future studies should include systematic documentation of both video usage and technical performance to enable a more comprehensive assessment of feasibility in clinical practice. Due to the small sample size and lack of detailed data on confirmed LVO status in relation to prehospital triage decisions, diagnostic performance metrics such as sensitivity, specificity, and predictive values could not be reliably calculated. The total number of potentially eligible patients during the study period was not systematically recorded, which limits the ability to assess how often the intervention was applied in eligible cases.

To mitigate these limitations, future studies should implement stratified randomization to ensure balanced allocation of ambulances across regions. Moreover, standardized training programs for EMS personnel could reduce variability in stroke recognition and prehospital decision-making. Collecting comprehensive patient severity data and other potential confounders, as well as including larger sample sizes, will allow more robust analyses, including adjustments for regional disparities, to better isolate the effect of video consultation.

This study has several strengths. It was conducted in a real-world prehospital setting, enhancing its external validity and relevance to clinical practice. The prospective design reduces the risk of recall bias. Furthermore, the inclusion of both prehospital and in-hospital time intervals allows for a comprehensive assessment of the entire stroke care pathway.

5 | Conclusions

This pilot study shows that video consultations between ANs and stroke neurologists are feasible in prehospital practice and can be implemented without prolonging on-scene or total prehospital time. The primary outcome (direct transport to the CSC) was observed more frequently in the video group (47% vs. 30%), though this difference did not reach statistical significance. The video-supported approach nonetheless eliminated secondary transfers in the video group and did not delay urgent treatments (IV thrombolysis or thrombectomy), which suggests it can streamline the stroke pathway without compromising care. As a feasibility study, these findings support larger trials to confirm whether video-supported prehospital assessment can indeed enhance LVO triage decisions and improve patient outcomes.

Nomenclature

LVO	large vessel occlusion
ED	emergency department
RN	registered nurse
AN	ambulance nurse
EMS	emergency service
TIA	transient ischemic attack
ACS	acute coronary syndrome
CT	computed tomography
WHO	World Health Organization
NIHSS	National Institutes of Health Stroke Scale
mNIHSS	modified National Institutes of Health Stroke Scale
ViPHS	video support in the prehospital stroke chain
ABCDE	airway, breathing, circulation, disability, and exposure
CSC	comprehensive stroke center

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Supporting Information.** File 1 STROBE checklist for observational studies.