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"Chain of survival" in acute stroke

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Summary

Stroke is the third leading cause of death in the U.S. after all other heart diseases and all forms of cancer. Nationally, only about 26% of the population is able to recognise the distinguishing signs and symptoms of stroke. These refer to difficulty in walking, weakness on one side, blurred vision or loss of vision, and slurred speech. Additionally, even experiencing these symptoms, most people are not able to recognise them for what they are. Having attached very great importance to the necessity of training and education, the American Stroke Association together with the American Heart Association, developed a new initiative called the "Stroke Program". The program targets three key audiences: healthcare professionals, emergency transport systems, and the general public. "Operation Stroke" provides the blueprint, outlining a "stroke chain of survival" including rapid recognition of a stroke's signs and symptoms; rapid activation of the EMS system from calling "94" immediately; rapid initiation of pre-hospital care; rapid EMS transport to the nearest appropriate hospital with pre-notification of emergency room personnel and rapid diagnosis and treatment at the hospital. In 1996, the U.S. Food and Drug Administration (FDA) approved a new thrombolytic drug known as tissue plasminogen activator (t-PA), which gave the medical community a new weapon against the possible lifetime sentence of patient disability. *Anestezjologia i Ratownictwo 2010; 4: 193-197.*

Keywords: stroke, chain of survival, pre-hospital management, thrombolytic drug

Introduction

Stroke incidence is gradually increasing and occurs mainly among the population at their most prolific age [1]. According to the Framingham study, 28% of stroke victims are younger than 65. Approximately 700,000 people a year have been recorded as suffering from strokes in the USA; that is, every 45 minutes somebody suffers the onset or recurrence of a stroke, and furthermore, every three minutes one person passes away from a stroke. The disease's incidence is increasing in transition countries, which has lead to the expectation that next year will be identified as the year of stroke epidemy [2]. The mortality rate in the course of the phase is 20-30% for ischemic stroke, and 60-90% for haemorrhagic strokes [3-5]. According to WHO research [5,6], strokes are the prevailing factor in in-hospital mortality in our country with reference to the younger population (aged 40-45). The initial lethal cause is among female population and subsequent cause, among male population [7]. In socio-economic terms, the cost of treatment, rehabilitation and care of stroke victims in the USA in 1993 was 17 billion dollars, rising to 52 billion dollars in 2000 [8].

Pre-hospital approach to stroke

Stroke is considered an emergency state in medicine demanding urgent out-of-hospital screening and treatment. The phase sequence in its treatment is presented as the "Stroke chain of survival", or the "7 Ds":

1. Detection – Onset identification of stroke symptoms,
2. Dispatch – Emergency medical services (EMS)

summoned, as well as onset identification of the stroke victim by the emergency medical dispatcher (high- priority response),
3. Delivery – Urgent intervention by the EMS team, pre-hospital treatment and transfer to the stroke unit (SU),
4. Door – Emergency Department (ED) triage,
5. Data - ED evaluation as a priority, including prompt computed tomography
6. Decision – The candidate choice for a specific therapy, and
7. Drug – Fibrinolytic therapy.

➢ *Detection*

The common delay in stroke treatment is due to the delay in recognition of symptoms by witnesses or the victims themselves, or due to ignorance of the need to immediately call the emergency medical services, and the fact that treatment is dependent on time. The National Stroke Association (NSA) has established that 40% of people in the USA are barely informed about the warning signs of stroke, and that only 1% are familiar with the fact that stroke is one of the leading causes of death. The NSA's data also indicates that only 42% of patients are admitted to ED within the first six hours of the symptoms' commencement and, consequently, 64% after being admitted after 48 hours [9]. Delays in thrombolytic treatment [10] are shorter, providing that the first symptoms are detected by witnesses, not by the patient themselves. Proper recognition of the warning signs is significant due to the fact that fibrinolytic therapy is likely to be carried out only within a three-hour-therapeutic window from onset. With this in mind, it is essential that public education should be conducted at all possible levels: with high risk patients, patients having already experienced stroke, families of stroke victims and the general public.

Educational programmes should be conducted via electronic media; on-line via various Internet sites providing their readers with text, audio and video presentations; off-line, perhaps via kinaesthetic materials; and directly, from patients having experience of being admitted and treated.

Public education should serve as a guideline for the general population, and should cover: 1) Detection of stroke symptoms, 2) Awareness of the need for urgent medical assistance, 3) Awareness of the need for urgent transportation to hospital, and 4) Awareness of the need for urgent admittance to the ED. The benefit of such extensive public education would be an increase in the number of patients receiving acute fibrinolytic treatment.

Educational objectives are aimed at encouraging witnesses to suspect stroke when the following symptoms are recognized: paralysis, numbness or weakness in the face, arms, legs, particularly in one side of the body; paresis/loss of sensibility; ataxia; blurred or sudden loss of vision, particularly in one eye; loss of speech or trouble understanding speech; dizziness, unsteadiness or sudden falls; sudden severe, unusual headaches and confusion/agitation.

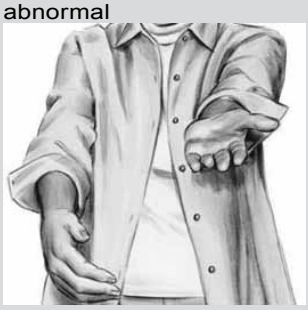
➢ *Dispatch*

Inaccurate onset diagnosis is another problem. The education of dispatch personnel within the emergency medical services is compulsory in many countries, for purposes of proper telephone triage in cases of suspected stroke of the acute myocardial infarction (AMI) type, or "red line" trauma [11]. It has been proven that telephone dispatchers may have a false evaluation rate of up to 50%, whereas with trained medical personnel this rate is up to 25%.

The emergency medical services of the City Agency in Belgrade, Serbia, have achieved several criteria of the Norwegian EMS Index, including: Coordination of Dispatcher's communications with the caller; Detection of visible or eventual signs of onset or actual stroke; Emergency rate establishment; Rapid triage; Directing EMS crews to the emergency's location; Keeping the caller on the line and giving appropriate advice until the EMS crew's arrival, and informing neurological units of incoming patients with suspected or visible stroke.

For all of this to work, the dispatcher needs the necessary information from the caller, including general information on the patient, an accurate address, the caller's 'phone number and the victim's current condition. Key questions asked by the dispatcher are:
1. Is the patient totally immobile?
2. Is the patient's respiration normal?
3. Is the patient able to speak as usual?
4. What is the reason for suspecting stroke? Does the patient have any difficulties moving, any problems with their vision, or any sort of paresis or loss of sensitivity?
5. How much time has elapsed since the suspected stroke symptoms manifested?
6. Has the patient ever experienced a stroke before?

Table 1. Cincinnati Prehospital Stroke Scale (CPSS)

FACIAL DROOP	Have the patient show their teeth or smile
normal 	Both sides of face move equally
abnormal 	One side of face does not move at all
ARM DRIFT	The patient closes their eyes and extends both arms straight out for 10s
normal 	Both arms move equally or not at all
abnormal 	One arm drifts compared to the other
SPEECH	The patient repeats "The sky is blue in Cincinnati".
normal	Patient uses correct words with no slurring
abnormal	Slurred or inappropriate words or mute

Interpretation: in case of only one criteria being abnormal, likelihood of stroke is 72%

The answers obtained determine: 1) Triage according to the degree of the emergency and determination of suspected stroke as a immediate (priority 1-RED) emergency, and 2) Routing of the victim to the nearest team of relevant doctors.

In order to conduct a screening of the stroke victim by the dispatcher and the EMS crew as fast as possible, the following methods are used: The Cincinnati Prehospital Stroke Scale (CPSS) (Table 1); FAST criteria (Figures: 1 and 2) [12], and the Los Angeles Pre-hospital Stroke Screen (LAPSS) (Tables: 2 and 3).

The CPSS works as a rough neurological evaluation of the patient for the duration of the "94" emergency call. The Duty Doctor guides the caller in checking: 1) Facial distortion, 2) Raising and control of the arms, and 3) Speech.

The LAPSS establishes whether the victim is aged 45 or less, is without epileptic attacks, has had symptoms lasting less than 24 hours, is without earlier strokes, has glycaemia 60-400 mg/dl (2,8-22,2 mmol/l), and clear asymmetry in some of the following categories: facial expression, grip and arm strength. LAPPSS

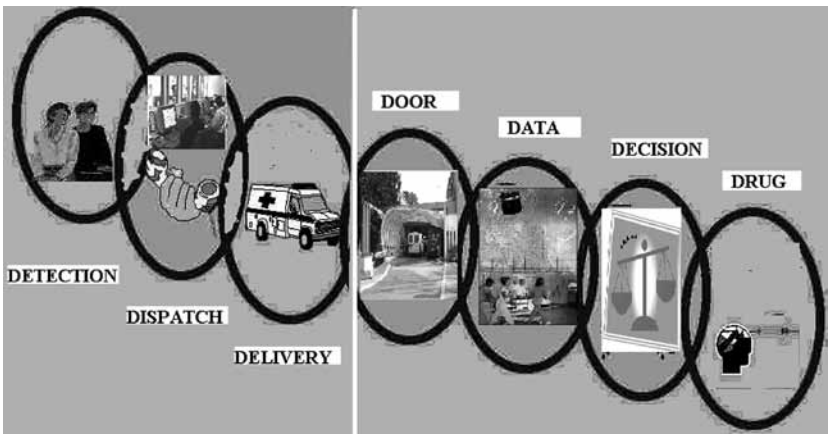


Figure 1. Stroke chain of survival
Legend: F -facial droop; A - arm drift; S - speech difficulty; T - time to call 911

Table 2. Los Angeles Prehospital Stroke Screen (LAPSS)

Screening Criteria		Finding		Point
age		> 45		1
		<= 45		0
		unknown		1
prior history of seizure disorder		yes		1
		no		0
		unknown		1
new onset of neurologic symptoms		< 24 h		1
		>= 24 h		0
		unknown		1
patient was ambulatory at baseline (prior to event)		yes		0
		no		1
		unknown		1
blood glucose		> 400 mg/dL (22,2 mmol/l)		0
		60-400 mg/dL (2,8-22,2 mmol/l		1
		< 60 mg/dL (2,8 mmol/l)		0
unilateral asymmetry	no	right	left	
facial smile/grimace		□ droop	□ droop	
hand grip		□ weak grip □ no grip	□ weak grip □ no grip	
arm weakness		□ drifts down □ falls rapidly	□ drifts down □ falls rapidly	

Interpretation: Positive answers to all 6 questions above - contact hospital en-route

is specified at 97% and sensitivity at 93%.

Practical use of these scales, as well as quick screening of victims, relies on pre-hospital education of all personnel involved [13,14]. In most countries, the continuous education of emergency medical technicians etc, is regulated by professional bodies issuing certifications for completed training. Education of doctors consists of the promotion of new knowledge in the area of stroke, with issuance of guidelines for treatment of stroke patients. For example, in Belgrade, a voluntary two week educational programme for EMS personnel has been initiated. In Serbia as a whole, neurologists can be seen on TV and in printed media offering advice and information. Furthermore, a work group within the Ministry of Health issued national guidelines for professional medical personnel in 2004.

Figure 2. FAST poster (http://www.cdc.gov/Pcd/issues/2008)

➢ *Delivery*

Early pre-hospital medical evaluation and adequate patient treatment requires establishment of early clinical and differential diagnosis of stroke, and rendering of vital support to the patient according to ABC principles, up to the moment of their admittance to hospital [15,16]. Pre-hospital treatment consists of: location of the patient in a safe, secure area; evaluation of vital functions; immobilisation of the C spine, if indicated; checking the openness of vein lines; ECG record (12 outflows); a rough neurological evaluation; determination of glycaemia levels in the blood and, if possible, administration of glucose in cases of low glucose levels. Should the patient be unconscious or experiencing an epileptic episode, they should be laid on their left side for transport. Another crucial part of the pre-hospital phase is record keeping, particularly of the medicaments applied.

The position of the patient in the course of their transportation should be determined based on the immobile parts of their body. Transportation is also considered one of the main reasons for lateness in treatment of stroke victims. Although the aim of rapid transportation is to arrive at the SU [17,18] within 60 minutes from onset of stroke in urban environments, and within 180 minutes in rural environments, there is a certain delay – even in the United States – of 115 minutes average. There are two reasons for this: victims would often rather call their personal physician than an ambulance, and when they do, EMS crews tend to classify transport of stroke victims as lower priority. As discussed though, there is a clear need for prioritisation of stroke victims, as well as AMI and trauma cases, as immediate (priority 1-RED) emergency, and this entails a change in the attitude of EMS crews.

Table 3. Belgrade prehospital screening for fibrinolytic stroke therapy

CRITERIA
1. Patients at the age between 45-65
2. Established lack of trauma
3. The patient conscious (GCS>8)
4. The patient has never experienced strokes before
5. Glycaemia 60-400 mg/dl (2,8-22,2 mmol/l)
6. The patient withou convulsions
7. Onset symptoms interval <3 hours
8. Clear lateralization (in accordance with Cincinnati scale)

To minimise the delay in pre-hospital transportation, small helicopters are often used in developing countries. Such helicopters are equipped with all necessary devices for urgent intervention, treatment and transportation of patients. In addition to small air ambulances, telemedicine is also seeing increasing usage. Telemedicine utilises modern IT and telecoms technology to provide medical care for individuals in remote locations in several distinct ways, two of which are Interactive (directly via telephone or videoconference etc), and Store-and-Forward (exchange of data, pictures, videos etc between patients and doctors, typically over the Internet).

On the way to the hospital, the EMS doctor should complete a thrombolytic checklist, which includes documentation of personal information. Belgrade medical facilities have been using such pre-hospital screening information since 2006, and it is primarily intended for identification of eventual fibrinolytic candidates (Table 3). Since the treatment window is shortened (3 hours), early detection of eventual fibrinolytic candidates by EMS crews may well be crucial in establishing the treatment of these patients.

➢ *Door*

It is at this point that the pre-hospital and hospital doctors meet, and each now has their specific duties

to carry out. The pre-hospital doctor should submit a copy of the patient's pre-hospital documentation to the hospital's main desk. This crucial part of the patient paper trail contains information vital to further hospital treatment. Time intervals that need to be recorded are:

1. Zero – Onset of symptoms,
2. Exact time of the emergency call,
3. Time until the nearest EMS crew took control of the call,
4. The time the EMS crew started,
5. The time of the EMS crew's arrival,
6. The time taken for initial patient examination and preparation for transport,
7. The time transport began,
8. Time taken for transport,
9. Time elapsed between the original emergency call and arrival at permanent medial facilities.

At this point, the level of urgency manifests itself as the "golden hour", or time window in which the patient has the highest likelihood of survival after prompt treatment. In the "chain of survival", this is the "door" phase, wherein the patient's journey through diagnosis and treatment at the hospital can be described according to the interval between each step of the process. According to NIH guidelines:

- "Door" to the Emergency dept. and initial check -up: < 10 minutes,
- "Door" to the neurologist: < 15 minutes,
- "Door" to the CT Scanner: < 25 minutes,
- "Door" to interpretation of CT scan results: < 45 minutes,
- "Door" to administration of medicaments < 60 minutes (80% agreed upon),
- "Door" to full admittance to the hospital < 3 hours.

➢ *Data*

Upon arrival at the ED in the first place, the main objective is evaluation of the patient in less than 10 minutes, including, for example, a SAMPLE history, ABC evaluation and re-evaluation of vital signs. Oxygen administration is recommended at an early stage in hypoxemic patients, and in establishing glycaemia (to be treated as hyperglycemia), coagulation status and other laboratory analyses. With cardiac monitoring, a 12-channel EKG is not a priority in relation to CT brain, but myocardial infarction or cardiac arrhythmia can then be detected as causes of embolic stroke [19].

Neurological examination is a must. The most useful scale for evaluation of a patient's consciousness on admittance is the GCS, whereas for evaluation of neurological deficiencies, the American NIHSS (National Institutes of Health Stroke Scale) is easily applied, is valid and reliable in the evaluation of vascular lesions' location, and may also help in patient categorisation – e.g. as candidates for thrombolytic therapy as well as those who will presumably develop haemorrhagic complications from thrombolytic therapy.

It is desirable for CT scans to be conducted within 25 minutes of the patient's admittance to the SU, with definition of results within 45 minutes of their initial admittance. If the scan results exclude haemorrhagia, the patient is a likely candidate for fibrinolysis [20].

➢ *Decision*

The SU doctor should reconsider excluding as well including criteria for i.v. fibrinolytic administration. In cases of the patient's neurological status spontaneously improving (if their neurological functions make a rapid return towards normal, for instance), then fibrinolytics' administration is not recommended [21].

➢ *Drugs*

Should the patient be a candidate for fibrinolytic therapy, the doctor should inform both the patient and their family of the risks and benefits of the therapy for the patient. In the case of both sides agreeing on commencement of fibrinolytic therapy (this should take the form of a signed agreement), the patient is to be given tPA and the algorithm for stroke immediately initiated [22,23]. Some studies (LOE 1) document the probability of good to excellent functional outcome when tPA is applied in the course of the 3 hours of onset symptoms.

The approach to *hypertension* in patients with stroke is controversial. Still, hypertension therapy plays a crucial therapeutic role. The aim of antihypertensive therapy within the initial 48 to 72 hours of onset is to achieve values slightly higher than the ABP level prior to insult incidence (lower than 185/110 mmHg).

Hyperglycemia therapy is also crucial in stroke patients, despite having been proven to have a negative outcome, and the level of glycemia should necessarily be within 100-150 mg/dL (5.5-8 mmol/l).

Respiratory function. The increase of pO_2 through oxygen administration is used to compensate for the ensuing disturbance to the respiratory function.

Indications for endotracheal intubation and artificial ventilation refer to patients who are in coma; pO_2 <50-60 mmHg; vital capacity <500-800 ml; tachypnea >30; indications of respiratory distress; dyspnoea; usage of subsidiary respiratory musculature; risk of aspiration.

Increase of intracranial pressure (ICP) can be decreased by controlled hyperventilation within 2 to 30 minutes. Use of 20% Mannitol – a hyperosmolar agent – via the osmotic gradient between the vascular space and the brain tissue, leads to the outflow of interstitial fluid and at lower levels, decreases liquid production and blood viscosity, resulting in improved microcirculation. At the same time, there is the possibility of bleeding, and so it is important to be careful in the course of administration in hemorrhagic diseases. Urgent detection and treatment of all associated diseases, together with their complications, is a must.

Despite publication of a number of works on the reducing the time taken from the initial emergency call to first treatment, the current system of education, transportation, triage, diagnostics and neurological consultation and final medical intervention is unfortunately still too slow to enable treatment within the therapeutic window.

Within a hospital's emergency department alone, there are four major weak links in the "chain of recovery" as described above: 1) Door, 2) Data, 3) Decision, and 4) Drug, although efforts are now being made to improve these. The American NINDS (National Institute of Neurological Disorders and Stroke), at a symposium on rapid identification and treatment of stroke, suggested that cumbersome logistics management was behind two of the biggest delays; ideal interval between arrival at the emergency dept. or SU to CT scanning (25 minutes), and the interval between arrival and treatment onset (60 minutes).

Conclusion

The generally accepted consensus on the urgency of stroke treatment is that "every minute counts". Shortening the therapeutic vacuum at all stages of the "chain of survival" is *qondito sine qua non*, is a precondition for successful therapeutic treatment, and is the main preoccupation of those dealing with the treatment and rehabilitation of stroke victims.

Unfortunately though, it is thought that the current system of education, transportation, triage, diagnostics and neurological consultation and final medical intervention is still too slow to enable treatment within the therapeutic window, and that it is crucial that the links in the "chain of survival" be tightened up. Attitudes need to change, beginning with ambulance crews and emergency dispatchers, and priority categories given to transport of stroke victims should be changed from minor (priority 3 – GREEN) or delayed (priority 2 – YELLOW), to immediate (priority 1 – RED). This change should then be accepted by neurological teams and reflected in their own attitude.

In the pre-hospital phase, increased education of both the general public and medical personnel is required for stroke symptoms to be recognisable much sooner. Within EMS crews' remit, it is important to shorten the time between initial evaluation and treatment onset through rapid triage and, in the first place, assignment of the call to the nearest possible vehicle. Ideally, more road lanes would be made available for exclusive use of ambulances, and municipal authorities would build more EMS substations.

At the hospital facility level, centralised Stroke Units staffed by dedicated stroke teams would be created, governed by detailed protocols containing clear guidelines and specifying the duties of each member of the team along with good practise measures for intra- and inter-hospital cooperation.

Eventually, it should also be emphasised that thrombolytic therapy can help not only with thrombus removal, but also with removal of the prevailing negative attitude.

Finally, by introducing telemedicine methods and where-ever possible, air ambulance services, the difference in the time until initial treatment would be decreased in both rural and urban environments.

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