



Corridor of Comprehensive Knowledge

## FROM EMERGENCY CALL TO HOSPITAL ARRIVAL



[cck@theccck.com](mailto:cck@theccck.com)

[www.theccck.com](http://www.theccck.com)

# From Emergency Call to Hospital Arrival

## 1) Background

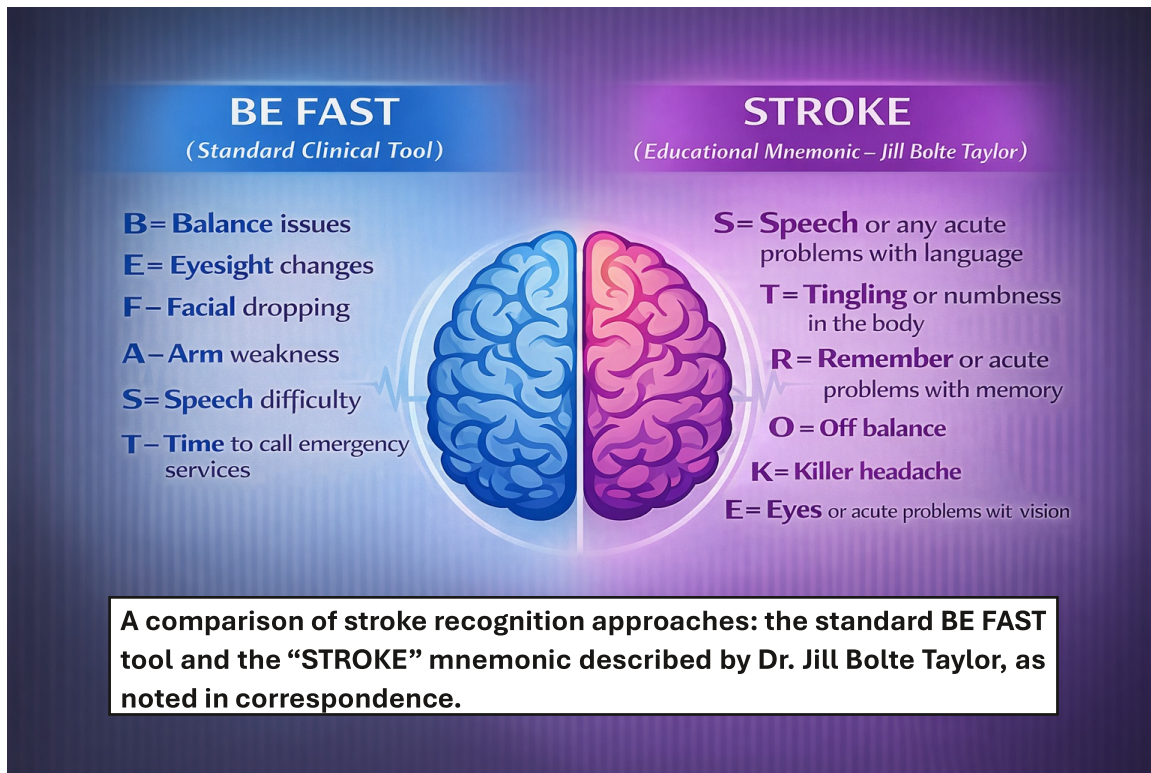
Clinical studies show that in stroke, every minute of delay in starting treatment is associated with the loss of a significant volume of neural tissue and a reduced chance of recovery. In practice, even reducing transport time to the hospital by tens of seconds contributes to this time saving and, together with other factors, can influence the final outcome of treatment. For this reason, emergency medical teams in many countries plan and train to reduce every minute – and even every second – in getting stroke patients to hospital.

## 2) Problem statement

At 14:05, an emergency call reports that a person has suddenly developed severe weakness in the right side of the face and arm, along with speech disturbance.

The ambulance team departs from the base for the patient's home at 14:06:00. The motion of the ambulance is described as follows: starting from rest, it accelerates with constant acceleration  $a_1$  until it reaches the constant speed  $v$ . Near the patient's home, it decelerates with constant acceleration  $a_2$  until it comes to rest next to the house (the same pattern holds for the trip from the home to the hospital). The on-scene time required to load the patient is  $t_{\text{scene}}$ , after which the ambulance departs for the hospital.  $D_1$  is the distance from the base to the home, and  $D_2$  is the distance from the home to the hospital.





Consider the following data for this problem:

$$a_1 = 1.5 \text{ m/s}^2, a_2 = -2.0 \text{ m/s}^2, v = 80 \text{ km/h}, t_{\text{scence}} = 4 \text{ min}, D_1 = 3.6 \text{ km}, D_2 = 8 \text{ km}$$

- At what clock time does the ambulance arrive at the hospital?
- Suppose that on the way from the patient's home to the hospital, when the ambulance is at a distance  $D_3 = 3.3 \text{ km}$  from the hospital, a car moving ahead with speed  $u = 20 \text{ km/h}$  does not respond to the warnings to move aside. The ambulance reduces its speed with constant acceleration  $a_2$  until its speed reaches  $u$ . When it reaches a distance  $D_4 = 3 \text{ km}$  from the hospital, the car finally pulls over completely and clears the way. At this point, the ambulance accelerates with constant acceleration  $a_1$  until it reaches the constant speed  $v$ , and near the hospital it again decelerates with constant acceleration  $-a_2$  and comes to rest next to the hospital. In this case, at what clock time does the ambulance arrive at the hospital?
- Sketch the speed–time and distance–time graphs for the entire motion of the ambulance in both cases (a) and (b).
- (Qualitative explanation) In a short paragraph (2–3 sentences), explain why reducing the time to hospital for a patient with stroke (even by as little as 30 seconds) is clinically very important.

### 3) Solutions

The given speeds in m/s and distances in m are:

$$v = 80/3.6 \approx 22.2\text{m/s}, u = 20/3.6 \approx 5.6\text{m/s}, D_1 = 3600\text{m},$$

$$D_2 = 8000\text{m}, D_3 = 3300\text{m}, D_4 = 3000\text{m}, d = 200\text{m}$$

- a)** Let  $t_1$  be the time it takes for the ambulance to accelerate from rest (when leaving the base) with acceleration  $a_1$  to the speed  $v$ . Then:

$$t_1 = v/a_1 = 22.2/1.5 = 14.8\text{s}$$

The distance covered in this time is:

$$d_1 = 0.5a_1t_1^2 = 0.5 \times 1.5 \times 14.8^2 \approx 164\text{m}$$

Let  $t_2$  be the time it takes to decelerate from speed  $v$  to rest (when reaching the home) with acceleration  $a_2$ . Then:

$$t_2 = (0 - v)/a_2 = (0 - 22.2)/-2 = 11.1\text{s}$$

The distance covered in this time is:

$$d_2 = vt_2 + 0.5a_2t_2^2 = 22.2 \times 11.1 - 0.5 \times 2 \times 11.1^2 \approx 216\text{m}$$

The distance  $d_3 = D_1 - d_1 - d_2$  is traveled at the constant speed  $v$  in the middle part of the motion from the base to the home:

$$d_3 = D_1 - d_1 - d_2 = 3600 - 164 - 216 = 3220\text{m}$$

The corresponding time  $t_3$  for this distance is:

$$t_3 = d_3/v = 3220/22.5 \approx 145\text{s}$$



Therefore, the total time  $T_1$  it takes the ambulance to reach the patient's home is:

$$T_1 = t_1 + t_2 + t_3 = 14.8 + 11.1 + 145 = 170.9\text{s}$$

The same times  $t_1$  and  $t_2$ , and the corresponding distances  $d_1$  and  $d_2$ , also apply to the start and end of the trip from the patient's home to the hospital. Thus, the distance  $d_4 = D_2 - d_1 - d_2$  which is traveled at constant speed  $v$  in the middle part of the motion from the home to the hospital, is:

$$d_4 = D_2 - d_1 - d_2 = 8000 - 164 - 216 = 7620\text{m}$$

The corresponding time  $t_4$  for this distance is:

$$t_4 = d_4/v = 7620/22.2 \approx 343\text{s}$$

Hence, the total time  $T_2$  it takes the ambulance to go from the patient's home to the hospital is:

$$T_2 = t_1 + t_2 + t_4 = 14.8 + 11.1 + 343 = 368.9\text{s}$$

Taking into account the time from receiving the call at the base (14:05), the one-minute delay before departure (the ambulance leaves at 14:06), the travel time  $T_1$  to reach the home, the on-scene time to load the patient ( $t_{\text{scene}} = 4 \text{ min} = 240 \text{ s}$ ), and the travel time  $T_2$  from the home to the hospital, the total elapsed time is:

$$T = 60 + t_{\text{scene}} + T_1 + T_2 = 60 + 240 + 170.9 + 368.9 = 839.8\text{s} \approx 14\text{min}$$

Therefore, the ambulance arrives at the hospital at approximately 14:19.





- b) Let  $t_5$  be the time it takes for the ambulance to slow down from speed  $v$  (when it is at distance  $D_3$  from the hospital) with acceleration  $a_2$  until its speed reaches  $u$ . Then:

$$t_5 = \frac{u - v}{a_2} = \frac{5.6 - 22.2}{-2} = 8.3s$$

The distance covered in this time is:

$$d_5 = vt_5 + 0.5a_2t_5^2 = 22.2 \times 8.3 - 0.5 \times 2 \times 8.3^2 \approx 115m$$

Therefore, the distance  $d_6 = D_3 - D_4 - d_5 = 185m$  is traveled at the constant speed  $u$ . The corresponding time  $t_6$  for this distance is

$$t_6 = \frac{d_6}{u} = \frac{185}{5.6} \approx 33s$$

Let  $t_7$  be the time it takes to accelerate again from speed  $u$  to speed  $v$  with acceleration  $a_1$ . Then:

$$t_7 = \frac{v - u}{a_1} = \frac{22.2 - 5.6}{1.5} \approx 11.1s$$

The distance covered in this time is:

$$d_7 = ut_7 + 0.5a_1t_7^2 = 5.6 \times 11.1 + 0.5 \times 1.5 \times 11.1^2 \approx 155m$$

Hence, the total distance over which the ambulance is forced to slow down and then speed up again because of the obstacle is:

$$D = D_3 - D_4 + d_7 = 300 + 155 = 455m$$

The time spent over this distance is:

$$T_V = t_5 + t_6 + t_7 = 8.3 + 33 + 11.1 = 52.4s$$

If there were no obstacle, the time  $T_r$  needed for the ambulance to travel the same distance  $D = 455m$  at speed  $v$  would be:

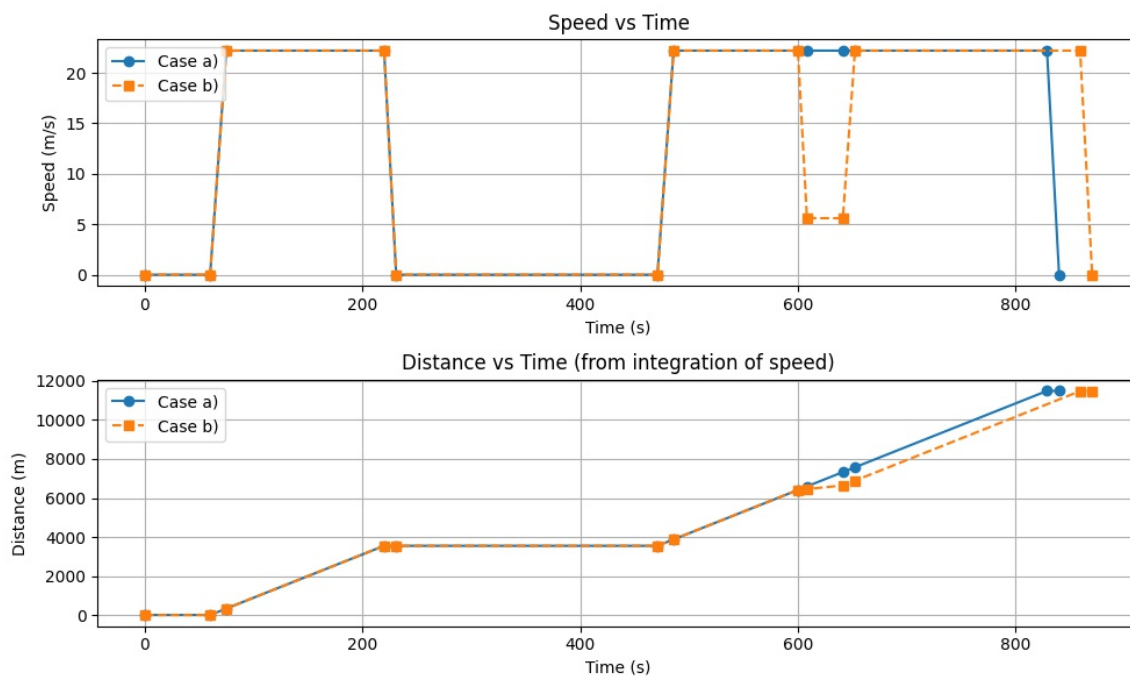
$$T_r = \frac{D}{v} = \frac{455}{22.2} \approx 22s$$

Thus the obstacle adds a delay of  $T_V - T_r = 52.4 - 22 = 30.4s$  in reaching the hospital.

c)

**Table 1. Ambulance speed at key time points (time in seconds) from base departure**

| Case a) |       | Case b) |       |
|---------|-------|---------|-------|
| Time    | Speed | Time    | Speed |
| 0       | 0     | 0       | 0     |
| 60      | 0     | 60      | 0     |
| 74.8    | 22.2  | 74.8    | 22.2  |
| 219.8   | 22.2  | 219.8   | 22.2  |
| 230.9   | 0     | 230.9   | 0     |
| 470.9   | 0     | 470.9   | 0     |
| 485.7   | 22.2  | 485.7   | 22.2  |
| 828.7   | 22.2  | 599.9   | 22.2  |
| 839.8   | 0     | 608.2   | 5.6   |
|         |       | 641.2   | 5.6   |
|         |       | 652.3   | 22.2  |
|         |       | 859.1   | 22.2  |
|         |       | 870.2   | 0     |



**d)** As explained in section 1, every minute of delay causes neuronal death and worse functional outcomes. Even 30 seconds faster arrival can improve prognosis and neurological recovery.

The Corridor of Comprehensive Knowledge (CCK) is a not-for-profit educational organization that develops problems, activities, and learning materials connecting mathematics, science, technology, art, and other fields within shared contexts.

Its work includes interdisciplinary workshops, thematic learning scenarios, original educational resources, and the interdisciplinary educational journal *The CCK Clerestory*, all designed to make connections visible, deepen conceptual understanding, and foster curiosity and critical thinking.

[cck@theccck.com](mailto:cck@theccck.com)

[www.theccck.com](http://www.theccck.com)