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RESEARCH

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Tanta stroke chain performance during era of COVID-19 pandemic: how to minimize the real/expectation gap

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Abstract

Background During the coronavirus disease of 2019 (COVID-19) pandemic, it would be so difficult to keep the balance between time-saving best stroke care and medical staff safety which obliges healthcare decision-makers to think extraordinarily. The objectives of this study were to evaluate the performance of the Tanta stroke chain (TSC) during the period of the study as well as to identify areas of strength and disparities of the system while dealing with the COVID-19 pandemic measures. The study was conducted on 492 acute ischemic stroke (AIS) patients who were divided into COVID-19 suspected (115 patients) and COVID-19 non-suspected (377 patients). The former group was further COVID-19 confirmed and COVID-19 negative patients. The latter group was subdivided according to the timing of the patient's arrival at the hospital in the morning, evening, and night shifts group while the fourth group constitute those reached during shifting hours. Patients received early stroke management regarding the 2018 AHA/ASA guideline and its 2019 update.

Results Suspected COVID-19 patients represented 23.37% of studied patients. Onset to needle time was significantly prolonged in suspected COVID-19 patients with little chance of utilizing IV thrombolysis (IVT) and consecutive higher morbidity and mortality rates. For COVID-19 non-suspected patients group, a higher rate of IVT utilization was noticed in those reached during the morning shift with a lower chance of utilization in those reached during the shifting hours.

Conclusion COVID-19 measures had an inverse effect on TSC logistics which needed upgrading of the service to better cope with the pandemic and to improve AIS patients' functional outcomes.

Keywords Acute ischemic stroke, COVID-19 pandemic, Tanta stroke chain, Stroke chain of survival

Introduction

Stroke is an apt description of the disease as it occurs "at a stroke", the insult is immediate, and the effects may be prolonged with physical, emotional, social, and financial consequences not only for those affected but also for their family and friends [1]. Treatment decisions in acute stroke settings are made after carefully considering clinical information and assessing available imaging which must be fast, reliable, and available around the clock. Stroke is the most prevalent acquired neurological disorder affecting the adult population worldwide with an incidence of 17 million new stroke cases every year [2].

The stroke system of care (SSC) describes an integrated approach to coordinate and promote timely based delivery of the full range of services associated with stroke prevention, treatment, and rehabilitation within a defined community. Effective SSC is associated with lower stroke-related morbidities and mortalities while

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ineffective SSC may be one of the most important modifiable factors associated with worse stroke outcomes and therefore an important area of focus [1].

The AHA/ASA Guidelines, as well as the WHO, put recommendations for the development of a regional SSC which should consist of healthcare facilities that provide measures of prevention and increase stroke awareness, initial emergency care, including administration of IV alteplase, and centers capable of performing endovascular stroke treatment with comprehensive per procedural care to which rapid transport can be arranged when appropriate [3].

Despite the unprecedented speed of vaccine development against the prevention of coronavirus disease of 2019 (COVID-19) and robust global mass vaccination efforts, the emergence of these new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variants threatens to overturn the significant progress made so far in limiting the spread of this viral illness, COVID-19 was the third leading cause of death in the U.S. in 2020 after heart disease and cancer [4, 5].

The World Stroke Organization documented that, the COVID-19 outbreak and its related severe adult respiratory distress syndrome as well as the COVID-19 phobia had highly deleterious effects on stroke services [6].

The COVID-19 pandemic had created unprecedented challenges to our global and national healthcare systems, by shifting the paradigm for many clinical stroke management strategies including its major effect in a decline of services and hospitalizations for COVID-19 suspected stroke patients and this phenomenon was explained by stay-at-home orders, social distancing, and fear of contracting SARS-CoV-2 in health care settings, delays in symptom recognition, particularly in the elderly who are isolated in quarantine [7].

At the same time, it caused an increase in pre-hospital and in-hospital delays through the donning and doffing of personal protective equipment and decontamination of critical healthcare resources like imaging scanners [8] it also affected TSC logistics in the form of marked delay in onset to door time and door-to-needle time which prolonged to 45–75 min (Fig. 1) [9]. All these effects caused regression in AIS patients' outcomes in the COVID-19 era decreased healthcare access or utilization may lead to more disabling or fatal strokes or more severe non-neurological complications related to stroke [10].

The work aimed to evaluate the performance of the Tanta stroke chain (TSC) during the period of the study as well as to identify areas of strength and disparities of the system while dealing with the COVID-19 pandemic measures.

Methods

This work was an observational cohort longitudinal study conducted on 492 AIS patients documented by clinical presentation, cranial non-contrast computed tomography (NCCT), and/or brain magnetic resonance imaging (MRI) attending the neurology emergency room at the Department of Neuropsychiatry and Center of Neurology and Psychiatry, Tanta University between 1st of February 2021 to end of August 2021.

Informed written consent was obtained from each patient, his first-degree relative, or patient guardian. The study was performed after approval by the Ethics Committee and Quality Assurance Unit, Faculty of Medicine, Tanta University Hospitals (approval code 34437/2/21).

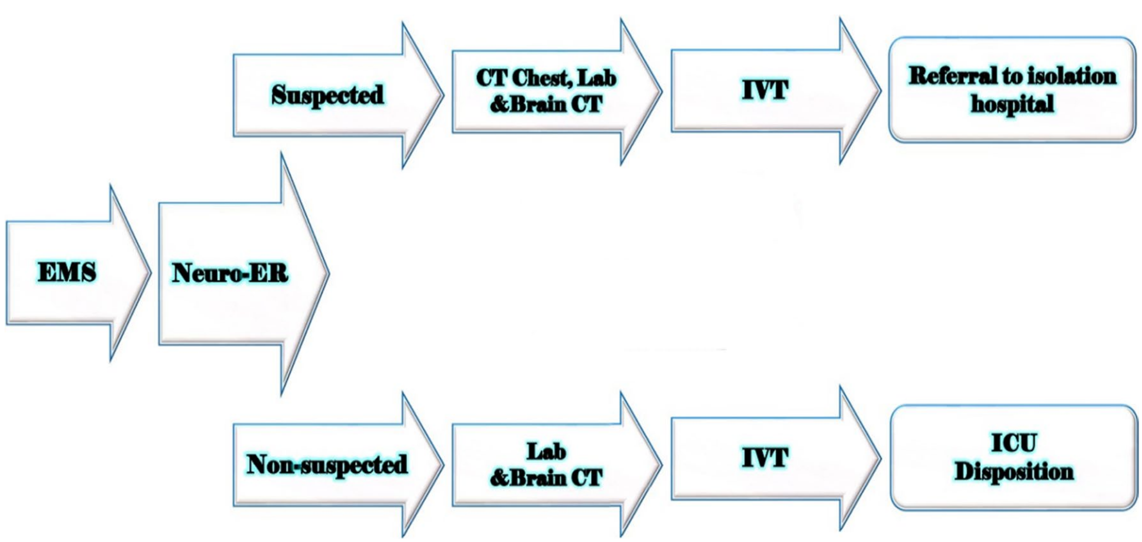

Fig. 1 The post-COVID-19 pathway for acute ischemic stroke patients

Exclusion criteria encompassed patients with AIS presentation below the age of 18 years as well as patients with cerebral sinus thrombosis.

Tanta stroke chain is a stroke system of care that was launched in Tanta University Hospitals in January 2020 for fast-track recognition and care of early acute stroke patients. It adopted the AHA/ASA guidelines for the early management of patients with AIS, 2018 as well as its 2019 update. Hence, the pre-hospital delay of AIS patients was defined when the OAT of the patient was > 4 h and the in-hospital delay was defined when the DNT of the patients was > 30 min [3, 11]. The in-hospital pathway was modified at the beginning of the COVID era to face the pandemic and reduce exposure to infection (Fig. 1). Secondary stroke prevention was performed regarding the AHA/ASA guidelines, 2021 for secondary stroke prevention [12, 13]

Studied patients were subjected to medical history taking, clinical examination, and stroke severity assessment using the National Institutes of Health Stroke Scale (NIHSS) [14, 15], laboratory investigation included the routine lab, hypercoagulable state biomarkers such as (protein C, S, factor V Leiden, anti-thrombin III) and markers of autoimmune disorders like (ESR, antinuclear antibody, anti-double strand DNA, antiphospholipid antibody, lupus erythematous cell test, anticardiolipin Ab, rheumatoid factor Ab).

Cardiac imaging and evaluation were also done through routine and long-term electrocardiography monitoring, and echocardiography (transthoracic echo, transesophageal echo was performed for patients with a high probability of cardiogenic stroke who had a normal transthoracic echo) and cervical and cerebral vessel imaging included cerebral/cervical magnetic resonance angiography and magnetic resonance venography, CT angiography, cervical and transcranial Doppler.

The studied patients were also subjected to brain imaging including NCCT scan, MRI and CT angiography, and chest imaging included chest NCCT with CORADS (COVID-19 Reporting and Data System) which was used to assess pulmonary involvement of coronavirus disease 2019 in suspected patients based on the features seen at unenhanced chest CT [16].

Patients' strokes were classified regarding stroke etiology into six categories according to the TOAST classification; large artery atherosclerosis, cardioembolic, small-artery occlusion (lacunar infarction), acute strokes of other determined etiology, strokes of undetermined etiology and cryptogenic strokes [17].

The studied patients were divided into a suspected patients group (n: 115) patients and a non-suspected COVID-19 patients group (n: 377). The non-suspected COVID-19 patients are subdivided into four main sub-groups according to the timing of the patient's arrival at the hospital in the four medical staff shifts into Group 1 which included 170 patients who attended the hospital at the morning shift, Group 2 which included 96 patients who attended the hospital at the evening shift and Group 3 which consisted of 81 patients who attended the hospital at the night shift and group 4 which consisted of 30 patients who attended the hospital at shifting times which are the half an hour between every 2 medical staff shifts (before and after the time of every shift).

After discharge, studied patients were followed up regularly for 3 months post-discharge by both phone communication as well as personal visits to the stroke clinic at The Center of Neurology and Psychiatry, Tanta University, at the end of the follow-up period, post-stroke functional outcome was performed using the modified Barthel index scale (MBI) [18, 19]

The pre-stroke basal activity of daily living of AIS patients was measured by the ADDL scale. The AADLs are a questionnaire that measures the subjects' ADLs through an assessment of their regular engagement in social, emotional, or physical activities in the past 6 months. The scale is composed of 13 items and the subject puts a circle around points 1–3 for each item (spans from 13 to 39 points) where 1 point means the activity has never been done, 2 points mean the individual has stopped doing the activity and 3 points mean that the subject is still doing the activity [20, 21].

Fifty-two patients dropped out during the follow-up period due to various causes, 36 patients were confirmed COVID-19 patients due to bad contact with them after being isolated in isolation hospitals while we lost contact with other 16 patients who were followed up in private hospitals and clinics.

Statistical presentation and analysis of the present study were conducted by SPSS V20, using the mean, and standard deviation for quantitative variables, unpaired Student's T-test was used to compare two groups in quantitative data. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test, linear correlation coefficient was used for the detection of correlation between two quantitative variables in one group, and analysis of variance [ANOVA] tests were used for comparison at different times in the same group in quantitative data. P value < 0.05 was considered significant.

Results

This study revealed that 155 (31.5%) of the studied patients received intravenous thrombolysis and 3 patients only received mechanical thrombectomy.

In this study, there was significant positive correlation was found between the advanced activity daily living

(AADL) scale and the 3 months outcomes of all studied patients measured by the MBI scale ($R=0.909$ $P<0.001$), while there was a significantly negative correlation was found between patients' outcomes by MBI and stroke severity measured by NIHSS ($r=-0.835$, $P<0.001$), the onset arrival time of all studied patients ($r=-0.225$, $P<0.001$) and door-to-needle time ($r=-0.476$, $P<0.001$) (Fig. 2).

This study showed no significant difference was found between suspected and non-suspected COVID-19 patients regarding age, receiving IVT, and stroke severity assessed by NIHSS (Table 1).

Regarding the etiology of stroke, the large atherothrombotic and cryptogenic stroke had significant differences with suspected COVID-19 patients while the

Table 1 Demographic data and comparison between suspected COVID-19 and non-suspected COVID-19 patients regarding age, receiving intravenous thrombolysis, the severity of stroke by NIHSS

	Suspected COVID-19 (n:115)	**Non-suspected COVID-19 (n:377)**	***P*-value**
Age	65.052 ± 14.297	65.621 ± 13.034	0.69
IVT	34 (29.57%)	121 (32.1%)	0.609
NIHSS	14.08 ± 7.92	12.55 ± 8.53	0.086

Data are presented as mean ± SD or frequency (%)

IVT intravenous thrombolysis, *NIHSS* National Institutes of Health Stroke Scale

*Significant as *P* value ≤ 0.05

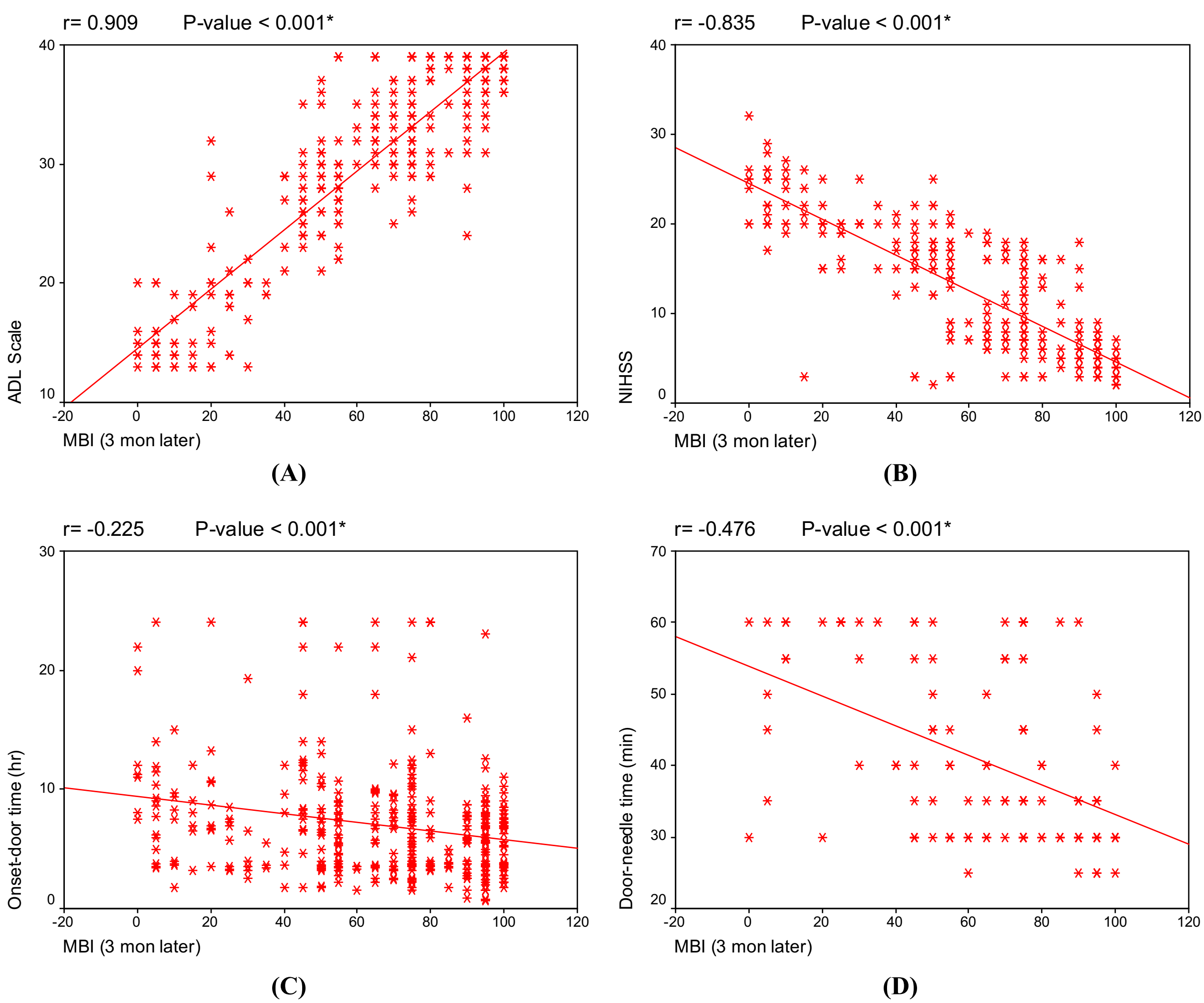

Fig. 2 Correlation between the studied patients' outcomes after the 3-month follow-up by MBI and **A** ADDL, **B** stroke severity by NIHSS, **C** OAT, and **D** DNT. *MBI* modified Barthel Index, *ADDL Scale* Advanced Activity Daily Living Scale, *NIHSS* National Institute of Health Stroke Scale, *OAT* onset arrival time, *DNT* door-to-needle time

cardioembolic and lacunar stroke had significant differences between non-suspected COVID-19 patients by *p*-value < 0.001 (Table 2).

Regarding OAT (onset arrival time) and DNT (door-to-needle time), it was significantly prolonged between suspected COVID-19 patients. Hence, the suspected patients had significantly worse outcomes after 3 months measured by the modified Barthel index with a *p*-value of 0.003, 0.004, and 0.004, respectively (Table 3).

There was found a significant difference between patients who came during the night shift and the most severe stroke (the largest NIHSS) and between the least severe stroke and patients who came to the hospital in the morning shift by *p*-value < 0.001. Also, there was significantly prolonged OAT and DNT of the patients who came during the night and shifting hours by *p*-value < 0.001. Hence, the patients who came during the morning shift had significantly better outcomes measured by MBI while the worst patients' outcomes were between the patients who came during the night shift by *p*-value < 0.001 (Table 4).

Cases vignette

A female patient aged 49 y hypertensive, diabetic, HCV + ve, history of DVT twice 3 years ago, non-suspected, Rt handed, married with 2 offspring, presented with acute Lt side weakness, speech disturbance, NIHSS was 10. On examination patient was conscious and oriented, Lt sided weakness grade 3, dysarthria, CT brain was done to show no new abnormality, and CT angiography was done show occlusion of the distal part of the internal carotid artery, and MT was done. In follow-up, the patient was discovered to have factor V Leiden deficiency. 3 months later follow-up by the modified Barthel index was 80 (Fig. 3).

Table 2 Comparison between suspected COVID-19 and non-suspected COVID-19 patients regarding TOAST classification

TOAST	Suspected COVID-19 (n:115)	Non-suspected COVID-19 (n:377)	*P*-value
Large artery	77 (66.96%)	239 (63.40%)	< 0.001*
Lacunar	14 (12.17%)	91 (24.14%)	< 0.001*
Cardioembolic	1 (0.87%)	33 (8.75%)	< 0.001*
Other determined cause	0 (0%)	7 (1.86%)	0.307
Undetermined cause	2 (1.74%)	7 (1.86%)	0.096
Cryptogenic	21 (18.26%)	0 (0%)	< 0.001*

Data are presented as mean ± SD or frequency (%)

TOAST Trial of Org 10,172 in Acute Stroke Treatment classification

*Significant as *P* value ≤ 0.05

Table 3 Comparison between suspected COVID-19 and non-suspected COVID-19 patients regarding onset arrival time, door-to-needle time and their outcomes at the 3-month follow-up

	Suspected COVID-19 (n:115)	Non-suspected COVID-19 (n:377)	*P*-value
OAT (h)	8.42 ± 6.76	6.88 ± 4.11	0.003*
DNT (min)	46.91 ± 12.12	40.21 ± 11.52	0.004*
MBI	56.47 ± 27.56	67.99 ± 28.73	0.004*
Dropped out	36 (36.7%)	16 (4.7%)	–
Dead	17 (14.8%)	39 (10.3%)	0.190

Data are presented as mean ± SD or frequency (%)

OAT onset to arrival time, *DNT* inter-hospital time, *MBI* modified Barthel Index

*Significant as *P* value ≤ 0.05

Male patient aged 29 y, no past medical history, non-suspected, Rt handed, married with one offering, presented with Lt side weakness and speech disturbance. NIHSS was 12. By examination the patient was conscious and oriented, Lt sided weakness grade 3, dysarthria, upper motor neuron facial palsy, BP 130/80' RBS was 95, CT brain was done showed no new neurological insult and CT angiography showed proximal MCA occlusion, the patient received IVT and mechanical thrombectomy was done, the patient came to the hospital at morning shift. In follow-up, the transesophageal echo patient was discovered to have patent foramen oval. MBI after 3 months was 90 (Fig. 4).

Discussion

In this study, 31.50% of included patients utilized received IVT while only 3 patients (< 1%) received MT. The higher incidence of IVT is most probably due to a higher rate of missing registered patients who did not

Table 4 Comparison between four sub-groups of non-suspected COVID-19 patients regarding stroke severity by NIHSS, onset arrival time, door-to-needle time and the patients' outcomes measured by MBI

	Morning (n:170)	Evening (n:96)	Night (n:81)	Shifting time (n:30)	*P*-value
NIHSS	7.73 ± 5.3	13.34 ± 6.92	20.42 ± 8.65	16 ± 9.6	< 0.001*
OAT (h)	5.53 ± 2.76	6.65 ± 2.99	7.80 ± 4.53	12.76 ± 6.29	< 0.001*
DNT (min)	31.47 ± 4.11	40.95 ± 7.52	51.25 ± 8.75	57 ± 3.68	< 0.001*
MBI	85.6 ± 15.4	57.9 ± 19.5	35.8 ± 34	60.2 ± 25.2	< 0.001*

Data are presented as mean ± SD or frequency (%)

NIHSS National Institutes of Health Stroke Scale, *OAT* onset to arrival time, *DNT* inter-hospital time, MBI modified Barthel Index

*Significant as *P* value ≤ 0.05

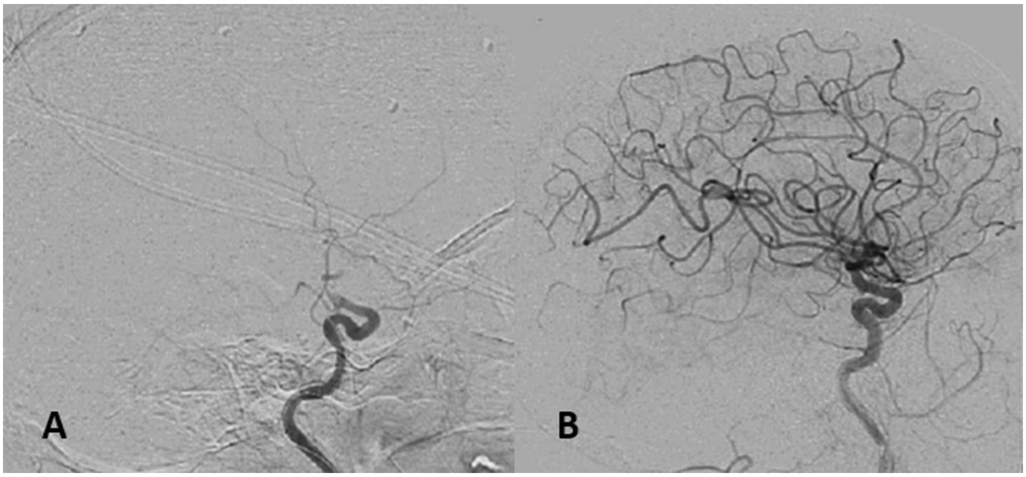

Fig. 3 Shows **A** pre-mechanical thrombectomy cerebral angiography showing occlusion of distal ICA and **B** post-thrombectomy angiography showing recanalization of distal ICA

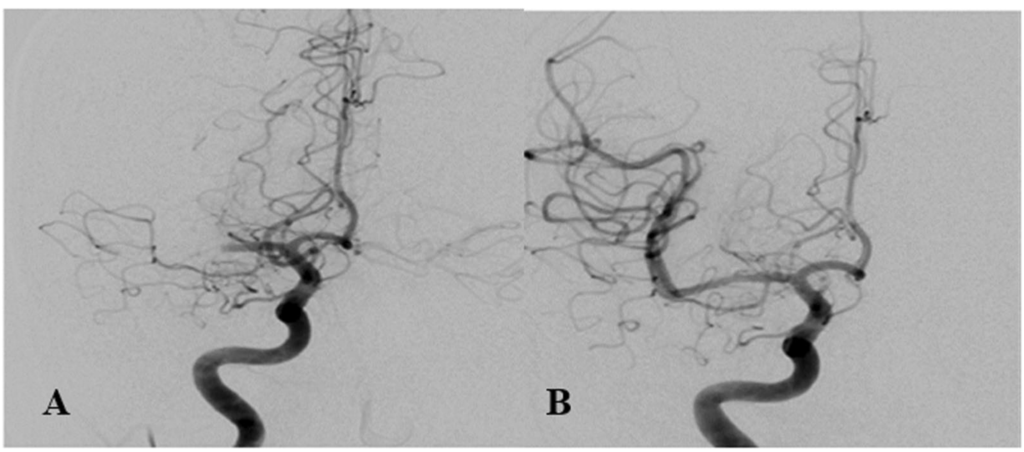

Fig. 4 Shows **a** pre-mechanical thrombectomy cerebral angiography showing occlusion of the proximal part of MCA and **b** post-mechanical thrombectomy angiography showing recanalization of MCA

receive r-tPa and who were either treated outpatient or transferred to other private hospitals at patients' request. On the other hand, this lower rate of utilization of MT was due to the transformation of Tanta Neurology and Psychiatry Center into an isolation hospital with consecutive closure of the interventional unit. These results were supported by the work of Naccarato and colleagues [22] who reported IVT in 30% of their studied population while only 2% underwent MT.

This study showed a significant positive correlation between the pre-stroke ADLs measured by the AADL scale and functional outcomes qualified by MBI at 3 months post-stroke visit. This result is following the work of Hartigan and colleagues [23] who revealed that higher post-stroke morbidity and mortality were not only associated with insufficient stroke services provided to AIS patients but also decreased pre-stroke ADL.

This work identified a non-significant difference in the rate of IVT utilization between suspected and non-suspected COVID-19 stroke patients as COVID-19 infection per se is not a contraindication of IVT. This result is consistent with previous reports from Naccarato and colleagues [22], Fuentes and colleagues [24], and Rinkel and colleagues [25]. On the other hand, Akhtar and colleagues [26], and Mathew and colleagues [27] showed a lower rate of utilization of IVT in COVID-19-positive patients. These discrepancies are related to different study designs as they perform COVID-19-related investigations before IVT injection which may result in the prolongation of DNT and consecutive bypassing of the time window.

The results of this study revealed that the NIHSS of studied patients was 12.9 ± 8.4 which was higher in the COVID-19 suspected patients but with no significant difference between them and non-suspected COVID-19 patients, possibly due to the higher incidence of a large vessel and cardiogenic stroke among these patients. These results are following the work of Koge and colleagues [28] as well as that of Wang and colleagues [29] who reported a higher NIHSS during the COVID-19 era with a consecutive significant increase in the probability of a poor functional outcome.

In this study, there was a significant increase in the incidence of atherosclerotic and cryptogenic strokes in COVID-19 suspected compared to non-suspected COVID-19 patients which are most probably due to atheromatous instability and ulceration induced by increased inflammation during COVID-19 infection as well as hypercoagulable state associating infection. These results are in harmony with the work of Mathew and colleagues [27] who identified a higher incidence of AIS due to large artery atherosclerosis in COVID-19-positive patients. This is contrary to the work of Elshereye and colleagues [30] who identified multiple lacunar infarcts in their case report of a COVID-19-positive stroke patient.

This work showed a higher incidence of cryptogenic stroke in COVID-19 suspected patients which point to the rule of COVID-19 infection triggering cerebrovascular complications. These results are following the studies of Douiri and colleagues [31] as well as Quiles and colleagues [32] who reported a history of a previous stroke in up to 80% of their included patients and concluded that COVID-19 infection is an important cause of stroke possibly through increasing the inflammatory markers and inducing a hypercoagulable state.

This study revealed that there was significant prolongation of both OAT and DNT for suspected COVID-19 patients due to fear of infection from the ER staff as well as the performance of NCCT in a distant CT machine dedicated for high-risk infection cases lacking stroke priority performance of the investigation. This result is in the same line as the work of Teo and colleagues [33] who showed the median stroke DNT was ≥ 1 h for COVID-19 suspected patients compared to COVID-19 non-suspected cases for whom DNT was < 40 min. On the other hand, Chmiela and colleagues [34] found a delay in the OAT in their studied patients but the DNT was not affected by the COVID-19 precaution measures in the Central Clinical Hospital of the Medical University of Silesia in Katowice, Poland. This discrepancy in results is most probably related to the good training of the ER personnel for the use of PPE as well as the use of protected stroke codes.

In this study, there was a significant probability of worse outcomes as measured by MBI and mortality rate at 3 months follow-up visits in suspected COVID-19 patients with stroke compared to non-suspected COVID-19 ones which is in harmony with the work of Mathew and colleagues [27] as well as Naccarato and colleagues [22] who showed worse functional outcome and degree of dependence in COVID-19 positive patients due to higher NIHSS at stroke onset compared to COVID-19 negative patients. On the other hand, the results of the present study are not in harmony with that of Rinkel and colleagues [25] who revealed a non-significant difference in stroke outcomes between COVID-19-positive and negative patients. These discrepancies in results are possibly due to the higher percentage of COVID-19-positive patients in their studied sample relative to our studied cohorts.

The results of the present study showed that the most prevalent in-hospital cause of delay among the studied patients was delayed imaging due to transportation of the patient to another hospital for NCCT acquisition due to the restriction of the nearby CT machine to do CT chest for suspected COVID-19 patients. This is followed by protective measures for infection control precautions against COVID-19 infection and lastly poor communication between hospital teams due to their duties at long distances from one another.

These results agreed with that of Fuentes and colleagues [24] who reported a significant in-hospital delay in patients who had undergone imaging during the COVID-19 era. At the same time, the work of Aref and colleagues [35] concluded that fear of COVID-19 and delay because of lockdown issues were two novel causes, representing 12% and 8.7% respectively among the important causes of delayed transfer of stroke patients to the hospital in Egypt.

Regarding non-suspected COVID-19 cases, in this study, the patients who arrived during the night shift had higher NIHSS compared to evening and morning shifts with a consecutive lower likelihood of a good functional outcome. These results are in agreement with the work of Ryu and colleagues [36] who reported that nightly arrived strokes were associated with the older age of the patients and higher presenting neurologic severity compared to daytime arrived strokes with consecutive worse short-term functional outcomes. At the same time, the work of Ding and colleagues [37] identified poorer quality of stroke services during the off-hours times of the day as reflected by increased pre-hospital and in-hospital delays.

The results of the present study showed marked prolongation of the OAT in patients who arrived during the night shift mostly due to waiting for spontaneous recovery as well as difficult private transportation due to long distance from the center and non-confidence of EMS response. In a related context, Darehed and colleagues [38] reported a marked reduction in DNT during the morning shifts while the in-hospital delay increased during the evening and night shifts due to lower performance and synchrony of the ER, radio diagnosis, and lab personnel.

At the same time, these results were in line with the study of the Swedish Stroke Registry by Darehed and colleagues [38] which noted that patients admitted at night time had a lower 90-day survival than those in the daytime and that finding is justified by the inefficient quality of stroke services during the evening hours with consecutive DNT prolongation and decreased likelihood of recanalization therapies.

The present work revealed a significant shortening of OAT and DNT with consecutively increased rates of IVT utilization and a greater likelihood of MT for patients who arrived during the morning shift. These results agreed with the work of Shokri and colleagues [39] who identified a higher number of patients who received IVT in the first 2 quarters of the day due to shorter onset to needle time. On the other hand, these results are disagreed by Jauss and colleagues [40] who found a slightly higher proportion of IVT utilization during the night shifts (17% of AIS patients) compared to the daytime shifts (16% of patients) mostly due to more difficult EMS transportation during the daytime by the crowded traffic during the rush hours.

In this study, the most significant cause of pre-hospital delay among the patients who came during the morning shift was fear of contracting COVID-19 infection, while the most significant cause of in-hospital delay among patients who came to the hospital during shifting hours was a delay during imaging.

Also, the current study found a decreased quality of the service with marked prolongation of DNT for the patients who arrived during the shifting hours due to some data loss between the on-duty and off-duty teams due to the absence of duties time overlap. At the same time, the whole team whether medical or paramedical shifts at the same time which may result in a gap time of suboptimal services. This observation is consistent with the results of many studies including Campbell and colleagues [41]; Lorenzano and colleagues [42] and Fang and colleagues [43] who demonstrated an in-hospital delay of treatment attributable to shifting hours. On the other hand, Jauss and colleagues [40] and Shokri and colleagues [39] reported no difference in the DNT between shifting time and duty hours or during morning working hours or during night shifts which might reflect a consistent in-hospital performance throughout the day. This could be explained by the availability of services in addition to a qualified well-trained ER team with more easiness of data transfer during the in-duty shifts.

The results of this work detected a significant increase in private transport of patients during the morning hours while governmental EMS transport was higher during the evening and night shifts, yet there was a non-significant difference in the time delay between both modes of transportation. These results were consistent with Aref and colleagues [35] who reported higher use of private cars for transportation to the hospital that largely outnumbered the use of ambulance service and usually resulted in earlier arrival. At the same time, Abdullah and colleagues [44] clarified that the excessive use of private transportation for stroke patients is an indicator of an inefficient ambulance system with untrained EMS personnel. The lack of pre-hospital notification by the EMS personnel may result in some prolongation of DNT with a decreased likelihood of IVT utilization.

Conclusion

In Egypt, stroke chains are still under construction and face many challenges making them unready to face another big obstacle like the COVID-19 pandemic and its related infection control precautions. Decrease the rate of hospitalization of stroke and recording the rate of AIS patients' presentation to hospital as well as delayed presentation due to keeping in-home strategy and fear of contracting COVID-19 infection. New adaptation measures in stroke system of care (SSC) to overcome the negative effect of this pandemic. TSC logistics are also affected by these negative effects. The rate of reperfusion therapy in TSC does not differ between suspected and non-suspected COVID-19 patients. Stroke services provided in TSC and its logistics are affected during the shifting hours which may be overcome by the 24-h resident shifts that could reduce the information transmission leak as well as the frequent gaps between shifts.

Adjustment and modification of the in-hospital stroke pathway should be done in every stroke center regarding its facilities and logistics for better coping with the COVID-19 pandemic. Tanta stroke chain needs updating of its crisis resource management to make a balance between fast-track recognition and management of AIS patients as well as appropriate protection of the stroke team staff through:

One of the proposed modifications includes designing multiple completely isolated pathways with an isolated injection room at the end of each after the provision of the stroke team with adequate PPE. This stroke chain will keep inaccessible contact COVID-19 suspected and non-suspected COVID-19 patients during the ER services including initial assessment, NCCT acquisition, and lab investigation while IVT is undertaken in multiple separate injection rooms. Confirming the diagnosis of COVID-19 by CT chest, lab workup including PCR is postponed till the end of IVT where COVID-19 confirmed patients are referred to isolation hospitals (Fig. 5).

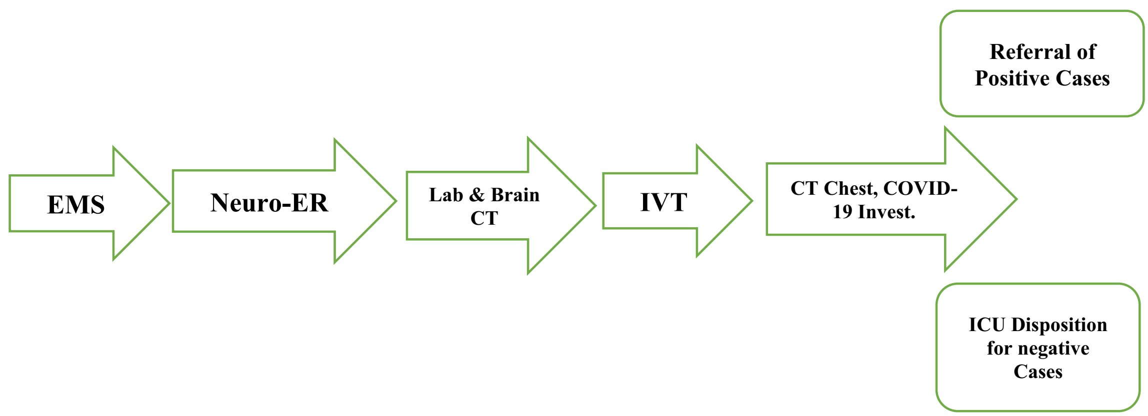

Fig. 5 Tanta stroke chain modified pathway for acute ischemic stroke patients in the COVID-19 pandemic

Limitations

The impact of COVID management protocols including steroid and anticoagulation therapies on stroke prognosis and outcome was not assessed precisely due to patients transfer to COVID isolation hospitals and loss of contact with them except cell-phone follow-up to quantify their disabilities.

Abbreviations

COVID-19	Coronavirus disease of 2019
TSC	Tanta stroke chain
AIS	Acute ischemic stroke
IVT	IV thrombolysis
SSC	Stroke system of care
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
NCCT	Non-contrast computed tomography
MRI	Magnetic resonance imaging
NIHSS	National Institutes of Health Stroke Scale
TOAST	Trial of Org 10,172 in Acute Stroke Treatment
MBI	Modified Barthel Index
AADL	Advanced Activity Daily Living Scale
OAT	Onset arrival time
DNT	Door-to-needle time
DVT	Deep vein thrombosis

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Author contributions

NTK: participated in the study's design, patients' selection, statistical analysis, data analysis, references collection, manuscript writing, HMA: participated in the study's idea, design, patients' selection, neurological examination, statistical analysis, data analysis, references collection, manuscript writing, revision, and final approval, WSB: participated in study's design, patients' assessment, manuscript revision, and final approval, EAE: participated in study's idea and design, patients' assessment and inclusion, data analysis, statistical analysis, manuscript writing, revision and final approval. All authors state that they have read and approved the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The manuscript was approved from The Research Ethics Committee and Quality Assurance Unit, Faculty of Medicine, Tanta University. The URL: http://tqac.tanta.edu.eg/new-tqac/; QualityAssuranceUnit@hotmail.com. Approval Code: 34437/2/21. Name of the PI: Nada Talaat Kasem. The study's protocol had been permitted by The Research Ethics Committee and Quality Assurance Unit, Faculty of Medicine, Tanta University. Participations were voluntary, informed written consents were approved by all participants and any possible risks were clarified.

Consent for publication

Not applicable.

Competing interests

All authors disclose that they have no competing interests related to the study.

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References

1. Adeoye O, Nyström KV, Yavagal DR, Luciano J, Nogueira RG, Zorowitz RD, et al. Recommendations for the establishment of stroke systems of care: a 2019 update. Stroke. 2019;50:e187–210.
2. Chugh C. Acute ischemic stroke: management approach. Indian J Crit Care Med. 2019;23:S140–6.
3. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2019;50:e344–418.
4. Acter T, Uddin N, Das J, Akhter A, Choudhury TR, Kim S. Evolution of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) as coronavirus disease 2019 (COVID-19) pandemic: a global health emergency. Sci Total Environ. 2020;730: 138996.
5. He N. Rapid evolution of the COVID-19 pandemic calls for a unified public health response. Biosci Trends. 2021;15:196-200.6.

6. Cascella M, Rajnik M, Aleem A, Dulebohn S, Di Napoli R. Features, Evaluation, and Treatment of Coronavirus (COVID-19). Treasure Island (FL): Statpearls; 2022.
7. Tong X, King S, Asaithambi G, Odom E, Yang Q, Yin X, et al. COVID-19 pandemic and quality of care and outcomes of acute stroke hospitalizations: the Paul Coverdell National Acute Stroke Program. Prevent Chronic Dis. 2021. https://doi.org/10.5888/pcd18.210130.
8. Srivastava PK, Zhang S, Xian Y, Xu H, Rutan C, Alger HM, et al. Treatment and outcomes of patients with ischemic stroke during COVID-19: an analysis from get with the guidelines-stroke. Stroke. 2021;52:3225–32.
9. Bahnasy WS, Ragab OAA, Elhassanien ME. Stroke onset to needle delay: where these golden hours are lost? An Egyptian center experience. e NeurologicalSci. 2019;14:68–71.
10. Sharma M, Lioutas VA, Madsen T, Clark J, O'Sullivan J, Elkind MSV, et al. Decline in stroke alerts and hospitalisations during the COVID-19 pandemic. Stroke Vasc Neurol. 2020;5:403–5.
11. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. 2018 Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2018;49:e46–110.
12. Kleindorfer DO, Towfighi A, Chaturvedi S, Cockroft KM, Gutierrez J, Lombardi-Hill D, et al. 2021 Guideline for the prevention of stroke in patients with stroke and transient ischemic attack: a guideline from the American Heart Association/American Stroke Association. Stroke. 2021;52(7):e364–467.
13. Adams RJ, Albers G, Alberts MJ, Benavente O, Furie K, Goldstein LB, et al. Update to the AHA/ASA recommendations for the prevention of stroke in patients with stroke and transient ischemic attack. Stroke. 2008;39(5):1647–52.
14. Lyden P, Brott T, Tilley B, Welch KM, Mascha EJ, Levine S, et al. Improved reliability of the NIH Stroke Scale using video training NINDS TPA Stroke Study Group. Stroke. 1994;25(11):2220–6.
15. Yu J, Park S, Lee H, Pyo CS, Lee YS. An elderly health monitoring system using machine learning and In-depth analysis techniques on the NIH stroke scale. Mathematics. 2020;8(7):11–5.
16. Prokop M, Van Everdingen W, Van Rees Vellinga T, Quarles van Ufford H, Stöger L, Beenen L, et al. COVID-19 standardized reporting working group of the Dutch Radiological Society CO-RADS: a categorical CT assessment scheme for patients Suspected of having COVID-19—definition and evaluation. Radiology. 2020;296(2):e97–104.
17. Adams HP, Jr, Bendixen BH, Kappelle LJ, Biller J, Love BB, Gordon DL, et al. Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. Stroke. 1993; 24:35–41.
18. Sinoff G, Ore L. The Barthel Activities of Daily Living Index: self-reporting versus actual performance in the old-old (≥ 75 years). J Am Geriatr Soc. 1997;45(7):832–6.
19. Lee SY, Kim DY, Sohn MK, Lee J, Lee SG, Shin Y-I, et al. Determining the cut-off score for the Modified Barthel Index and the Modified Rankin Scale for assessment of functional independence and residual disability after stroke. PLoS ONE. 2020;15(1): e0226324:1–11.
20. Cornelis E, Gorus E, Van Schelvergem N, De Vriendt P. The relationship between basic, instrumental, and advanced activities of daily living and executive functioning in geriatric patients with neurocognitive disorders. Int J Geriatr Psychiatry. 2019;34(6):889–99.
21. Dias EN, Silva JV, Pais-Ribeiro JL, Martins T. Validation of the advanced activities of daily living scale. Geriatr Nurs. 2019;40:7–12.
22. Naccarato M, Scali I, Olivo S, Ajčević M, Buoite Stella A, Furlanis G, et al. Has COVID-19 played an unexpected "stroke" on the chain of survival? J Neurol Sci. 2020;414: 116889.
23. Hartigan I. A comparative review of the Katz ADL and the Barthel Index in assessing the activities of daily living of older people. Int J Older People Nurs. 2007;2(3):204–12.
24. Fuentes B, Alonso de Leciñana M, García-Madrona S, Díaz-Otero F, Aguirre C, Calleja P, et al. Stroke acute management and outcomes during the COVID-19 outbreak: a cohort study from the Madrid Stroke Network. Stroke. 2021;52:552–62.
25. Rinkel LA, Prick JCM, Slot RER, Sombroek NMA, Burggraaff J, Groot AE, et al. Impact of the COVID-19 outbreak on acute stroke care. J Neurol. 2021;268:403–8.
26. Akhtar N, Abid FB, Kamran S, Singh R, Imam Y, AlJerdi S, et al. Characteristics and comparison of 32 COVID-19 and non-COVID-19 ischemic strokes and historical stroke patients. J Stroke Cerebrovasc Dis. 2021;30: 105435.
27. Mathew T, John SK, Sarma G, Nadig R, Kumar RS, Murgod U, et al. COVID-19-related strokes are associated with increased mortality and morbidity: a multicenter comparative study from Bengaluru, South India. Int J Stroke. 2021;16:429–36.
28. Koge J, Shiozawa M, Toyoda K. Acute stroke care in the with-COVID-19 era: experience at a comprehensive stroke center in Japan. Front Neurol. 2020;11: 611504.
29. Wang J, Chaudhry SA, Tahsili-Fahadan P, Altaweel LR, Bashir S, Bahiru Z, et al. The impact of COVID-19 on acute ischemic stroke admissions: analysis from a community-based tertiary care center. J Stroke Cerebrovasc Dis. 2020;29: 105344.
30. Elshereye A, Erdinc B. Multiple lacunar cerebral infarcts as the initial presentation of COVID-19. Cureus. 2020;12: e9638.
31. Douiri A, Muruet W, Bhalla A, James M, Paley L, Stanley K, et al. Stroke care in the United Kingdom during the COVID-19 pandemic. Stroke. 2021;52:2125–33.
32. Quiles LEP, Diamante PAB, Pascual JLV. Impact of the COVID-19 pandemic in the acute stroke admissions and outcomes in a Philippine Tertiary Hospital. Cerebrovasc Dis Extra. 2022;12:76–84.
33. Teo KC, Leung WCY, Wong YK, Liu RKC, Chan AHY, Choi OMY, et al. Delays in stroke onset to hospital arrival time during COVID-19. Stroke. 2020;51:2228–31.
34. Chmiela T, Rzepka M, Kuca M, Serwońska K, Laskowski M, Koperczak A, et al. Intravenous thrombolysis for acute ischemic stroke during the COVID-19 Pandemic-Polish Single-Center retrospective cohort study. Life (Basel). 2022; 12.
35. Aref HM, Shokri H, Roushdy TM, Fathalla F, El Nahas NM. Pre-hospital causes for delayed arrival in acute ischemic stroke before and during the COVID-19 pandemic: a study at two stroke centers in Egypt. PLoS ONE. 2021;16: e0254228.
36. Ryu WS, Hong KS, Jeong SW, Park JE, Kim BJ, Kim JT, et al. Association of ischemic stroke onset time with presenting severity, acute progression, and long-term outcome: a cohort study. PLoS Med. 2022;19: e1003910.
37. Ding J, Bai Z, Zhou D, Li X, Rajah GB, Ding Y, et al. Circadian rhythms may not influence the outcomes of thrombolysis in patients with ischemic stroke: a study from China. Chronobiol Int. 2018;35:1533–42.
38. Darehed D, Blom M, Glader EL, Niklasson J, Norrving B, Bray BD, et al. Diurnal variations in the quality of stroke care in Sweden. Acta Neurol Scand. 2019;140:123–30.
39. Shokri HM, El Nahas NM, Aref HM, Dawood NL, Abushady EM, Abd Eldayem EH, et al. Factors related to the time of stroke onset versus time of hospital arrival: a SITS registry-based study in an Egyptian stroke center. PLoS ONE. 2020;15: e0238305.
40. Jauss M, Schütz HJ, Tanislav C, Misselwitz B, Rosenow F. Effect of daytime, weekday and year of admission on outcome in acute ischaemic stroke patients treated with thrombolytic therapy. Eur J Neurol. 2010;17:555–61.
41. Campbell JT, Bray BD, Hoffman AM, Kavanagh SJ, Rudd AG, Tyrrell PJ. The effect of out-of-hour presentation with acute stroke on processes of care and outcomes: analysis of data from the Stroke Improvement National Audit Programme (SINAP). PLoS ONE. 2014;9: e87946.
42. Lorenzano S, Ahmed N, Tatlisumak T, Gomis M, Dávalos A, Mikulik R, et al. Within-day and weekly variations of thrombolysis in acute ischemic stroke: results from the safe implementation of treatments in stroke-international stroke thrombolysis register. Stroke. 2014;45:176–84.
43. Fang K, Churilov L, Weir L, Dong Q, Davis S, Yan B. Thrombolysis for acute ischemic stroke: do patients treated out of hours have a worse outcome? J Stroke Cerebrovasc Dis. 2014;23:427–32.
44. Abdullah AR, Smith EE, Biddinger PD, Kalenderian D, Schwamm LH. Advance hospital notification by EMS in acute stroke is associated with shorter door-to-computed tomography time and increased likelihood of administration of tissue-plasminogen activator. Prehosp Emerg Care. 2008;12:426–31.

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