Impact of a novel pre-hospital stroke notification programme on acute stroke care key performance indicators in Hong Kong: a multicentre prospective cohort study with historical controls

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ABSTRACT

Introduction: Early identification and initiation of reperfusion therapy is essential for suspected acute ischaemic stroke. A pre-hospital stroke notification (PSN) protocol using FASE (facial drooping, arm weakness, speech difficulties, and eye palsy) was implemented to improve key performance indicators (KPIs) in acute stroke care delivery. We assessed KPIs and clinical outcomes before and after PSN implementation in Hong Kong.

Methods: This prospective cohort study with historical controls was conducted in the Accident and Emergency Departments of four public hospitals in Hong Kong. Patients were screened using the PSN protocol between August 2021 and February 2022. Suspected stroke patients between August 2020 and February 2021 were included as historical controls. Door-to-needle (DTN) and door-to–computed tomography (DTC) times before and after PSN implementation were compared. Clinical outcomes including National Institutes of Health Stroke Scale score at 24 hours and modified Rankin Scale score at 3 months after intravenous recombinant tissue-type plasminogen activator (IV-rtPA) were also assessed.

Results: Among the 715 patients (266 PSN and 449 non-PSN) included, 50.8% of PSN patients and 37.7% of non-PSN patients had a DTC time within 25 minutes (P<0.001). For the 58 PSN and 134 non-PSN patients given IV-rtPA, median DTN times were 67 and 75.5 minutes, respectively (P=0.007). The percentage of patients with a DTN time within 60 minutes was higher in the PSN group than in the non-PSN group (37.9% vs 21.6%; P=0.019). No statistically significant differences in clinical outcomes were observed.

Conclusion: Although the PSN protocol shortened DTC and DTN times, clinical outcomes did not significantly differ.

Hong Kong Med J 2024;30:94–101
https://doi.org/10.12809/hkmj2210413

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This article was published on 5 Apr 2024 at www.hkmj.org.

New knowledge added by this study

- This study validates findings from a previous study that pre-hospital stroke notification (PSN) improves key performance indicators among stroke patients in Hong Kong.
- It is unclear whether PSN improves overall clinical outcomes among stroke patients.

Implications for clinical practice or policy

- Further research is warranted to assess whether PSN improves patient outcomes and other acute care parameters.
- Considering the resource-intensive nature of PSN, its cost-effectiveness requires additional investigation.

Introduction

In Hong Kong, approximately 3000 stroke-related deaths occur annually; stroke is among the top three reasons for hospital admission.[1] Strokes lead to prolonged hospital stays, and affected patients are likely to require long-term residential care.[2] Early accurate identification of acute ischaemic stroke and initiation of reperfusion therapy have been associated with significant improvements in functional outcomes and a lower likelihood of hospital mortality.[3,4] Therefore, efforts to shorten any steps within the stroke onset-to-treatment cascade can enhance outcomes for these patients.

The 2019 update to the American Stroke Association (ASA) 2018 guidelines for the management of acute ischaemic stroke recommends early stroke recognition and notification during initial medical contact using validated screening tools in suspected stroke patients.[5] Pre-hospital notification to the receiving hospital allows early resource mobilisation prior to arrival of the suspected stroke patient, ensuring timely management. In Hong Kong, a recent study demonstrated improvements in several major benchmarks for acute stroke care.[6] In August 2021, a pre-hospital stroke notification (PSN) protocol using the FASE protocol (facial drooping, arm weakness, speech difficulties, and eye palsy) was implemented across the Kowloon West Cluster, the largest service cluster in Hong Kong, which serves nearly 2 million residents.[7] The inclusion of eye palsy in FASE aims to detect often-missed cases of posterior stroke[8,9] and aid the identification of large vessel occlusion (LVO).[10] In this study, we aimed to assess key performance indicators (KPIs) and clinical outcomes before and after the implementation of PSN.

新的院前中風通報安排對香港急性中風護理的關鍵病情指標的影響：附歷史對照的多中心前瞻性隊列研究

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引言：及早識別並展開再灌注治療對於懷疑急性缺血性中風來説屬必要。我們基於FASE評估法（臉部下垂、手臂無力、言語困難和眼睛麻痺）實施新的院前中風通報安排（PSN），以改善急性中風護理的關鍵病情指標。本研究評估香港採用相關安排前後的關鍵病情指標及臨床結果。

方法：這項前瞻性隊列研究附有歷史對照，在本港四間醫院的急症室進行。2021年8月至2022年2月期間的患者接受篩選，2020年8月至2021年2月期間疑似中風患者則被用作歷史對照。我們比較了採用PSN安排前後的到院至藥物注射（DTN）時間及到院至完成腦部電腦斷層掃描（DTC）時間，並評估了兩項臨床結果，包括24小時後的美國國家衛生院腦中風量表（NIHSS）評分及進行靜脈注射重組組織胞漿素原活化劑（IV-rtPA）3個月後的雷氏修正量表評分。

結果：本研究共包括715名患者（266名PSN組患者及449名非PSN組患者），結果顯示50.8%的PSN組患者及37.7%的非PNS組患者的DTC時間為25分鐘內（P<0.001）。接受IV-rtPA的58名PSN組患者及134名非PNS組患者，其DTN時間中位數分別為67及75.5分鐘（P=0.007）。DTN時間少於60分鐘的PSN組患者比例較非PNS組患者高（37.9%與21.6%；P=0.019）。臨床結果沒有統計學上的顯著差異。

結論：雖然PSN安排縮短了DTC及DTN時間，但臨床結果沒有顯著差異。

Methods

Study design

This multicentre prospective cohort study with historical controls involved four Accident and Emergency Departments (AEDs) in the Kowloon West Cluster, namely, Princess Margaret Hospital, North Lantau Hospital, Caritas Medical Centre and Yan Chai Hospital, and their respective neurology divisions. Prior to implementation of the PSN FASE protocol, there was no established emergency medical services (EMS) ambulance protocol for pre-hospital notification of suspected stroke patients. The non-PSN FAST protocol (facial drooping, arm weakness, speech difficulty, and time) was used at the AED to screen suspected stroke patients. In this study, all suspected stroke patients between August 2021 and February 2022 were screened using the PSN FASE protocol and included in the PSN group; similar patients between August 2020 and February 2021 served as historical controls in the non-PSN group. Data were collected from each hospital's neurology division and clinical data system; accuracy was confirmed by two independent authors. Suspected LVO was defined as the presence of clinical signs and symptoms compatible with internal carotid artery, middle cerebral artery, or basilar artery infarcts, along with radiological evidence from computed tomography (CT) brain scans, as reviewed by a neurologist. Confirmed LVO was defined as the presence of LVO on computed tomography angiography (CTA).

Patients

The PSN FASE protocol was implemented during initial contact by EMS personnel during ambulance transfer. This protocol specifies that the patient must be aged ≥18 years and exhibits acute stroke symptoms of facial weakness, unilateral arm and/or leg weakness, speech disturbance, or eye palsy within 4 hours. Protocol exclusion criteria included symptoms with suspected trauma aetiology, Glasgow Coma Scale score ≤8, systolic blood pressure <100 mm Hg, previous medical history of seizure/epilepsy, or long-term chairbound or bedbound

status. If a patient meets inclusion criteria with no exclusion criteria, EMS personnel activate the PSN protocol by informing the closest AED to prepare for the incoming stroke patient. In the present study, patients transported with this protocol constituted suspected stroke patients in the PSN group.

In contrast, the non-PSN FAST protocol is activated by a physician in the AED. This protocol requires the patient to display acute stroke symptoms of facial asymmetry, limb weakness, or speech disturbance, while meeting all of the following criteria: (1) age ≥18 years; (2) onset of stroke symptoms within 3.5 hours before the request for intravenous recombinant tissue-type plasminogen activator (IV-rtPA) administration; (3) signs and symptoms compatible with acute stroke; and (4) reasonable premorbid functional status (at least not bedbound). Protocol exclusion criteria included active internal bleeding, recent severe head trauma or intracranial/spinal surgery within the preceding 3 months, clinical presentation suggestive of subarachnoid haemorrhage or aortic dissection, acute stroke symptoms in the context of infective endocarditis, intra-axial intracranial neoplasm, coagulopathy (platelet count $<100 \times 10^9$/L or international normalised ratio >1.7), or ongoing use of anticoagulant medication.

FASE protocol of pre-hospital stroke notification

In the PSN FASE protocol, EMS personnel are trained to screen potentially IV-rtPA–eligible stroke patients and to notify the receiving AED about patients with thrombolytic eligibility. An AED physician and a nursing team are prepared for immediate assessment upon patient arrival; an experienced on-duty stroke nurse is notified prior to arrival. The AED physician immediately determines whether the patient should be considered for thrombolytic therapy. If the thrombolytic therapy criteria are met, the patient undergoes a plain CT brain scan and assessment by an on-call neurologist for intravenous thrombolytic therapy. If IV-rtPA treatment is approved by the on-call neurologist, IV-rtPA is administered to the patient; this administration was similar for both historical and prospective groups.

Outcomes measurement

The primary outcome in this study was door-to-needle (DTN) time, which the ASA recommends to be within 60 minutes. The secondary outcomes were onset-to-door (OTD) and door-to-CT (DTC) times. The recommended DTC time is within 25 minutes, but no specific recommendation exists for OTD time.[11] The National Institutes of Health Stroke Scale (NIHSS) score at 24 hours post-rtPA and modified Rankin Scale (mRS) score at 3 months post-rtPA were also recorded. A good clinical outcome was defined as a reduction of ≥4 in NIHSS score at 24 hours post-rtPA or an mRS score of 0 to 1 at 3 months post-rtPA.

Statistical analysis

Baseline characteristics, KPIs, and clinical outcomes were presented as count (%), mean ± standard deviation, or median (interquartile range). The Pearson Chi squared test, Fisher's exact test, Mann-Whitney *U* test, and independent *t* test were used to compare the PSN and non-PSN groups. Further comparisons between the two groups were performed after one-to-one matching based on hospital, sex, age-group (≤80 years and >80 years), and NIHSS score at onset. Sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV), along with 95% confidence intervals, were computed for the PSN group using the FAS protocol (facial drooping, arm weakness, and speech difficulties) with or without eye palsy, as well as eye palsy alone. The PPVs of the protocols were compared using relative predictive values in a paired study design, as proposed by Moskowitz and Pepe.[12] Statistical analyses were performed using SPSS software (Windows version 26.0; IBM Corp, Armonk [NY], United States) and the DTComPair package in R software (version 3.6.1). P values <0.05 were considered statistically significant.

Results

In total, 715 suspected stroke patients were included, with 449 in the non-PSN group and 266 in the PSN group. Intravenous recombinant tissue-type plasminogen activator was administered to 134 (29.8%) patients and 58 (21.8%) patients in the non-PSN and PSN groups, respectively (P=0.019) [Table 1]. Among the remaining 208 patients (78.2%) not given IV-rtPA in the PSN group, 43 patients were beyond the IV-rtPA window, and 46 patients had alternative unknown diagnoses at AED attendance. Twenty-one patients had symptoms that resolved or improved by the time of AED attendance (Fig).

Comparison in all suspected stroke patients

Demographic characteristics were compared between the non-PSN and PSN groups, as shown in Table 1. Age and hyperlipidaemia significantly differed between the two groups. The median ages were 69.7 years in the non-PSN group and 72.4 years in the PSN group (P=0.022). The percentages of patients with hyperlipidaemia were 53.9% in the non-PSN group and 43.9% in the PSN group (P=0.010). Door-to-CT time was significantly shorter in the PSN group than in the non-PSN group (24.5 vs 31 minutes; P<0.001). The percentage of patients achieving the DCT time goal of 25 minutes was greater in the PSN group than in the non-PSN

group (50.8% vs 37.7%; P<0.001). However, the median OTD time was longer in the PSN group than in the non-PSN group (97 vs 85.5 minutes; P=0.003).

Comparison in patients given intravenous recombinant tissue-type plasminogen activator

Among stroke patients given IV-rtPA, sex, hypertension, and hyperlipidaemia significantly differed between the two groups, as illustrated in Table 2. In the non-PSN group, 53.7% of patients were men, compared with 69.0% in the PSN group (P=0.049). Regarding key risk factors for ischaemic stroke, the respective prevalences of hypertension and hyperlipidaemia were 74.6% and 61.9% in the non-PSN group, whereas they were 53.4% and 44.8% in the PSN group. The NIHSS scores at symptom onset were similar between the non-PSN and PSN groups. The percentages of patients with suspected LVO were also similar between the PSN and non-PSN groups (40.4% vs 37.3%; P=0.759), as were the percentages of patients with CTA-confirmed LVO (52.6% vs 60.0%; P=1.000).

The DTN time was shorter in the PSN group than in the non-PSN group (67 vs 75.5 minutes; P=0.007). Additionally, the percentage of patients achieving the DTN time goal of 60 minutes was greater in the PSN group (37.9% vs 21.6%; P=0.019). However, there were no differences in median DTC time and percentage of patients achieving the DTC time goal of 25 minutes (Table 2). As shown in Table 3, the percentages of patients with good clinical outcomes after IV-rtPA were similar between non-PSN and PSN groups, as indicated by a reduction of ≥4 in NIHSS score at 24 hours (50.8% vs 49.0%; P=0.829) and an mRS score of 0 to 1 at 90 days (43.3% vs 35.4%; P=0.342).

Matched comparison of patients given intravenous recombinant tissue-type plasminogen activator

The non-PSN and PSN groups were matched based on hospital, sex, age-group, and NIHSS score at onset. After matching, the percentage of patients achieving the DTC time goal of 25 minutes was greater in the PSN group than in the non-PSN group (64.0% vs 44.0%; P=0.045). The median DTN time was also shorter in the PSN group (65.5 vs 76.5 minutes; P=0.003). Moreover, the percentage of patients achieving the DTN time goal of 60 minutes was greater in the PSN group than in the non-PSN group (42.0% vs 18.0%; P=0.009) [Table 2]. Finally, the percentages of patients with good clinical outcomes after IV-rtPA were similar between non-PSN and PSN groups, as evidenced by a reduction of ≥4 in NIHSS score at 24 hours (47.7% vs 48.9%; P=0.913) and an mRS score of 0 to 1 at 90 days (36.0% vs 33.3%; P=0.789) [Table 3].

TABLE 1. Comparison of baseline characteristics and key performance indicators of suspected stroke patients between pre-hospital stroke notification (PSN) and non-PSN groups*

	PSN group (n=266)	Non-PSN group (n=449)	P value
Male sex	140 (52.6%)	251 (55.9%)	0.396
Age, y	72.4 ± 13.0	69.7 ± 14.3	0.022
≤80	183 (68.8%)	319 (71.0%)	0.525
Smoking†	55 (20.8%)	116 (26.0%)	0.123
Diabetes mellitus†	80 (30.3%)	111 (24.8%)	0.112
Hypertension†	175 (66.3%)	311 (69.6%)	0.363
Hyperlipidaemia†	116 (43.9%)	241 (53.9%)	0.010
Onset-to-door time, min‡	97 (55-202.5)	85.5 (49-153.75)	0.003
Door-to-CT time, min§	24.5 (18-34)	31 (20-48.75)	<0.001
≤25	127 (50.8%)	169 (37.7%)	<0.001
Total IV-rtPA given	58 (21.8%)	134 (29.8%)	0.019

Abbreviations: CT = computed tomography; IV-rtPA = intravenous recombinant tissue-type plasminogen activator

* Data are shown as No. (%), mean ± standard deviation, or median (interquartile range)

† Data were missing for four patients. PSN group (n=264); non-PSN group (n=447)

‡ Data were missing for 24 patients. PSN group (n=249); non-PSN group (n=442)

§ For patients with only performed CT. PSN group (n=250); non-PSN group (n=448)

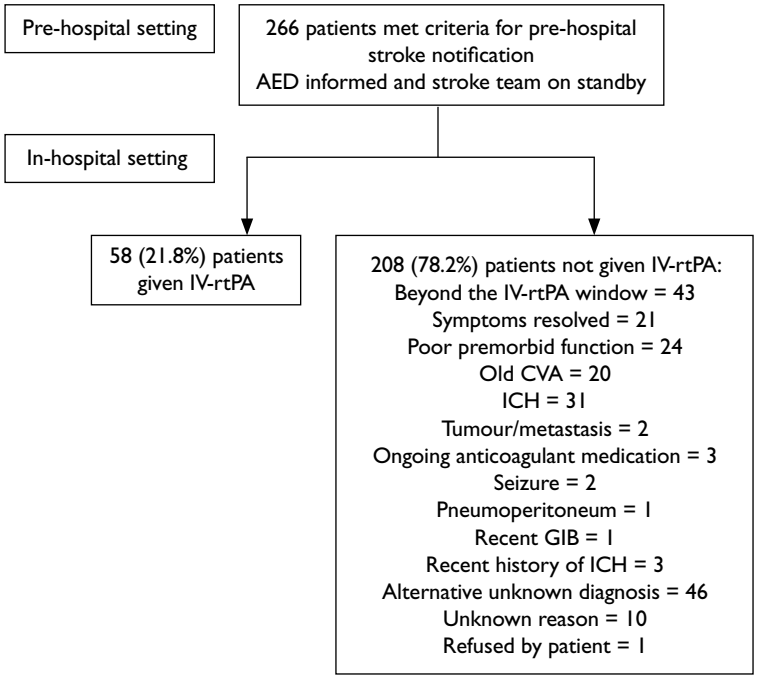

FIG. Summary of stroke patients screened using the pre-hospital stroke notification protocol

Abbreviations: AED = Accident and Emergency Department; CVA = cerebrovascular accident; GIB = gastrointestinal bleeding; ICH = intracranial haemorrhage; IV-rtPA = intravenous recombinant tissue-type plasminogen activator

TABLE 2. Comparison of baseline characteristics and key performance indicators of stroke patients given intravenous recombinant tissue-type plasminogen activator between pre-hospital stroke notification (PSN) and non-PSN groups*

	All patients given IV-rtPA			Matched patients given IV-rtPA†		
	PSN group (n=58)	Non-PSN group (n=134)	P value	PSN group (n=50)	Non-PSN group (n=50)	P value
Male sex	40 (69.0%)	72 (53.7%)	0.049	32 (64.0%)	32 (64.0%)	1
Age, y	71.5 ± 11.6	72.1 ± 12.8	0.764	72.6 ± 11.5	71.9 ± 13.8	0.765
≤80	40 (69.0%)	91 (67.9%)	0.885	33 (66.0%)	33 (66.0%)	1
Smoking	19 (32.8%)	43 (32.1%)	0.927	15 (30.0%)	18 (36.0%)	0.523
Diabetes mellitus	12 (20.7%)	34 (25.4%)	0.485	11 (22.0%)	13 (26.0%)	0.640
Hypertension	31 (53.4%)	100 (74.6%)	0.004	26 (52.0%)	36 (72.0%)	0.039
Hyperlipidaemia	26 (44.8%)	83 (61.9%)	0.028	24 (48.0%)	25 (50.0%)	0.841
NIHSS score at onset‡	15 (6, 21)	11 (5, 22)	0.573	15 (6, 21.5)	11.5 (5.75, 22)	0.790
0	0	0	0.842	0	0	1
1-4	10 (17.5%)	24 (17.9%)		8 (16.0%)	8 (16.0%)	
5-15	20 (35.1%)	52 (38.8%)		20 (40.0%)	20 (40.0%)	
16-20	11 (19.3%)	19 (14.2%)		7 (14.0%)	7 (14.0%)	
21-42	16 (28.1%)	39 (29.1%)		15 (30.0%)	15 (30.0%)	
Suspected LVO	23 (40.4%)	50 (37.3%)	0.759	18 (36.0%)	19 (38.0%)	0.836
CTA done	19 (32.8%)	10 (7.5%)		15 (30.0%)	5 (10.0%)	
CTA-confirmed LVO	10 (52.6%)	6 (60.0%)	1.000	7 (46.7%)	4 (80.0%)	0.319
Onset-to-door time, min	74 (48.75-118)	68 (43.75-123.25)	0.346	76 (51.75-118)	66.5 (42.2-122.5)	0.266
Door-to-CT time, min	22 (18.75-30)	25 (16-40.25)	0.135	22 (18.75-30)	26 (17.75-38.5)	0.082
≤25	37 (63.8%)	65 (48.5%)	0.051	32 (64.0%)	22 (44.0%)	0.045
Door-to-needle time, min	67 (58-80)	75.5 (61-95.25)	0.007	65.5 (57.75-76.5)	76.5 (64.5-93.25)	0.003
≤60	22 (37.9%)	29 (21.6%)	0.019	21 (42.0%)	9 (18.0%)	0.009
Onset-to-needle time, min	144.5 (122.25-196.25)	159 (120-214.5)	0.525	144.5 (124-196.25)	165 (127-211.5)	0.560

Abbreviations: CT = computed tomography; CTA = computed tomography angiography; IV-rtPA = intravenous recombinant tissue-type plasminogen activator; LVO = large vessel occlusion; NIHSS = National Institutes of Health Stroke Scale

* Data are shown as No. (%), mean ± standard deviation, or median (interquartile range)

† One-to-one matching based on hospital, sex, age-group, and NIHSS score at onset

‡ Missing data for one patient in the PSN group

Predictive value of eye palsy assessment in the pre-hospital stroke notification protocol

Among the 22 patients with eye palsy in the PSN group, 18 patients had either facial drooping, arm weakness or speech difficulties; seven patients were administered IV-rtPA. In the PSN group, the PPVs for using FAS, eye palsy alone, and FAS with eye palsy to identify stroke patients eligible for IV-rtPA were 22.14%, 31.82%, and 38.89%, respectively (Table 4). Compared with the PPV of FAS, the PPV of FAS with eye palsy was significantly higher (P=0.046), whereas the PPV of eye palsy alone did not significantly differ (P=0.223).

Discussion

The AHA and ASA recommend specific time goals for KPIs in stroke patients, such as OTD, DTC, and DTN times. Early recognition of stroke and utilisation of PSN for these patients are emphasised in the recent ASA guidelines as recommendations that can facilitate achievement of these goals. The recent adoption of a PSN protocol by the public hospital system in Hong Kong is intended to improve these KPIs and, ultimately, clinical outcomes among stroke patients.

In the present study, the PSN FASE protocol resulted in shorter DTC and DTN times, compared with the non-PSN protocol. A shorter DTN is associated with improved patient outcomes[3,4] and enables more patients to receive IV-rtPA within the therapeutic window.[13] However, the onset-to-needle time did not differ between the two groups (144.5 vs 159 minutes; P=0.525) [Table 2], which may be explained by the longer OTD time in the PSN group than in the non-PSN group (97 vs 85.5

TABLE 3. Comparison of short-term and long-term clinical outcomes of stroke patients given intravenous recombinant tissue-type plasminogen activator between pre-hospital stroke notification (PSN) and non-PSN groups*

	All patients given IV-rtPA			Matched patients given IV-rtPA†		
	PSN group (n=58)	Non-PSN group (n=134)	P value	PSN group (n=50)	Non-PSN group (n=50)	P value
Length of stay, d	6.5 (2.75-21.5)	7 (3-28.75)	0.536	9.5 (3-23.25)	6 (3-27)	0.904
Short-term outcome at 24 hours						
No. of patients	49	126		45	44	
NIHSS score	4 (1-15.5)	5 (1-17)	0.486	4 (1-18.5)	5 (2.25-14)	0.417
0	11 (22.4%)	21 (16.7%)	0.732	10 (22.2%)	5 (11.4%)	0.594
1-4	16 (32.7%)	37 (29.4%)		14 (31.1%)	16 (36.4%)	
5-15	10 (20.4%)	33 (26.2%)		9 (20.0%)	13 (29.5%)	
16-20	2 (4.1%)	10 (7.9%)		2 (4.4%)	2 (4.5%)	
21-42	10 (20.4%)	25 (19.8%)		10 (22.2%)	8 (18.2%)	
Any NIHSS score reduction	35 (71.4%)	93 (73.8%)	0.75	32 (71.1%)	31 (70.5%)	0.946
NIHSS score reduction ≥4‡	24 (49.0%)	64 (50.8%)	0.829	22 (48.9%)	21 (47.7%)	0.913
Long-term outcome at 90 days						
No. of patients	48	134		42	50	
mRS score			0.165			0.100
0	14 (29.2%)	42 (31.3%)		11 (26.2%)	12 (24.0%)	
1	3 (6.3%)	16 (11.9%)		3 (7.1%)	6 (12.0%)	
2	7 (14.6%)	9 (6.7%)		7 (16.7%)	4 (8.0%)	
3	2 (4.2%)	15 (11.2%)		1 (2.4%)	9 (18.0%)	
4	8 (16.7%)	13 (9.7%)		8 (19.0%)	5 (10.0%)	
5	3 (6.3%)	17 (12.7%)		2 (4.8%)	6 (12.0%)	
6	11 (22.9%)	22 (16.4%)		10 (23.8%)	8 (16.0%)	
Favourable outcome (mRS score 0-1)	17 (35.4%)	58 (43.3%)	0.342	14 (33.3%)	18 (36.0%)	0.789
Independent outcome (mRS score 0-2)	24 (50.0%)	67 (50.0%)	1	21 (50.0%)	22 (44.0%)	0.566

Abbreviations: IV-rtPA = intravenous recombinant tissue plasminogen activator; mRS = modified Rankin Scale; NIHSS = National Institutes of Health Stroke Scale

* Data are shown as No. (%) or median (interquartile range), unless otherwise specified

† One-to-one matching based on hospital, sex, age-group, and NIHSS score at onset

‡ Improvement in NIHSS score by ≥4 or complete resolution of neurological deficit

minutes; P=0.003) [Table 1]. To control for potential confounding factors, we matched the non-PSN and PSN stroke patients based on multiple variables; the results confirmed that DTC and DTN times were shorter in the PSN group.

However, these improvements in KPIs did not lead to statistically significant improvements in clinical outcomes, as evidenced by a reduction of ≥4 in NIHSS score at 24 hours post-rtPA (50.8% vs 49.0%; P=0.829) and an mRS score of 0 to 1 at 90 days (43.3% vs 35.4%; P=0.342) [Table 3]. The results of previous studies have suggested favourable mRS score outcomes in 33% to 41% of stroke patients given IV-rtPA[12,14]; the absence of favourable neurological outcomes in the present study may be attributed to the higher baseline level of neurological improvement in the non-PSN group. Moreover, the relatively small sample sizes in the PSN and non-PSN

TABLE 4. Eye palsy as a predictive factor for intravenous recombinant tissue-type plasminogen activator among suspected stroke patients in pre-hospital stroke notification group only (n=266)*

	F/A/S	E only	E with F/A/S
True positive	58	7	7
False positive	204	15	11
True negative	4	193	197
False negative	0	51	51
Sensitivity, %	100 (93.79-100)	12.07 (5.97-22.88)	12.07 (5.97-22.88)
Specificity, %	1.92 (0.75-4.84)	92.79 (88.44-95.58)	94.71 (90.78-97.02)
Accuracy, %	23.31 (18.63-28.75)	75.19 (69.66-80)	76.69 (71.25-81.37)
PPV, %	22.14 (17.53-27.55)	31.82 (16.36-52.68)	38.89 (20.31-61.38)
NPV, %	100 (51.01-100)	79.10 (73.57-83.73)	79.44 (73.97-84)

Abbreviations: A = arm weakness; E = eye palsy; F = facial drooping; NPV = negative predictive value; PPV = positive predictive value; S = speech difficulties

* Data are shown as No. or median (interquartile range)

groups (58 vs 134; P=0.019) [Table 1] may explain the lack of statistically significant clinical benefit in this study; future studies with larger sample sizes may provide further insights. The longer OTD time in the PSN group compared with the non-PSN group suggests that patients in the PSN group were administered IV-rtPA later than patients in the non-PSN group, potentially resulting in worse clinical outcomes. Finally, the lack of statistically significant improvements in clinical outcomes may be explained by the higher NIHSS score at onset in the PSN group (15 vs 11; P=0.573) [Table 2]; regardless of matching to control for potential confounding factors, we did not observe any statistically significant improvement in clinical outcomes.

A higher percentage of stroke patients received IV-rtPA in the non-PSN group compared with the PSN group, which may differ from the findings in some recent studies.[6,15] This discrepancy may be attributed to the learning curve associated with the new FASE protocol in the PSN group; EMS personnel may have engaged in 'over-activation' for borderline suspected stroke patients during early implementation. Additionally, because screening in the PSN group was performed by EMS personnel, it may have been less accurate than screening by physicians (ie, in the non-PSN group). The longer OTD time in the PSN group suggested that patients in the PSN group presented to the AED later than patients in the non-PSN group, increasing the likelihood that they would miss the 4-hour window for IV-rtPA administration.

The inclusion of eye palsy in the FASE protocol is intended to identify potential cases of posterior stroke[8,9] and aid the identification of LVO.[10] Although we found that the FASE protocol had a higher PPV (compared with the FAST protocol) for identifying stroke patients eligible for IV-rtPA, we did not assess whether the FASE protocol reliably identified patients with posterior strokes. Future studies validating the FASE protocol would provide additional insights. Considering the role of conjugate eye deviation in identifying LVO strokes,[16,17] research exploring the ability of the FASE protocol to identify these patients would be valuable. Investigations of EMS personnel accuracy in eye palsy recognition may also be useful.

Limitations

Possible limitations of this study include the potential for experimenter bias, considering that most investigators were also clinicians involved in patient management. However, it may be difficult to address this bias due to staffing constraints in peripheral acute hospitals, where researchers also serve as clinicians. Furthermore, the findings in this study are consistent with the results of other studies regarding pre-hospital notification protocols for suspected stroke patients.

We also included the percentage of stroke patients with CTA-confirmed LVO to provide a more comprehensive analysis, considering that LVO strokes have been linked to worse clinical outcomes compared with non-LVO strokes.[18] We observed no statistically significant differences in the percentages of suspected LVO and CTA-confirmed LVO strokes between the two study groups. However, because logistical considerations and resource limitations hindered our ability to perform diagnostic CTA for all patients, the true number of CTA-confirmed LVO strokes may be underestimated. Finally, the relatively small sample size may restrict our capacity to draw definitive conclusions.

Conclusion

This study validated the previous finding that a PSN protocol improves multiple stroke KPIs in Hong Kong. It also improves the understanding of whether a PSN protocol directly improves overall clinical outcomes among stroke patients, an area with limited evidence in current literature.[19] The implementation of a PSN protocol using the new FASE assessment guideline shortened DTN and DTC times compared with a non-PSN protocol. However, this study did not reveal any statistically significant improvement in overall clinical neurological outcomes between these two protocols. Further research may be warranted to assess whether PSN improves patient outcomes and other acute care parameters.

Author contributions

Concept or design: KY Cheng, ELM Yu.
Acquisition of data: KY Cheng, T Yamamoto.
Analysis or interpretation of data: KY Cheng, ELM Yu.
Drafting of the manuscript: KY Cheng, ELM Yu.
Critical revision of the manuscript for important intellectual content: All authors.

All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

Acknowledgement

The authors thank Mr Kin-wah Tam from North Lantau Hospital for data retrieval at the Hospital.

Funding/support

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics approval

This research was approved by the Kowloon West Cluster Research Ethics Committee of Hospital Authority, Hong Kong [Ref No.: KW/EX-21-134(163-12)]. A waiver of patient

consent was granted by the Committee since the data had been collected prior to this research and the risk of identification is minimal, and no new additional data was required for the research.

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