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The diagnostic value of the field assessment stroke triage as an emergency destination tool in identifying the obstruction of large cerebral vessels: a systematic review and meta-analysis

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Abstract: **Objective:** In this study, we investigate the diagnostic value of the field assessment stroke triage for emergency destination (FAST-ED) tool in the diagnosis of large vessels occlusion (LVO) in a systematic review and meta-analysis.
Methods: We conducted a search in Medline (PubMed), Embase, Scopus, and Web of Science databases until the 21^{st} of September 2022, as well as a manual search in Google ,and Google scholar to find related articles. Studies of diagnostic value in adult population were included. Screening, data collection and quality control of articles were done by two independent researchers. The data were entered and analyzed in STATA 17.0 statistical program.
Results: The data from 30 articles were entered. The best cut-off points for FAST-ED were 3 or 4. The sensitivity and specificity of FAST-ED at cut-off points 3 were 0.77 (95% CI:0.73,0.80) and 0.76 (95% CI:0.72,0.80), respectively. These values for cut-off point 4 were 0.72 (95% CI:0.65,0.78) and 0.79 (95% CI:0.75,0.82), respectively. Meta-regression showed that the sensitivity and specificity of FAST-ED performed by a neurologist was more accurate compared to emergency physician (P for sensitivity=0.01; P for specificity<0.001) and emergency medical technicians (P for sensitivity=0.03; P for specificity<0.001). Finally, it was found that the sensitivity of FAST-ED performed by the emergency physician and the emergency medical technician has no statistically significant difference (P=0.76). However, the specificity of FAST-ED reported by the emergency physician is significantly higher (P<0.001). The false negative rate of this tool at cut-off points 3 and 4 is 22.5% and 28.8%, respectively.
Conclusion: Although FAST-ED has an acceptable sensitivity in identifying LVO, its false negative rate varies between 22.5% and 28.8%. A percentage this high is unacceptable for a screening tool to aid in the diagnosis of strokes considering it has a high rate or morbidity and mortality. Therefore, it is recommended to use another diagnostic tool for the stroke screening.

Keywords: Large Vessel Obstruction; Screening; Stroke

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1. Introduction

As one of the leading causes of mortality, strokes were responsible for 143 million disability-adjusted life years (DALYs), 6.55 million deaths and 101 million new cases in 2019. Estimates indicate an increasing trend in number of newly diagnosed cases of strokes (1). Early diagnosis and treatment of stroke can limit adverse events and vastly improve outcomes for patients. For example, studies show that early endovascular therapy can significantly reduce morbidity and mortality associated with cerebrovascular occlusion (2-6). Therefore, reliable identification of stroke patients in the clinical setting has received much attention.
In recent years, several biomarkers and decision-making tools have been introduced for the rapid diagnosis of cerebral vascular occlusion. An umbrella review of systematic reviews and meta-analyses introduced 34 decision-making tools used to identify different types of strokes and the useful-

ness of these tools in the diagnosis of strokes (7). One of the diagnostic tools featured in the umbrella review is the field assessment stroke triage for emergency destination (FAST-ED). The umbrella review showed that 7 studies reporting the diagnostic value of FAST-ED in the diagnosis of cerebral vascular occlusion has a diagnostic odds ratio of 9.48 (7). However, researchers have identified that the number of original studies available on FAST-ED is more than 7 articles. Consequently, this highlights the importance of conducting a systematic review in this field (8-42).

FAST-ED, which is designed based on the National Institute of Health Stroke Scale (NIHSS) instrument includes facial palsy, arm weakness, speech changes, time, eye deviation, and denial/neglect, based on identifying high-risk patients for large vessel cerebral occlusion (29). While recent studies have highlighted the diagnostic value of the FAST-ED tool, the lack of a systematic review and reliable meta-analysis in this area of study has limited our abilities of coming up with a comprehensive conclusion. Based on this, the present systematic review and meta-analysis was designed with the aim of investigating the diagnostic value of FAST-ED in identifying patients with large cerebral artery occlusion.

2. Methods

2.1. Study design

The present systematic review and meta-analysis investigates the value of the FAST-ED scoring system in identifying large cerebral artery occlusion; Therefore, PICO was defined as follows. Problem (P): diagnostic value studies conducted on adult patients suspected of occlusion of large cerebral vessels; index (I): FAST-ED tool; comparison (C): comparison with CT scan; outcome (O): occlusion of large cerebral vessels.

2.2. Search strategy

To achieve the goals of this study, an extensive search in Medline, Embase, Scopus and Web of Science databases was conducted from the beginning of their establishment until the end of October 2022. A manual search in Google and Google Scholar, as well as in the references section of related articles, was also done. The search strategy for all databases were presented in appendix 1.

2.3. Selection criteria

Inclusion criteria were studies of diagnostic value conducted on adult patients. Exclusion criteria were review studies, lack of large vessel occlusion (LVO) assessment as an outcome, lack of a non-LVO control group in the study, retracted studies, and duplicate studies.

2.4. Data synthesis

Two independent researchers performed the initial screening by investigating the titles and abstracts of the qualified articles after removing the duplicates by the Endnote program. In the next step, possible related articles found in the initial screening were studied at the full text level and related articles were included in the present study. These articles were summarized in a checklist that was designed based on the guidelines of the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement (43). In case of disagreement, conflicts were resolved through discussion with the third researcher.

The collected data included the surname of the first author, the year of publication, the country where the study was conducted, the demographic characteristics of samples, the sample size, the time interval between the injury and the evaluation of the tools, the cut-off points, and outcome. Sensitivity and specificity, area under the curve, true and false positive and negative values were also recorded.

2.5. Risk of bias assessment

The quality control of the articles was performed based on the quality assessment of diagnostic accuracy studies 2 (QUADAS-2) guidelines, and in case of a disagreement, the conflict was resolved through discussion with the third researcher (44). The QUADAS-2 has two sections, the risk of bias and applicability, in which the risk of bias and applicability of articles in the domains of patient setting, index test, reference standard, and flow and timing are examined. The score of each domain is reported as low/unclear/high.

2.6. Statistical analysis

Data were analyzed in STATA 17.0 statistical program. The data were collected as true positive, false positive, true negative and false negative, and the area under the curve, sensitivity, specificity, and diagnostic odds ratio were calculated. If true and false positives and negatives were not reported in an article and sensitivity and specificity were reported instead, the values of sensitivity and specificity were calculated using the standard formula. The "midas" package of the statistical program was used to perform meta-analyses. Heterogeneity between studies was checked based on the I2 test, and bivariate random effect model was used for analysis. Due to the report of the diagnostic value of FAST-ED in different cut-off points, the results were stratified according to the cut-off points. Also, subgroup analysis was performed based on the expertise of the FAST-ED examiner. Finally, Deeks' funnel asymmetry plot was used to identify publication bias.

3. Results

A total of 208 articles were initially collected, 195 by a systematic search and 13 by manual search. After removing the duplicates and reading the titles and abstracts, 47 articles were reviewed in full detail. Finally, 30 articles were included in this systematic review and meta-analysis (Figure 1) (8-14,16,17,20-33,35,36,38-42). 14 articles were completed in the USA, 4 articles in China and 3 articles in Germany. Other articles were conducted on data collected from Taiwan, Hungary, Brazil, Iran, Netherlands, Finland, Australia, France,

Table 1 Characteristics of the included studies

Study	Design	Sample size	Age (median)	Male (n)	FAST-ED evaluation time (hrs)	Reference	Specialty	LVO (n)	Non-LVO (n)	Cut-off point
Anadani, 2019, USA	RCS	439	66.7	231	0	CTA	Neurologist	213	226	4
Bhatt, 2021, USA	PCS	173	63	82	0	CTA/MRA	Paramedic/EMS	16	157	3
Carr, 2020, USA	RCS	402	73	222	0	NR	Paramedic/EMS	92	386	4
Chen, 2018, China	RCS	777	69	483	0	CTA/MRA	Neurologist	453	324	3
Chiu, 2020, Taiwan	RCS	1231	70.5	704	NR	CTA/MRA	Neurologist	285	946	4
Daly, 2021, USA	PCS	95	72.8	52	0	CTA	Paramedic/EMS or ED physician	14	81	4
Dowbiggin, 2022, USA	PCS	1359	69.4	608	0	CTA	Paramedic/EMS	153	1206	4
Duloquin, 2021, France	PCS	946	79	456	0	CTA/MRA/MRI	ED physician	123	772	4
Esfahani, 2021, Iran	PCS	314	67.95	184	0	MRI	ED physician	274	40	3, 4, 5, 6
Frank, 2021, Germany	RCS	2815	NR	NR	0	CTA/TCD	Neurologist	442	2373	3, 4
Gropen, 2017, USA	RCS	218 1663	65.5 62	96 898	0 171	CTA/MRA 1492	Paramedic/EMS 4	83	135	1
Guillory, 2020, USA	PCS	135	72.6	NR	0	CTA	Paramedic/EMS or ED physician	32	103	1, 2, 3, 4, 5, 6
Inoue, 2018, Japan	R-Cross	196	68.6	123	0	CTA/MRA	Neurologist	56	140	4
Johannes, 2021, Germany	RCS	904	72.3	479	0	CTA/MRA	Paramedic/EMS	324	580	4
Keenan, 2019, USA	PCS	735	NR	NR	NR	CT/CTA	Neurologist	241	494	3, 6
Keenan, 2021, USA	PCS	68	66	36	0	CT/CTA	Neurologist	23	45	4
Keenan, 2022, USA	RCS	184	70	94	0	CT/CTA	Neurologist	29 (30)	155 (190)	4, 6
Krebs, 2020, Germany	PCS	741	72.1	389	0	CTA/MRA	Neurologist	323	418	4
Li, 2020, China	RCS	657	62	470	0	CTA/MRA	Neurologist	311	60	3
Lima, 2016, USA	PCS	727	68.1	378	0	CTA	Neurologist	240	487	3, 4, 5, 6
Mayasi, 2018, USA	RCS	274	69	148	0	CT/CTA/MRA	Neurologist	46	228	4
Navalkele, 2020, USA	RCS	244	66	119	0	CTA/MRA	ED physician	75	169	4
Nguyen, 2021, Netherlands	PCS	2007	71.1	1021	0	NR	Paramedic/EMS	158	1849	4
Noorian, 2018, USA	PCS	94	70	48	0	CTA/MRA	Paramedic/EMS	45	49	4
Puolakka, 2021, Finland	RCS	509	NR	NR	0	CTA	Neurologist or ED physician	57	452	4
Rynor, 2020, USA	RCS & PCS	1153	73	531	0	NR	Paramedic/EMS	85	1068	4, 6
Tárkányi, 2021, Hungary	R-Cross	180	68.2	94	0	CTA	Paramedic/EMS	98	82	5
Wang, 2021, China	RCS	11440	70	7072	0	CTA/TOF-MRA	Paramedic/EMS	3244	8196	4

Table 1 Characteristics of the included studies (continued)

Study	Design	Sample size	Age (median)	Male (n)	FAST-ED evaluation time (hrs)	Reference	Specialty	LVO (n)	Non-LVO (n)	Cut-off point
Zhang, 2021, China	PCS	351	65	NR	6	CTA/TOF-MRA	Paramedic/EMS	112	239	3
Zhao, 2017, Australia	PCS	565	75	288	0	CTA	Neurologist	82	175	4

CT: Computed tomography scan; CTA: Computed tomography angiography; ED: Emergency department;
EMS: Emergency medical service; FAST-ED: field assessment stroke triage for emergency destination;
LVO: Large vessel occlusion; MRA: Magnetic resonance angiography; MRI: Magnetic resonance imaging; NR: Not reported;
PCS: Prospective cohort study; RCS: Retrospective cohort study; R-Cross: Retrospective cross-sectional study;
TCD: Transcranial Doppler ultrasound; TOF-MRA: Time-of-flight magnetic resonance angiography

and Japan. Of the included studies, 28 articles were cohort, and 2 articles were conducted cross-sectionally. The overall sample size was 31596 patients. The average age range of samples varied from 62 to 73 years. In 5 articles, the number of patients in each gender was not reported separately; However, in the rest of the articles, among 27051 patients, 15306 patients were male. Two articles had a FAST-ED cut-off point of ≤1, one article had a cut-off point of ≤2, 9 articles had a cut-off point of ≤3, 24 articles had a cut-off point of ≤4, 4 articles had a cut-off point of ≤5 and 7 articles had a cut-off point of ≤6. FAST-ED evaluation was done by neurologists in 13 articles, by a paramedic/ambulance technician in 11 articles and by an emergency physician in 3 articles. Additionally, in 3 articles the FAST-ED tool was assessed by an ambulance technician or an emergency physician and in one article by either a neurologist or an emergency physician (Table 1).

3.1. Meta-analysis

3.1.1. Diagnostic value of FAST-ED in identifying LVO

In the present study, analyzes were stratified according to the cut-off points reported for FAST-ED. Since only 2 articles evaluated the diagnostic value of FAST-ED at cut-off point of ≥1 and 1 article assessed the value at cut-off point of 2, it was not possible to conduct a meta-analyzes for these cut-off points.

The area under the curve in different cut-off points were as follows: in FAST-ED≥3, AUC=0.83 (95% CI:0.80,0.86), in FAST-ED≥4, AUC=0.83 (95% CI:0.79,0.86), in FAST-ED≥5, AUC=0.73 (95% CI:0.69,0.76) and in FAST-ED≥6, AUC=0.71 (95% CI:0.67,0.75) (Figure 2).

The sensitivity and specificity of FAST-ED at cut-off point 3 were 0.77 (95% CI:0.73,0.80) and 0.76 (95% CI:0.72,0.80), respectively. These values for cut-off point 4 were equal to 0.72 (95% CI:0.65,0.78) and 0.79 (95% CI:0.75,0.82), respectively. The sensitivity and specificity of FAST-ED at cut-off point 5 is equal to 0.49 (95% CI:0.40,0.58) and 0.92 (95% CI:0.86,0.96) and at cut-off point 6 is equal to 0.39 (95% CI:0.26,0.54) and 0.93 (95% CI:0.83,0.97), respectively. Diagnostic odds ratio of FAST-ED in cut-off points 3, 4, 5 and 6 are also 10.59 (95% CI:7.65,14.66), 9.74 (95% CI:7.34,12.94), 10.79 (95% CI:5.70,20.42) and 8.65 (95% CI:5.31,14.09) (Figure 2 and supplementary figures 1 to 4). Based on the examination of the area under the curve and the sensitivity and specificity, it seems that the best cut-off points for FAST-ED are cut-off points 3 and 4.

3.1.2. Accuracy of neurologist, emergency physician and EMS personnel-assessed FAST-ED

Since the number of articles that investigated the value of FAST-ED at cut-off point 3 was small, the analyzes were limited to cut-off point 4.

The AUC of FAST-ED in LVO diagnosis evaluated by neurologists was 0.85 (95% CI:0.82,0.88). The sensitivity and specificity were 0.73 (95% CI:0.67,0.79) and 0.83 (95% CI:0.78,0.87), respectively. The area under the curve, sensitivity, and specificity in evaluation by emergency physicians are 0.80 (95% CI:0.77,0.84), 0.65 (95% CI:0.50,0.77), and 0.80 (95% CI:0.71,0.86), respectively. Finally, these values for the ambulance technician were 0.80 (95% CI:0.76,0.83), 0.71 (95% CI:0.58,0.82), and 0.76 (95% CI:0.71,0.80), respectively (Figure 3).

The meta-regression test showed that the sensitivity and specificity of FAST-ED performed by the neurologist was significantly better than the emergency physician (P for sensitivity=0.01; P for specificity<0.001) and the ambulance technician (P for sensitivity=0.03; P for specificity<0.001). It was found that the sensitivity of FAST-ED performed by the emergency physician and the ambulance technician has no statistically significant difference (P=0.76), but the specificity of FAST-ED reported by the emergency physician is significantly higher (P<0.001).

3.2. Publication bias

Deek's funnel asymmetry test showed that there is no publication bias in cut-off points 3 (P=0.20), 4 (P=0.67), 5 (P=0.92) and 6 (P=0.22) (Supplementary figure 5).

3.3. Risk of bias assessment

Risk of bias assessment showed that the risk of bias and applicability in three studies was unclear in the reference standard section, because a single reference standard was not used, or a golden standard test was not reported for all pa-

Table 2 Risk of bias assessment of the included studies

Study	Risk of bias				Applicability			Overall
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard	
Anadani, 2019	Low	Low	Low	Low	Low	Low	Low	Low
Bhatt, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Carr, 2020	Low	Low	Unclear	Low	Low	Low	Unclear	Some concern
Chen, 2018	Low	Low	Low	Low	Low	Low	Low	Low
Chiu, 2020	Low	Low	Low	Low	Low	Low	Low	Low
Daly, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Dowbiggin, 2022	Low	Low	Low	Low	Low	Low	Low	Low
Duloquin, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Esfahani, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Frank, 2021	Low	Low	High	Low	Low	Low	Low	Low
Gropen, 2017	Low	Low	Low	Low	Low	Low	Low	Low
Guillory, 2020	Low	Low	Low	Low	Low	Low	Low	Low
Inoue, 2018	Low	Low	Low	Low	Low	Low	Low	Low
Johannes, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Keenan, 2019	Low	Low	Low	Low	Low	Low	Low	Low
Keenan, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Keenan, 2022	Low	Low	Low	Low	Low	Low	Low	Low
krebs, 2020	Low	Low	Low	Low	Low	Low	Low	Low
Li, 2020	Low	Low	Low	Low	Low	Low	Low	Low
Lima, 2016	Low	Low	Low	Low	Low	Low	Low	Low
Myasi, 2018	Low	Low	Low	Low	Low	Low	Low	Low
Navalkele, 2020	Low	Low	Low	Low	Low	Low	Low	Low
Nguyen, 2021	Low	Low	Unclear	Low	Low	Low	Unclear	Some concern
Noorian, 2018	Low	Low	Low	Low	Low	Low	Low	Low
Puolakka, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Rynor, 2020	Low	Low	Unclear	Low	Low	Low	Unclear	Some concern
Tárkányi, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Wang, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Zhang, 2021	Low	Low	Low	Low	Low	Low	Low	Low
Zhao, 2017	Low	Low	Low	Low	Low	Low	Low	Low

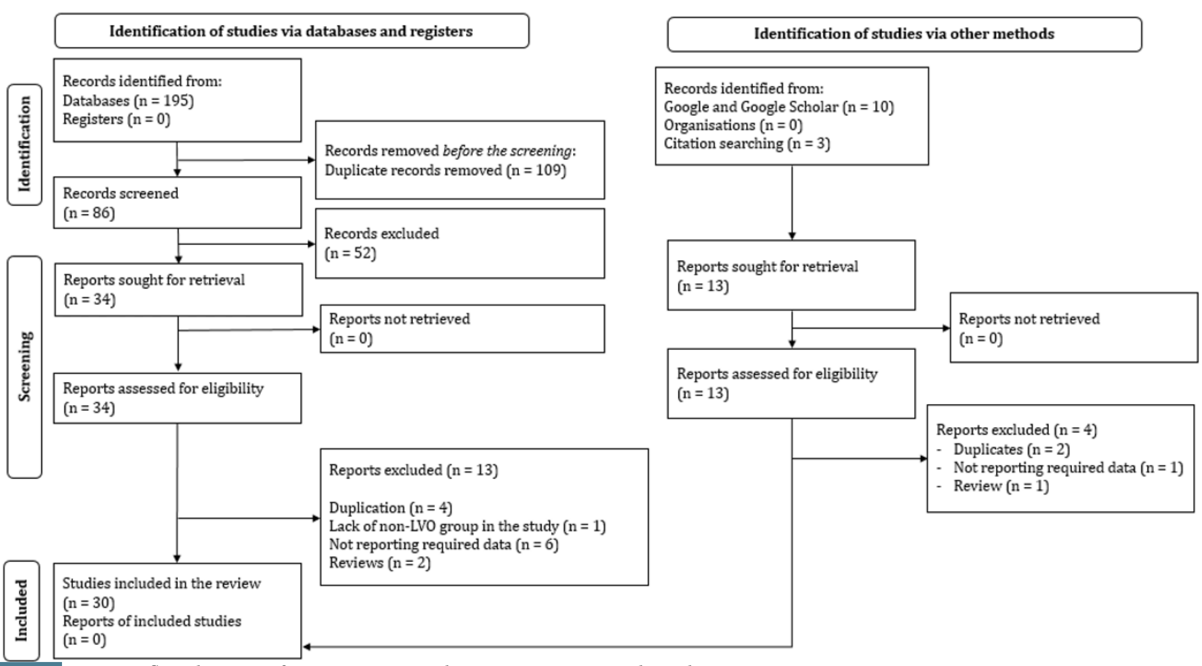

Figure 1 PRISMA flow diagram of current meta-analysis; LVO: Large vessels occlusion

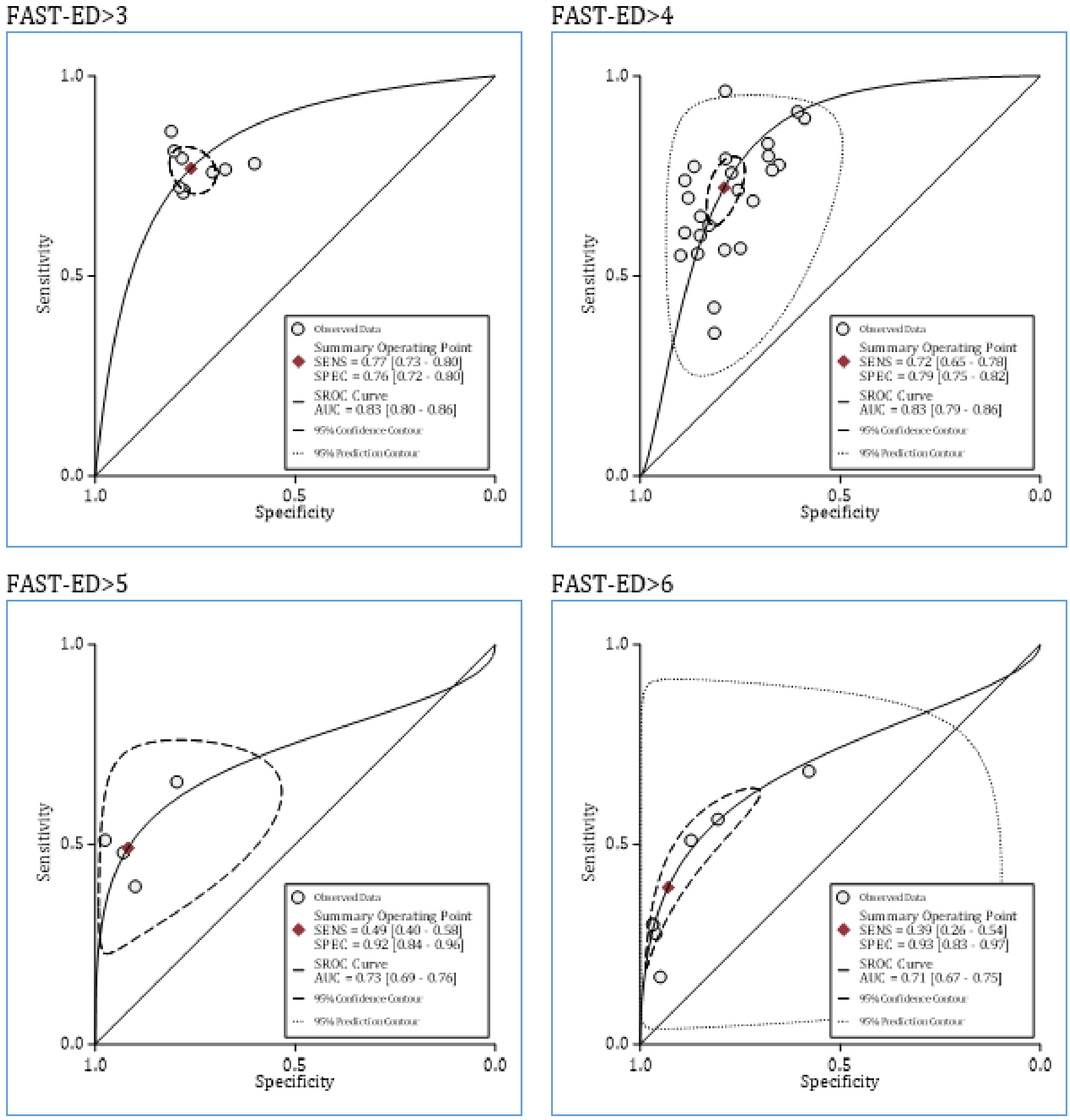

Figure 2 Area under the curve (AUC) of FAST-ED in detection of stroke in different cut-off points

tients. Risk of bias of reference standard was high in one study, since transcranial Doppler ultrasound was used for some patients. Based on this, the overall risk of bias in the included studies was considered "some concern" in three studies and low in the remaining ones (Table 2).

4. Discussion

The findings of the present study showed that the FAST-ED diagnostic tool does not perform well in identifying LVO in suspected ischemic stroke patients. The best cut-off points of this tool in our study were 3 and 4. Analyzes showed that FAST-ED performed by a neurologist had higher diagnostic accuracy than by an emergency physician or a paramedic/emergency medical technician.

A good screening test is a tool that has high sensitivity in identifying high-risk patients in addition to having an acceptable specificity.

Having both a high sensitivity and specificity means there are few false negatives and false positives, and thus few cases of the disease are missed. One of the main uses of a good screening tool is to identify people who do not need gold standard testing. Therefore, it is necessary to calculate the false positive rate to determine to what extent the use of the screening FAST-ED tool can reduce unnecessary diagnostic interventions in such a way that the cases of false negative

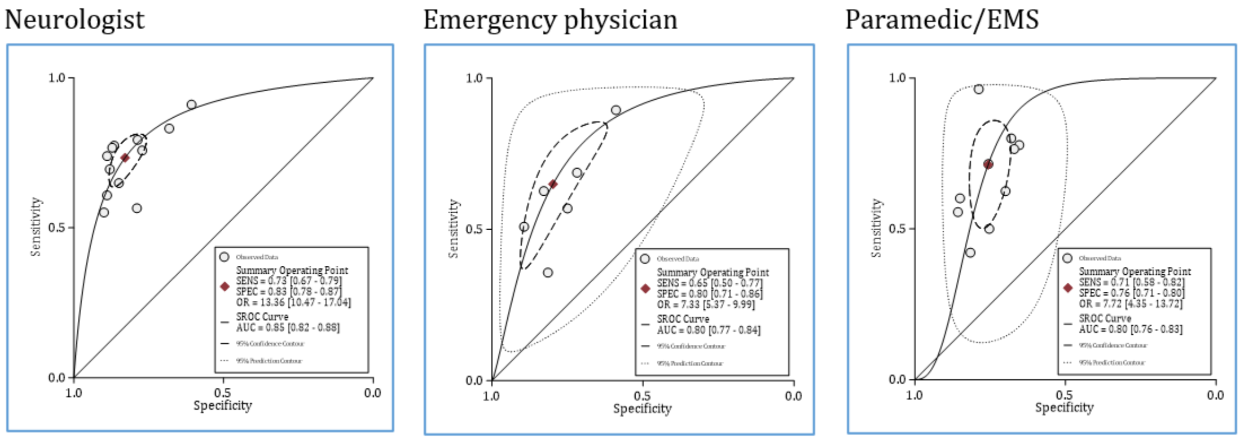

Figure 3 Area under the curve (AUC) of FAST-ED in detection of stroke in cut-off points of more than 4, in detection of stroke according to assessor specialty

rate are as low as possible. In the current study, FAST-ED had a sensitivity of 0.72 to 0.79 and a specificity of 0.76 to 0.79 in the best cut-off points (3 and 4). By examining the total number of patients included in cut-off points 3 and 4, the false positive rate was 21.21% and 22.59%, respectively. In other words, using FAST-ED with cut-off points of 3 or 4 can correctly identify 78.8% and 77.4% of non-stroke people, respectively, and reduce the need for laboratory tests and subsequent imaging studies. However, the false negative rate of this tool at cut-off points 3 and 4 is 22.5% and 28.8%, respectively, which is a big obstacle on the way of using it in the clinic and to screen patients because it does not detect this number of patients. Since stroke is a life-threatening disease, this extent of false negative rate in a screening tool is not satisfactory.

In comparison with the findings of the present study, Antipova et al., with a qualitative review of only 6 studies, stated that FAST-ED is one of the best tools in diagnosing LVO (45). One of the possible reasons for the observed difference between Antipova and the present study, may be due to the small number of included articles in Antipova's study. Additionally, failure to conduct a meta-analysis and provide a general conclusion without considering the differences between studies in the cut-off points is another reason for the observed inconsistency. Moreover, Koster et al. considered an acceptable diagnostic value for FAST-ED, having the mentioned issues that existed in Antipova et al.'s study (46). In another umbrella review that was conducted on 7 studies, researchers showed that the sensitivity and specificity of FAST-ED are 0.61 and 0.86, respectively, regardless of a specific cut-off point (7). The findings of this study are in line with the current study that the sensitivity and specificity of FAST-ED in cut-off points between 3 and 6 varied between 0.39 to 0.77 and 0.76 to 0.93, respectively.

As a secondary finding, it can be mentioned that the expertise of the FAST-ED examiner affects its diagnostic performance. The findings of the present study showed that the diagnostic value of FAST-ED performed by a neurologist is slightly better than that of an emergency physician and a paramedic/emergency medical technician. This may be due to the higher knowledge and skill of neurologists in the assessment of stroke patients compared to other providers in the clinical setting. However, the difference in performance among these health care providers may be due to the timing of presentation of stroke symptoms. Emergency medical technicians and emergency physicians examine suspected stroke patients earlier than neurologists. The time it takes for stroke patients to be evaluated by a neurologist from the time they encounter an emergency medical technician may allow for progression of symptoms, making the signs more obvious. However, since accurate data from the time of examination of patients has not been reported in the included studies, it is not possible to comment with certainty on this factor.

5. Limitations

One of the limitations of our study is the lack of evidence on cut-off points other than 4. Since in the FAST-ED score derivation study, the cut-off points of 4 was introduced as the best cut-off point, most of the following studies also introduced this cut-off point for FAST-ED. On the other hand, although the diagnostic value of FAST-ED in identifying LVO at cut-off point 3 was slightly better than at cut-off point 4, due to the low number of studies in cut-off point 3 it cannot be said with certainty which cut-off point is the optimal one.

6. Conclusion

The findings of the present study show that FAST-ED is not a precise tool in LVO diagnosis in suspected ischemic stroke patients. Although many efforts have been made in recent years in this field, it is recommended to use other tools to identify patients with LVO.

7. Declarations

7.1. Acknowledgement

None.

7.2. Authors' contribution

Study design: MY and RM; data gathering: ANV, YB, MY; analysis: MY, ANV; interpretation of results: All authors; drafting: ANV, MY; revision: All authors.

7.3. Conflict of interest

The authors declared that there is no conflict of interest.

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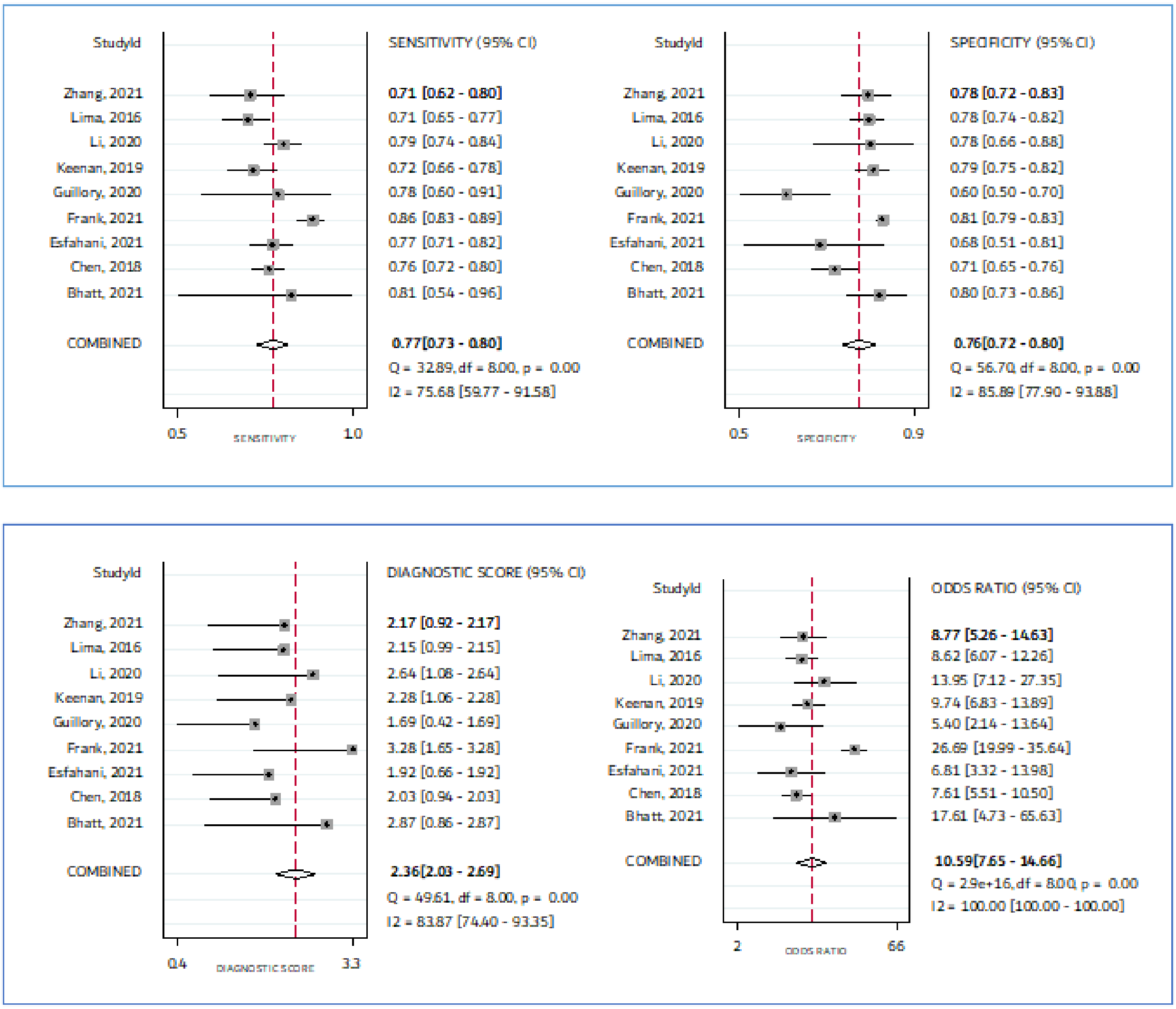
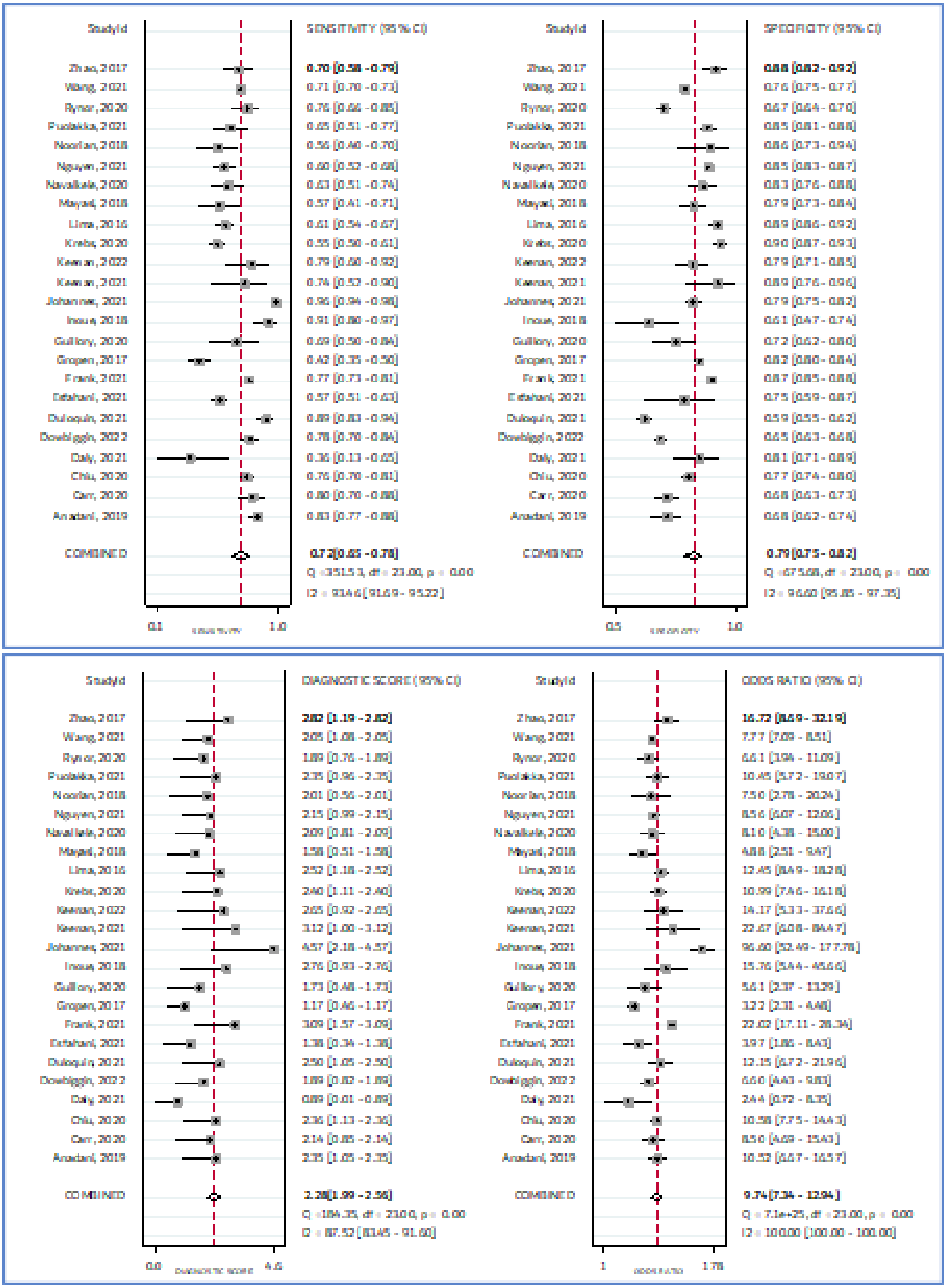
References

1. Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study. J Am Coll Cardiol. 2020;76(25):2982-3021.
2. Berkhemer OA, Fransen PS, Beumer D, Van Den Berg LA, Lingsma HF, Yoo AJ, et al. A randomized trial of intraarterial treatment for acute ischemic stroke. N Engl J Med. 2015;372(1):11-20.
3. Campbell BC, Mitchell PJ, Kleinig TJ, Dewey HM, Churilov L, Yassi N, et al. Endovascular therapy for ischemic stroke with perfusion-imaging selection. N Engl J Med. 2015;372(11):1009-18.
4. Goyal M, Demchuk AM, Menon BK, Eesa M, Rempel JL, Thornton J, et al. Randomized assessment of rapid endovascular treatment of ischemic stroke. N Engl J Med. 2015;372(11):1019-30.
5. Jovin TG, Chamorro A, Cobo E, de Miquel MA, Molina CA, Rovira A, et al. Thrombectomy within 8 hours after symptom onset in ischemic stroke. N Engl J Med. 2015;372(24):2296-306.
6. Saver JL, Goyal M, Bonafe A, Diener H-C, Levy EI, Pereira VM, et al. Stent-retriever thrombectomy after intravenous t-PA vs. t-PA alone in stroke. N Engl J Med. 2015;372(24):2285-95.
7. Baratloo A, Mohamadi M, Mohammadi M, Toloui A, Neishaboori AM, Alavi SNR, et al. The value of predictive instruments in the screening of acute stroke: an umbrella review on previous systematic reviews. Front Emerg Med. 2022;6(3):e38.
8. Anadani M, Almallouhi E, Wahlquist AE, Debenham E, Holmstedt CA. The accuracy of large vessel occlusion recognition scales in telestroke setting. Telemed J E Health. 2019;25(11):1071-6.
9. Bhatt NR, Frankel MR, Nogueira RG, Fleming C, Bianchi NA, Morgan O, et al. Reliability of field assessment stroke triage for emergency destination scale use by paramedics: mobile stroke unit first-year experience. Stroke. 2021;52(8):2530-6.
10. Carr K, Yang Y, Roach A, Shivashankar R, Pasquale D, Serulle Y. Mechanical revascularization in the era of the field assessment stroke triage for emergency destination (FAST-ED): a retrospective cohort assessment in a community stroke practice. J Stroke Cerebrovasc Dis. 2020;29(1):104472.
11. Chen Z, Zhang R, Xu F, Gong X, Shi F, Zhang M, et al. Novel prehospital prediction model of large vessel occlusion using artificial neural network. Front Aging Neurosci. 2018;10:181.
12. Chiu YC, Hsieh MJ, Lin YH, Tang SC, Sun JT, Chiang WC, et al. External validation of prehospital stroke scales for emergent large vessel occlusion. Am J Emerg Med. 2021;41:35-9.
13. Daly M, Cummings C, Kittell M, Dubuque A, Plante L, Linares G, et al. Validation of field assessment stroke triage for emergency destination for prehospital use in a rural EMS system. Am J Emerg Med. 2021;50:178-82.
14. Dowbiggin PL, Infinger AE, Purick GT, Swanson DR, Asimos A, Rhoten JB, et al. Prehospital evaluation of the FAST-ED as a secondary stroke screen to identify large vessel occlusion strokes. Prehosp Emerg Care. 2022;26(3):333-8.
15. Dowbiggin PL, Infinger AI, Purick G, Swanson DR, Studnek JR. Inter-rater reliability of the FAST-ED in the out-of-hospital setting. Prehosp Emerg Care. 2021:1-8.
16. Duloquin G, Graber M, Garnier L, Mohr S, Giroud M, Vergely C, et al. Assessment of clinical scales for detection of large vessel occlusion in ischemic stroke patients from the Dijon stroke registry. J Clin Med. 2021;10(24):5893.
17. Frank B, Fabian F, Brune B, Bozkurt B, Deuschl C, Nogueira RG, et al. Validation of a shortened FAST-ED algorithm for smartphone app guided stroke triage. Ther Adv Neurol Disord. 2021;14:17562864211057639.
18. Frank B, Lembeck T, Toppe N, Brune B, Bozkurt B, Deuschl C, et al. FAST-ED scale smartphone app-based prediction of large vessel occlusion in suspected stroke by emergency medical service. Ther Adv Neurol Disord. 2021;14:17562864211054962.
19. Grewal P, Lahoti S, Aroor S, Snyder K, Pettigrew LC, Goldstein LB. Effect of known atrial fibrillation and anticoagulation status on the prehospital identification of large vessel occlusion. J Stroke Cerebrovasc Dis. 2019;28(12):104404.
20. Gropen TI, Boehme A, Martin-Schild S, Albright K, Samai A, Pishanidar S, et al. Derivation and validation of the emergency medical stroke assessment and comparison of large vessel occlusion scales. J Stroke Cerebrovasc Dis. 2018;27(3):806-15.
21. Guillory BC, Gupta AA, Cubeddu LX, Boge LA. Can prehospital personnel accurately triage patients for large vessel occlusion strokes? J Emerg Med. 2020;58(6):917-

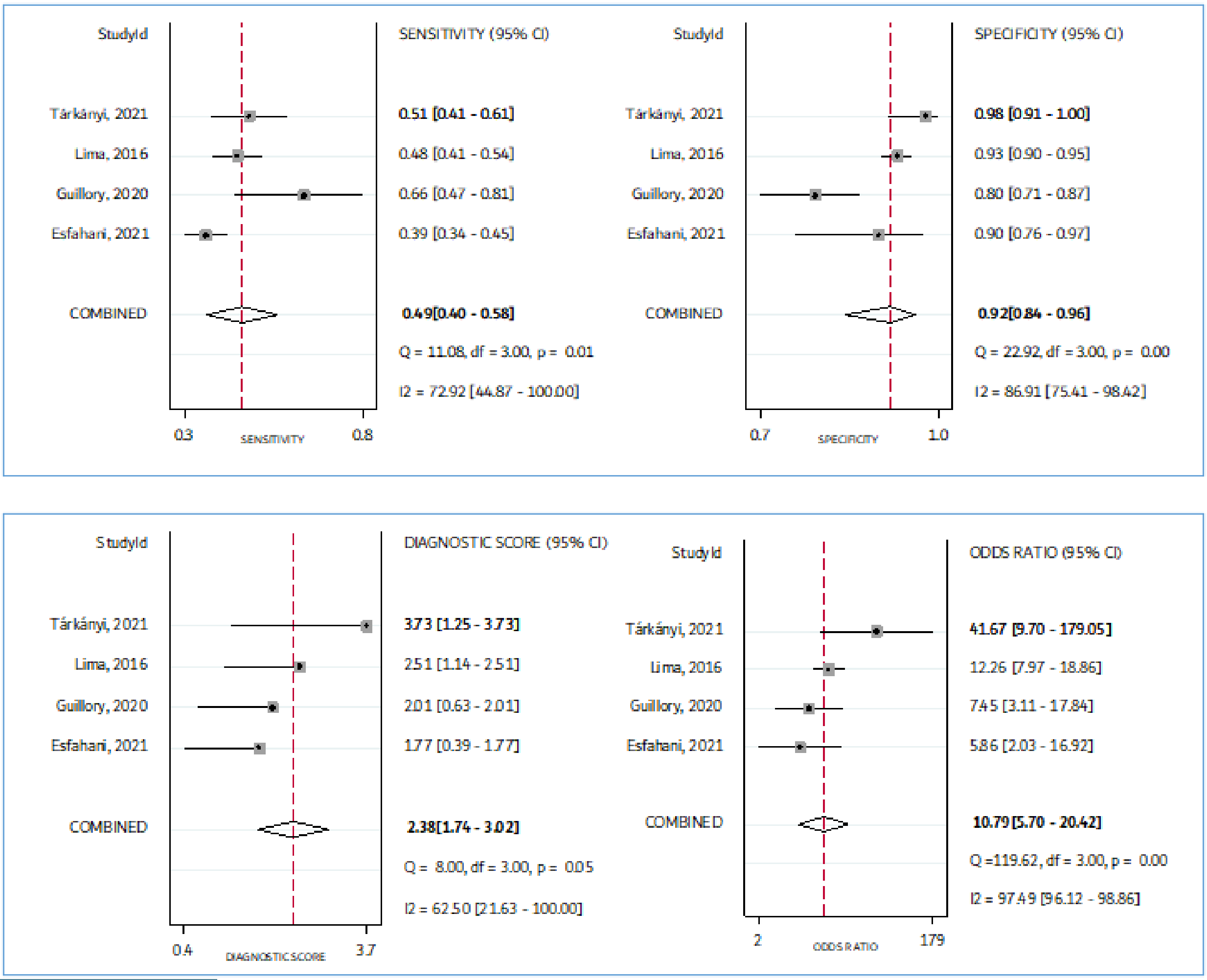
21.
22. Inoue M, Noda R, Yamaguchi S, Tamai Y, Miyahara M, Yanagisawa S, et al. Specific factors to predict large-vessel occlusion in acute stroke patients. J Stroke Cerebrovasc Dis. 2018;27(4):886-91.
23. Johannes B, Habib P, Schürmann K, Nikoubashman O, Wiesmann M, Schulz JB, et al. Gaze deviation and paresis score (GPS) sufficiently predicts emergent large vessel occluding strokes. J Stroke Cerebrovasc Dis. 2021;30(3):105518.
24. Keenan KJ, Lovoi PA, Smith WS. The neurological examination improves cranial accelerometry large vessel occlusion prediction accuracy. Neurocrit Care. 2021;35(1):103-12.
25. Keenan KJ, Smith WS. The speech arm vision eyes (SAVE) scale predicts large vessel occlusion stroke as well as more complicated scales. J Neurointerv Surg. 2019;11(7):659-63.
26. Keenan KJ, Smith WS, Cole SB, Martin C, Hemphill JC, Madhok DY. Large vessel occlusion prediction scales provide high negative but low positive predictive values in prehospital suspected stroke patients. BMJ Neurol Open. 2022;4(2):e000272.
27. Krebs S, Roth D, Knoflach M, Baubin M, Lang W, Beisteiner R, et al. Design and derivation of the Austrian prehospital stroke scale (APSS) to predict severe stroke with large vessel occlusion. Prehosp Emerg Care. 2021;25(6):790-5.
28. Li S, Wang A, Zhang X, Wang Y. Design and validation of prehospital acute stroke triage (PAST) scale to predict large vessel occlusion. Atherosclerosis. 2020;306:1-5.
29. Lima FO, Silva GS, Furie KL, Frankel MR, Lev MH, Camargo É C, et al. Field assessment stroke triage for emergency destination: a simple and accurate prehospital scale to detect large vessel occlusion strokes. Stroke. 2016;47(8):1997-2002.
30. Mayasi Y, Goddeau R, Moonis M, Silver B, Jun-O'Connell AH, Puri AS, et al. Leukoaraiosis attenuates diagnostic accuracy of large-vessel occlusion scales. Am J Neuroradiol. 2018;39(2):317-22.
31. Nasr-Esfahani M, Heydari F, Izadi-Dastgerdi E, Golsefidi AF, Noorshargh P. Accuracy of field assessment stroke triage for emergency destination for diagnosis of acute ischemic stroke patients. Eurasian J Emerg Med. 2021;20(2):113-20.
32. Navalkele D, Vahidy F, Kendrick S, Traylor A, Haydel M, Drury S, et al. Vision, aphasia, neglect assessment for large vessel occlusion stroke. J Stroke Cerebrovasc Dis. 2020;29(1):104478.
33. Nguyen TTM, van den Wijngaard IR, Bosch J, van Belle E, van Zwet EW, Dofferhoff-Vermeulen T, et al. Comparison of prehospital scales for predicting large anterior vessel occlusion in the ambulance setting. JAMA Neurol. 2021;78(2):157-64.
34. Nogueira RG, Silva GS, Lima FO, Yeh YC, Fleming C, Branco D, et al. The FAST-ED app: a smartphone platform for the field triage of patients with stroke. Stroke. 2017;48(5):1278-84.
35. Noorian AR, Sanossian N, Shkirkova K, Liebeskind DS, Eckstein M, Stratton SJ, et al. Los Angeles motor scale to identify large vessel occlusion: prehospital validation and comparison with other screens. Stroke. 2018;49(3):565-72.
36. Puolakka T, Virtanen P, Kinnunen J, Kuisma M, Strbian D. Prehospital identification of large vessel occlusion using the FAST-ED score. Acta Neurol Scand. 2021;144(4):400-7.
37. Puolakka T, Virtanen P, Kuisma M, Strbian D. Comparison of large vessel occlusion scales using prehospital patient reports. Acta Neurol Scand. 2022;145(3):265-72.
38. Rynor H, Levine J, Souchak J, Shashoua N, Ramirez M, Gonzalez IC, et al. The effect of a county prehospital FAST-ED initiative on endovascular treatment times. J Stroke Cerebrovasc Dis. 2020;29(11):105220.
39. Tárkányi G, Karádi ZN, Csécsei P, Bosnyák E, Fehér G, Molnár T, et al. Capability of stroke scales to detect large vessel occlusion in acute ischemic stroke- a pilot study. Ideggyogy Sz. 2021;74(3-4):99-103.
40. Wang J, Gong X, Zhong W, Zhou Y, Lou M. Novel prehospital triage scale for detecting large vessel occlusion and its cause. J Am Heart Assoc. 2021;10(17):e021201.
41. Zhang B, Huo X, Yuan F, Song G, Liu L, Ma G, et al. Design and validation of a recognition instrument—the stroke aid for emergency scale—to predict large vessel occlusion stroke. Aging (Albany NY). 2021;13(10):13680-92.
42. Zhao H, Coote S, Pesavento L, Churilov L, Dewey HM, Davis SM, et al. Large vessel occlusion scales increase delivery to endovascular centers without excessive harm from misclassifications. Stroke. 2017;48(3):568-73.
43. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151(4):264-9.
44. Whiting PF, Rutjes AW, Westwood ME, Mallett S, Deeks JJ, Reitsma JB, et al. QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies. Ann Intern Med. 2011;155(8):529-36.
45. Antipova D, Eadie L, Macaden A, Wilson P. Diagnostic accuracy of clinical tools for assessment of acute stroke: a systematic review. BMC Emerg Med. 2019;19(1):49.
46. Koster GT, Nguyen TTM, van Zwet EW, Garcia BL, Rowling HR, Bosch J, et al. Clinical prediction of thrombectomy eligibility: a systematic review and 4-item decision tree. Int J Stroke. 2019;14(5):530-9.



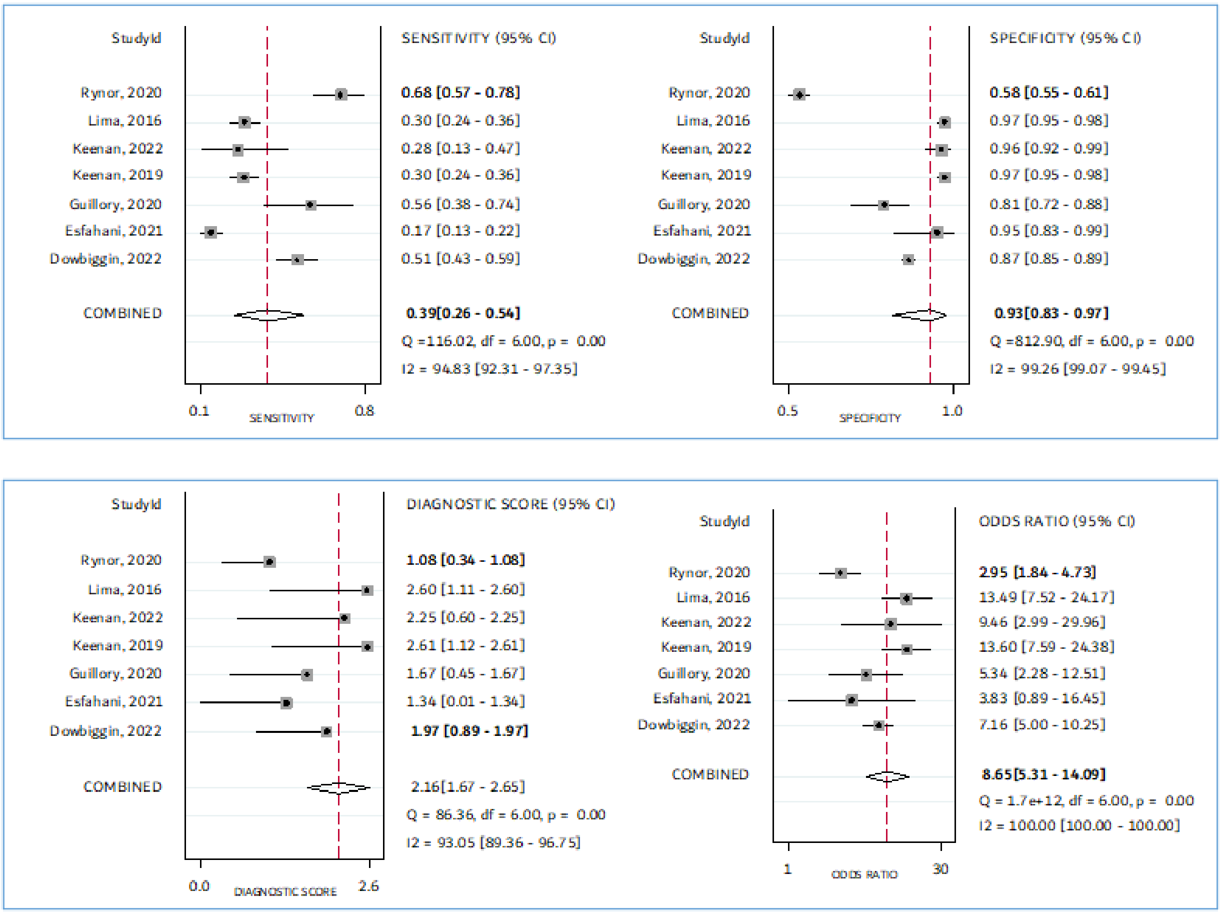
Supplementary figure 1 Sensitivity, specificity and diagnostic odds ratio of FAST-ED in cut-off points of more than 3, in detection of stroke



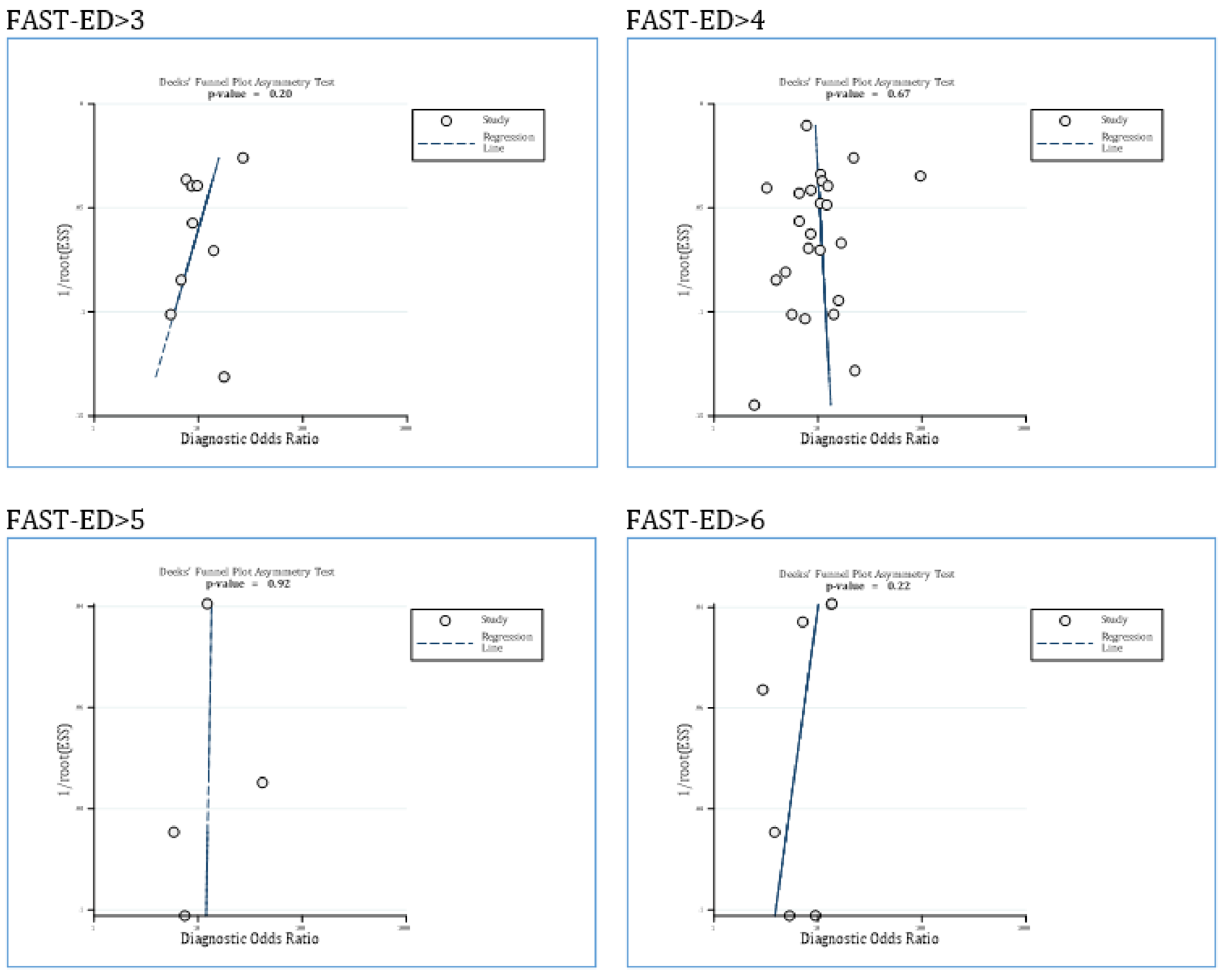
Supplementary figure 2 Sensitivity, specificity and diagnostic odds ratio of FAST-ED in cut-off points of more than 4, in detection of stroke



Supplementary figure 3 Sensitivity, specificity and diagnostic odds ratio of FAST-ED in cut-off points of more than 5, in detection of stroke



Supplementary figure 4 Sensitivity, specificity and diagnostic odds ratio of FAST-ED in cut-off points of more than 6, in detection of stroke



Supplementary figure 5 Publication bias of FAST-ED in different cut-off points in detection of stroke

Appendix 1 Queries for records retrieval from Medline (via PubMed), Embase, Scopus, and Web of Science

PubMed

1- "Stroke"[Mesh terms] OR "Ischemic Stroke"[Mesh terms] OR "Embolic Stroke"[Mesh terms] OR "Cerebral Infarction"[Mesh terms] OR "Infarction, middle cerebral artery"[Mesh terms] OR "Brain infarction"[Mesh terms] OR "Stroke, Lacunar"[Mesh terms] OR "Thrombotic Stroke"[Mesh terms] OR Stroke[Title/Abstract] OR Cerebral Infarction[Title/Abstract] OR Brain infarction[Title/Abstract] OR middle cerebral artery infarct*[Title/Abstract] OR middle cerebral artery occlusion[Title/Abstract] OR Cerebral Infarct*[Title/Abstract] OR Brain Infarct*[Title/Abstract] OR Stroke[Title/Abstract] OR Cerebrovascular Accident[Title/Abstract] OR Cerebrovascular Accident, [Title/Abstract] OR Apoplexy[Title/Abstract] OR Brain Vascular Accident*[Title/Abstract] OR Cryptogenic Embolism[Title/Abstract] OR Cerebral Infarct*[Title/Abstract] OR Subcortical Infarction[Title/Abstract] OR Choroidal Artery Infarction [Title/Abstract] OR MCA Infarction[Title/Abstract] OR Cerebral Artery Infarction[Title/Abstract] OR Cerebral Artery Embol*[Title/Abstract] OR Cerebral Artery Occlusion[Title/Abstract] OR Cerebral Artery Thromb*[Title/Abstract] OR Brain Venous Infarction[Title/Abstract] OR cerebral ischemia reperfusion injury[Title/Abstract] OR brain ischemi* reperfusion injury[Title/Abstract] OR brain ischemia/reperfusion[Title/Abstract] OR cerebral ischemia/reperfusion[Title/Abstract] OR cerebral reperfusion injury[Title/Abstract] OR reperfusion brain injury[Title/Abstract] OR acute cerebrovascular lesion[Title/Abstract] OR acute focal cerebral vasculopathy[Title/Abstract] OR brain vascular accident[Title/Abstract] OR cerebrovascular injury[Title/Abstract] OR cortical infarction[Title/Abstract] OR hemisphere infarct*[Title/Abstract] OR hemispheric infarct*[Title/Abstract] OR brain stem infarction*[Title/Abstract] OR brainstem infarction[Title/Abstract] OR cerebellar infarction[Title/Abstract] OR brain ischemia[Title/Abstract] OR brain ischaemic attack[Title/Abstract] OR brain ischemic attack[Title/Abstract]

2- "field assessment stroke triage for emergency destination" OR "FAST-ED"

3- #1 AND #2

Embase

1- 'cerebral ischemia reperfusion injury'/exp OR 'cerebrovascular accident'/exp OR 'cardioembolic stroke'/exp OR 'brain infarction'/exp OR 'brain stem infarction'/exp OR 'cerebellum infarction'/exp OR 'brain ischemia'/exp OR 'transient ischemic attack'/exp OR 'Stroke' OR 'Cerebral Infarction' OR 'Brain infarction' OR 'middle cerebral artery infarct*' OR 'middle cerebral artery occlusion' OR 'Cerebral Infarct*' OR 'Brain Infarct*' OR 'Hemorrhagic Strokes' OR 'Stroke' OR 'Cerebrovascular Accident' OR 'Cerebrovascular Accident, ' OR 'Apoplexy' OR 'Brain Vascular Accident*' OR 'Cryptogenic Embolism' OR 'Cerebral Infarct*' OR 'Subcortical Infarction' OR 'Choroidal Artery Infarction ' OR 'MCA Infarction' OR 'Cerebral Artery Infarction' OR 'Cerebral Artery Embol*' OR 'Cerebral Artery Occlusion' OR 'Cerebral Artery Thromb*' OR 'Brain Venous Infarction' OR 'cerebral ischemia reperfusion injury' OR 'brain ischemi* reperfusion injury' OR 'brain ischemia/reperfusion' OR 'cerebral ischemia/reperfusion' OR 'cerebral reperfusion injury' OR 'reperfusion brain injury' OR 'acute cerebrovascular lesion' OR 'acute focal cerebral vasculopathy' OR 'brain vascular accident' OR 'cerebrovascular injury' OR 'cortical infarction' OR 'hemisphere infarct*' OR 'hemispheric infarct*' OR 'brain stem infarction*' OR 'brainstem infarction' OR 'cerebellar infarction' OR 'brain ischemia' OR 'brain ischaemic attack' OR 'brain ischemic attack'

2- 'field assessment stroke triage for emergency destination'/exp OR 'field assessment stroke triage for emergency destination' OR 'fast-ed'

3- #1 AND #2

Scopus

1- TITLE-ABS-KEY("Stroke" OR " Cerebral Infarction" OR " Brain infarction" OR " middle cerebral artery infarct*" OR " middle cerebral artery occlusion" OR " Cerebral Infarct*" OR " Brain Infarct*" OR " Hemorrhagic Strokes" OR " Stroke" OR " Cerebrovascular Accident" OR " Cerebrovascular Accident, " OR " Apoplexy" OR " Brain Vascular Accident*" OR " Cryptogenic Embolism" OR " Cerebral Infarct*" OR " Subcortical Infarction" OR " Choroidal Artery Infarction " OR " MCA Infarction" OR " Cerebral Artery Infarction" OR " Cerebral Artery Embol*" OR " Cerebral Artery Occlusion" OR " Cerebral Artery Thromb*" OR " Brain Venous Infarction" OR " cerebral ischemia reperfusion injury" OR " brain ischemi* reperfusion injury" OR " brain ischemia/reperfusion" OR " cerebral ischemia/reperfusion" OR " cerebral reperfusion injury" OR " reperfusion brain injury" OR " acute cerebrovascular lesion" OR " acute focal cerebral vasculopathy" OR " brain vascular accident" OR " cerebrovascular injury" OR " cortical infarction" OR " hemisphere infarct*" OR " hemispheric infarct*" OR " brain stem infarction*" OR " brainstem infarction" OR " cerebellar infarction" OR " brain ischemia" OR " brain ischaemic attack" OR " brain ischemic attack")

2- TITLE-ABS-KEY("field assessment stroke triage for emergency destination" OR "FAST-ED")

3- #1 AND #2

Appendix 1 Queries for records retrieval from Medline (via PubMed), Embase, Scopus, and Web of Science

Web of Science
1- TS=("Stroke" OR " Cerebral Infarction" OR " Brain infarction" OR " middle cerebral artery infarct*" OR " middle cerebral artery occlusion" OR " Cerebral Infarct*" OR " Brain Infarct*" OR " Hemorrhagic Strokes" OR " Stroke" OR " Cerebrovascular Accident" OR " Cerebrovascular Accident, " OR " Apoplexy" OR " Brain Vascular Accident*" OR " Cryptogenic Embolism" OR " Cerebral Infarct*" OR " Subcortical Infarction" OR " Choroidal Artery Infarction " OR " MCA Infarction" OR " Cerebral Artery Infarction" OR " Cerebral Artery Embol*" OR " Cerebral Artery Occlusion" OR " Cerebral Artery Thromb*" OR " Brain Venous Infarction" OR " cerebral ischemia reperfusion injury" OR " brain ischemi* reperfusion injury" OR " brain ischemia/reperfusion" OR " cerebral ischemia/reperfusion" OR " cerebral reperfusion injury" OR " reperfusion brain injury" OR " acute cerebrovascular lesion" OR " acute focal cerebral vasculopathy" OR " brain vascular accident" OR " cerebrovascular injury" OR " cortical infarction" OR " hemisphere infarct*" OR " hemispheric infarct*" OR " brain stem infarction*" OR " brainstem infarction" OR " cerebellar infarction" OR " brain ischemia" OR " brain ischaemic attack" OR " brain ischemic attack")
2- TS=("field assessment stroke triage for emergency destination" OR "FAST-ED")
3- #1 AND #2